# Group Decision and Negotiation (GND) 2013

International Conference Stockholm, Sweden, June 17-20, 2013 Proceedings

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ISBN 978-91-637-3490-8

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# PREFACE

Group Decision and Negotiation 2013 is the 13<sup>th</sup> meeting organized by the INFORMS section on Group Decision and Negotiation with the EURO Working Group Decision and Negotiation and hosted by the Department of Computer and Systems Sciences at University of Stockholm, Sweden.

The GDN conference series started in Glasgow in 2000, and continued in La Rochelle (2001), Perth (2002), Istanbul (2003), Banff (2004), Vienna (2005), Karlsruhe (2006), Montreal (2007), Coimbra (2008), Toronto (2009), Delft (2010) and Recife, Brazil (2012). The meetings in Istanbul, Banff, and Toronto were held as streams within a larger INFORMS Conference.

GDN conferences traditionally bring together international researchers from the Americas, Asia, Europe, Africa, and Oceania, with a stimulating variety of backgrounds, and representing a wide range of disciplines: economics, operational research, game theory, social sciences, and information systems. While many of us come from different traditions, we all share a common passion: research into complex decision taking and negotiation involving multiple stakeholders, different perspectives, issues and emotions, requiring decision and negotiation support for both process and content.

The aim of GDN research is not only to improve our understanding of group decision and negotiation processes, methods, tools, and techniques, but also to improve connectedness, support decision makers and negotiators and help them achieve better results. The contributions in these proceedings reflect the richness of GDN scholarship. Using a variety of research approaches including real organizational settings and laboratory situations, they focus on the development, application and evaluation of concepts, theories, methods, and techniques.

Bilyana Martinovski (Program and Organizing Chair)

Melvin F. Shakun, D. Marc Kilgour, and Gregory Kersten (General Chairs)

# FOREWORD

The 13<sup>th</sup> International Meeting on Group Decision and Negotiation (GDN2013) proceedings include 66 extended abstracts/full papers, 6 keynote presentations, 4 workshops and 1 panel. The themes cover areas such as conflict resolution in energy and environmental management, automated collaboration, facilitation, group decision and negotiation support systems, modeling negotiation contexts, e-negotiations, relation between society, behavior and group decision and negotiation as well as shareholder rights and auctions.

To commemorate the first United Nations Conference on the Human Environment, held in Stockholm almost exactly 40 years ago (5 - 16 June 1972), GDN2013 takes Environmental Negotiations as its special theme, 17 presentations are dedicated to that theme. Because of their long-term implications and worldwide scope, the processes of negotiation and decision on the environment offer distinctive challenges. By choosing this special theme for GDN2013, we honor four decades of effort and progress on Environment Negotiations, and hope to stimulate further development and understanding of this vital human endeavor.

A workshop on Virtual Human Technology and Its Applications is held in parallel and in relation to GDN2013, supported by STINT.

GDN2013 continues the tradition of Doctoral Consortium in Group Decision and Negotiation held on June 17, 2013 and chaired by Rudolf Vetschera. It offers PhD students an opportunity to present and discuss their dissertation research together with international faculty and colleagues.

The passion, competence, professionalism, and punctuality of the international GDN community and the program committee carried out the review process and contributed to the quality of the research reported in proceedings.

GDN2013 is hosted by the Department of Computer and Systems Sciences (DSV) at University of Stockholm, Sweden and supported directly by the Swedish Central Bank Fund (Riksbankens Jubileumsfond), the City of Stockholm and Kista Science City. I offer my gratitude to Love Ekenberg for his courage, openness and professionalism, to our generous supporters, to the tireless general chairs and committees, to the talented authors and presenters, and to the entire team of kind-hearted and competent DSV assistants. Special thanks to my friend Ann-Cathrine Sigrid Ståhlberg and my wonderful family for their loving support. On behalf of the GDN community, the committees and the host I extend gratitude to Thomas Andersson for his supportive guidance, to Christina Gudmundsson for her kindness and to Daniel Ruhe for his fearless and humorous assistance during the conference preparation process, the proceedings wouldn't look as good without his irreplaceable insight and hard work.

Bilyana Martinovski (Program and Organizing Chair)

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# PART I Keynote presentations

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# A Participatory Model for Public Decision Analysis

#### Love Ekenberg<sup>1</sup>

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**Abstract**: In most decent societies, incorporating citizens' input in the process of public planning decision-making is important for the legitimacy of any outcome. However, simply enabling more participation will not result in enhanced democracy by itself and an adequate mechanism for participation exercises is vital regardless of the democracy model. Furthermore, it seems reasonable that various new media are of relevance in this context. There have been some suggestions lately, but contemporary methods are to a large extent locked into traditional ways of using computer-based texts and images that largely hamper the capacity for communicating and we will discuss how this might be changed. This keynote describes some current achievements in a project in which the objective is to design a process that involves public participation in a much broader sense than usual. The public is invited to the process by various means, including art projects, flash polls, and various means for dialogues. To a large extent, the area of e-participation lacks real interdisciplinary research. This work within the project can be seen as an attempt to bridge some important paradigms in these respects.

Keywords: Participatory decision making, Societal planning, Regional development, Democracy.

## Background

Whilst there have been many decision analytical approaches proposed during the last two hundred years, these usually place far too many requirements on decision-makers for realistic and rational decision making. Similarly, they normally impose working processes that are not already parts of the regular processes used in organisations. Consequently, decision theoretical methods are severely underutilized in real-life practice and, when used, often cause significant errors due to oversimplifications. At the same time, it has become increasingly obvious that cognitive limitations of the human mind render the processing of large amounts of complex information intrinsic in many decision making situations very difficult to handle and the handling must be strongly supported by more elaborated decision analytical based support systems. Naturally, in public decision making, components such as citizen involvement and transparency issues complicate this tremendously as, e.g., (Hanson et al., 2012) discusses extensively.

We have for a number of years as discussed in e.g., (Danielson et al., 2007a, 2009, 2010) been conducting projects regarding different facets of decision making with the goal to enhance the efficiency, transparency, and rationality involving utilization of new communication modalities for handling rationality in multicriteria, multi-user settings. Along this line, at present we are, within a FORMAS<sup>1</sup> supported project designing and implementing a process for public participatory decision making in two municipalities in the greater Stockholm area. In these we try, through various participation channels, to investigate the issues of citizen communication, elicitation, and involvement, while as far as possible attempting a rational and systematic treatment of the information delivered. The processes include multi-modal communication, elicitation methods, utilization of vague and numerically imprecise information, a negotiation module for multi-criteria trade-off calculations and visibility as well as an elaborated decision analytical component. Thus, in short the idea is trying to enhance the efficiency and transparency as well as rationality, while developing methods for realistic decision making in public settings. This is done in the context of a process model for public decision making, which is inclusive to many stakeholders and decision-makers.

Our research is focusing on creating a decision-theoretical framework, but at the same time on providing meaningful tools, developed in the context of public decision making including interaction and the investigation work of civil servants, while taking theories on communication and negotiation in planning as points-of-departure. In this we are bridging two fields, analytic decision support and public e-participation, by addressing both the problem of communication, internally within the governmental body and externally to citizens, and that of modeling and analysis of decision alternatives.

<sup>&</sup>lt;sup>1</sup> The Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning

An important aspect of this undertaking is to analyze the complex issues of how governance arrangements and formal planning processes as such can be structured to effectively accommodate inputs from various citizens in a decision framework, including usable and transparent decision methods equipped for handling a multitude of citizens and multiple decision-makers. This aspect of the research agenda focuses more extensively on means and tools for how citizen content may be analyzed, distributed, and utilized by decision making authorities in public decision making and planning. The general need to facilitate the expression of views, concerns, and opinions of general stakeholders is crucial not only to support decision-makers but to actually take part in the decision-making process. One proviso here is thus that decision rationales are clearly communicated to the citizens concerned. This means, among other things, that the background information as well as the decision principles should be communicated together with means to understand and utilize them.

# **Democratic Participation**

For a process such as the above to be considered as reasonably democratic, it must at least be sensitive to the interests of various citizens, and consequently (i) allow for modeling of outcomes based on the different preferences, as well as (ii) facilitate a negotiation process where different views can be interactively adjusted when considering calculated outcomes, and (iii) provide a reasonable basis for broad participation. Traditionally, decision analytical systems are inclined to find a set of non-dominated solutions, while democratic discourses are closer to negotiation processes between different world views where there can be several feasible solutions, each pertaining to a specific set of preferences. Our approach to democratic decision making processes is supposed to be attentive to process models derived from both these approaches. In the literature, some earlier general process models, decision making methods and accompanied tools and means for participation have been suggested. This includes tools like web-based platforms supporting public and transparent decision making processes in an informative and participatory manner. However, less work has been done on providing means for the public to provide decision-makers with information in various forms through easily accessible channels, facilitating for decision-makers to understand and make planning decisions at least partly based on citizens' views, values, and opinions.

A full design process in a public decision process implementation must acknowledge various views of citizens; at the same time, available facts must be used to increase citizens' insights into the outcomes of applying different preferences. Furthermore, it must also include models for how enriched content may be incorporated in real-life decision making and planning. This calls for a common model encompassing different points-of-view, different perspectives, multiple objectives, and multiple stakeholders using different methods for appraisals. Therefore, such a decision framework must allow for different points-of-view. For instance, in the case of planning decisions, this includes environmental impact assessments as well as political ideology alignment assessments. Thus, a minimum requirement for a participatory approach to make sense is that the resulting process is transparent, encouraging participation, for example by adequate feedback mechanisms, and enabling a rational treatment of the information delivered, preferably through a multitude of participation channels, even in more innovative forms such as artistic performances such as described in (Hansson et al., 2011). Needless to say, all of this put quite strong requirements on the general public fully occupied with just living.

# **Designing a Participatory Framework**

On an abstract level, a participatory framework can be divided in four subcomponents: a) a discursive part, where opinions are developed and the agenda defined; b) an interaction part, facilitating communication and mapping of interests among stakeholders; c) an elicitation part, containing means for modeling the interests, ideas, assessments, as well as attitudes of the citizens and decision-makers; and d) a substantial decision evaluation and analysis part enabling the use of methods for evaluating decision alternatives with multiple objectives where the alternatives are assessed from different perspectives having conflicting and/or information. Conceptually, this participatory analytic decision model consists of four interacting layers further elaborated in (Hansson et al., 2012, 2013):



**a.** The *discursive layer* where public opinions are developed, containing the deliberative process of setting the agenda, using a broad spectrum of multimodal tools to support organization and discussion, and using web statistics to clarify the representativeness of the information.

**b.** The *public interaction layer* that enables feedback from inhabitants and stakeholders, containing interaction with affected stakeholders, organized stakeholder groups and citizens, using web-based techniques for interaction.

**c.** The *investigation layer* where data is gathered, consisting of the local government's administrative process making the investigations and assessments necessary for taking the process further.

d. The analysis layer or inner decision layer.

In the latter, data and information from the other three layers are gathered and modeled using techniques and tools from multi-criteria decision analysis. The results of the analyses carried out in this layer are communicated to the investigation layer.

The discursive layer is particularly complicated and needs innovative approaches to fulfil its role. For instance, during two-years, as a part of a research project, an art project was running in an area that, in the public eye, is regarded as a problem area and is a neighbourhood associated with segregation, exclusion, unemployment, and other social problems. Several artists were engaged with local residents in creating and developing art. This interaction was strongly tinged by dialogues that integrated thoughts on community development, i.e. how can art and culture reflect residents' views and aspirations for the development of the area. In parallel, artists' completed works were displayed at a local art exhibition in the public space. The works were presented and discussed at public meetings. We wanted to see whether art can form a basis for constructive dialogues and expressions of preferences for community development as well as finding more nuances beyond the prevailing hegemonic discourse and find new problem formulations and solutions.

Through all these layers, transparency is crucial. Likewise, the iterative communication flow between the layers is essential for the recursive process of the model. The process model will carry the decision from agenda setting and problem awareness to feasible courses of action via objectives formulations, alternative generation, consequence assessments, and trade-off clarifications. The formal decision mechanism is normally problematical, both regarding hidden agendas and lack of capacity of the decision makers. In the model described, to execute the decision steps appropriately, the decision structuring and evaluation procedure are developed as an extension to a proven decision analytic method and tools based on the DELTA decision method, cf. e.g, (Danielson and Ekenberg, 2007), (Danielson et al., 2007b). The method has been used in several large decision problems involving many stakeholders, such as, e.g., the design of a flood insurance system for Hungary (Danielson and Ekenberg, 2013), deposition of nuclear fuel, purchasing decisions at the Swedish Rail Administration, investment decision analyses in industry, flood management (Hansson et al., 2013), emergency management (Larsson et al., 2010 a), energy pricing and demining (Larsson et al., 2010b), and many others. The elicitation part of (Danielson et al., 2009b) has recently been further enhanced in (Riabacke et al., 2012) by studying how groups of political decision-makers desire to express values and priorities. Formal decision analysis is in my opinion a necessary requirement in democratic transparent processes, but it has obvious limitations that must be kept in mind. However, the alternative approach of working with some kind of (often misguided) intuition will neither provide adequate transparency nor correctness as soon as the decisions at hand are starting to get just slightly complex.

## **Concluding remarks**

Over a number of years we have been examining different types of decisions and the processes surrounding them. We have looked at transparency in processes and in the underlying data. We have looked at various systems of rules for decision making and participation. We have undertaken a succession of projects in order to try to understand how one can create open regulatory systems and methods for making decisions. We have worked with politicians, government agencies, and their staff. Many have been well-disposed towards our research while some have been negative. This is a difficult area and we have sought to understand why, and what one could do to ameliorate the situation. In our current work, we design and implement a process for public participatory decision making emphasizing the issues of citizen communication, elicitation, and involvement, in combination with a computational model for rational and systematic decision making. More specifically, the following elements have been developed:

- Tools and procedures for multimodal communication between citizens, stakeholders, and decision-makers
- Process models for the distribution of content mediated through multimodal communication between decision-makers, stakeholders, and the general public
- Process models for the incorporation of this content in public planning and decision making, decision methods included

We have developed a set of procedures that seem to be prima facie reasonably and we have processes for decision making as well as means for negotiation and conflict resolution. While the strategies seem to work quite well in controlled middle-class environments, the general success of this framework is yet unproven. We have, e.g., partially implemented some of these ideas in what in the public eyes is regarded as a problem area, i.e. a neighbourhood associated with segregation, exclusion, unemployment, and other social problems. We tried what we believe are reasonably innovative ways of communicating important questions for city planning, such as the conceptual ownership of the public areas. However, the outreach is still limited and the activities did not automatically increase participation. The upside is that the artists to some extent nevertheless seemed to improve the conditions for communication by creating new arenas where discourses can develop more independently from the political agenda. There remains, however, substantial work before a reasonable level of general inclusion can be met and it is clear that the prevailing E-democracy approaches, such as E-panels, surveys, web portals, E-petitioning, E-deliberative polling, E-consultation, E-voting, etc, are far from sufficient.

Acknowledgments. This research was funded by the Swedish Research Council Formas, project number, 2011-3313-20412-31, as well as by Strategic funds from the Swedish government within ICT – The Next Generation. Many thanks to Göran Cars, Mats Danielson, Aron Larsson and, in particular, the incomparable Karin Hansson and Rebecca Forsberg for invaluable input.

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# Justice in International Negotiation: Negotiating an End to Civil Wars and Other Issue Areas

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**Abstract**: In this address, I discuss research on the role of justice in international negotiation. Two types of justice are investigated in several issue areas. One is distributive justice (DJ) and is manifest in the provisions of the agreements that deal with allocating benefits and burdens. The other is referred to as procedural justice (PJ) and is reflected in the way that the negotiation process unfolds. Impacts of DJ and PJ are explored on several dependent variables: durability of the agreements, durable peace following the agreements, and effectiveness of the negotiations. Durability and durable peace are examined in the context of negotiations to end civil wars. Of particular interest is the finding that durability depends on the centrality of the DJ principle of equality in the agreements. But durability is also only modesty correlated with durable peace: Durable agreements do not lead to lasting peace in many countries ravaged by civil wars. Effectiveness is explored in the context of trade, arms control, and environmental negotiations. The findings indicate that the effects of justice may be context specific, with PJ being particularly important in trade talks while DJ influences effectiveness in multilateral arms control and bilateral environmental talks. Implications of these findings for theory and practice are discussed.

**Keywords**: Distributive justice, durability, durable peace, negotiation effectiveness, peace agreements, procedural justice

In this keynote address I discuss our research on the role of justice in international negotiation. Focusing primarily on agreements to end civil wars, the research addresses questions of the durability of the agreements and on the extent to which durable peace follows. Two types of justice are investigated. One is referred to as distributive justice (DJ) and is manifest in the provisions of the agreements that deal with allocating benefits and burdens: the DJ principles include equality, proportionality, compensation, and need. The other is referred to as procedural justice (PJ) and is reflected in way that the negotiation process unfolds: the PJ principles include fair play, fair representation, transparency, and voluntary decisions. The initial study explored the relationship between DJ and PJ, on the one hand, and the durability of peace agreements on the other. The 16 agreements were negotiated during the early years following the end of the Cold War.

The study was framed in terms of competing hypotheses referred to as root causes and normative considerations. The former posits that adherence to justice principles will enhance durability. This occurs because claims made by rebel groups are addressed in the agreement. The latter posits that adherence to justice principles reduces durability. This occurs because raising justice issues stirs controversy over the "correct" principle. These opposed hypotheses are further developed in the context of the larger environment in which the conflict is played out. The root causes argument is expected to hold in relatively low conflict environments; the normative argument may hold in more intense conflict environments. These contingent effects are analyzed statistically and with qualitative focused comparisons.

The results indicate some support for the root causes argument. The strong inverse correlation found between the conflict environment and durability is reduced when DJ principles are significant in the agreements. DJ serves to moderate the negative effects of an intense conflict environment on durability. These principles do not reduce durability or escalate the conflict, as posited by the normative considerations hypothesis. Further analyses discovered that these results were due to one DJ principle, equality: More durable agreements occurred when the equality principle was central; as well, equality moderated the negative impact of conflict intensity on durability. These principles also played an important role in the relationship between PJ and durability. When PJ principles guided the process, durability increased only when equality principles were also central in the agreements. Thus, equality is a key to durable peace agreements.

In an attempt to explore the generality of these findings, we analyzed the role played by justice in three other issue areas: trade, arms control and the environment. These studies showed that justice effects are context-specific. Procedures mattered most in both bilateral and multilateral trade and in multilateral environmental

talks whereas distributive principles had a stronger impact on the effectiveness of multilateral arms control and environmental negotiations. Unlike peace agreements, equality was not the driving principle in these domains. Reasons for these different effects are discussed in the address.

Our current research extends the earlier work on peace agreements in two directions. We analyze a larger sample of 50 historical agreements: The sample of agreements cover the end of civil wars over the past 40 years on most continents of the world. And, we focus on durable peace rather than durability: By durable peace we refer to four elements: reconciliation, security institutions, governing institutions, and economic stability. Effects on these elements of DJ, PJ, and the conflict environment are being explored. Two findings obtained to date are interesting. One is the modest correlation obtained between durability and durable peace (r = .55). This means that durable agreements lead to a durable peace in only about a quarter of the cases. Adherence to the provisions of the agreements is only one influence on long-term peace. Another finding refers to the element of economic stability. We find that this element is largely independent of (or uncorrelated with) the three other parts of the durable peace index. This means that economic development may occur for reasons unrelated to reconciliation and the development of security and governing institutions. Cambodia provides an example: Improvements in the economy occurred despite a rather abysmal record of changes in reconciliation, power sharing, democratization, and demobilization. These are some of the findings that will be discussed during the keynote session.

# Humans are Parochial Altruists: Neurocognitive Foundations with Implications for Intergroup Negotiation

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**Abstract**: Humans have a stunning capacity for cooperation yet, at the same time, create and escalate conflict with often devastating consequences. Here I argue that both tendencies -- to cooperate and to aggress -- can be understood as manifestations of parochial altruism--the tendency to benefit, at a cost to oneself, the group to which one belongs and to fight or derogate rival out-groups. I present evidence that humans display parochialism because of in-group love more than out-group hate, that especially those with pro-social value orientations are parochial rather than universal altruists, and that parochial altruism is intuitive rather than calculated and deliberate. I conclude with the neurobiological origins of parochial altruism, focusing on the oxytonergic circuitry, and with implications for negotiation in intergroup competition and conflict.

Keywords: cooperation, group decision, negotiation, altruism, neurobiology, psychology

Intergroup competition and conflict are pervasive problems in human society, giving rise to such phenomena as prejudice, terrorism, ethnic cleansing, and interstate war (Choi & Bowles, 2007). Results can be devastating: Governmental genocidal policies killed over 210 million people during the 20th century alone, and since 2000 over 30,000 people have been killed by terrorists (Cohen & Insko, 2008). Yet at the same time, it has been suggested that throughout evolution the paramount challenge for humans was the necessity of dealing with fellow humans in social circumstances that became increasingly more complex and unpredictable. Alexander (1990) conjectured, for example, that nothing would select more potently for increased social intelligence than a within-species coalitionary arms race in which success depended on effectiveness in social compe¬tition (Alexander, 1990). Indeed, scientific progress such as the discovery of DNA has been attributed to the intense hatred and rivalry between two world-famous laboratories, and the discovery of nuclear energy and the development of the atomic bomb were primarily stimulated by World War II. Thus, whether in ancestral environments or in today's complex economic market system, intergroup competition often turns into costly and exceedingly violent conflicts yet may also boost social change, technological innovation, and economic prosperity (De Dreu, 2010a).

Intergroup competition and conflict operates at two distinct yet closely intertwined levels of analysis: that of the individual and that of the group to which one belongs (henceforth, the in-group). Intergroup competition and conflict thus represents an amalgam of individual self-interests, values, and beliefs that converge into and are informed by group interests, values, and beliefs, and both the individual and group-level interests, values, and beliefs are shaped by and instrumental to the intergroup competition and conflict. Accordingly, social identity theory clarifies that individuals derive part of their self-concept from the group to which they belong, and to uphold and improve a positive social identity, individuals may derogate outgroups and expend effort to ensure that their in-group wins a competition with a rival out-group (Ellemers, 2012). Along similar lines, work has documented that individuals can justify competitive behavior towards rival out-groups in terms of trying to help their in-group, whereby intergroup competition becomes a manifestation of within-group cooperation. Indeed, being in competition with a rival out-group triggers a host of processes within each group, such as norm formation and maintenance, leadership selection and endorsement, and individual self-sacrifice and willingness to cooperate with in-group members (Bornstein, 2003; Bowles, 2009).

These brief illustrations show that (1) intergroup competition and conflict are important triggers of withingroup cooperation, and (2) within-group cooperation serves as a trigger for intergroup distrust, rivalry, and outright aggression. Here I focus on a key behavioral tendency in such intergroup competition – parochial altruism. Parochial altruism is defined as the tendency to self-sacrifice to benefit one's in-group and to derogate and hurt rival out-groups. I address five interrelated questions:

- 1. Parochial altruism can be decomposed into in-group love (the tendency to benefit the in-group at a personal cost), and out-group hate (the tendency to derogate and hurt the out-group at a personal cost) (Brewer, 1999). I discuss the results of a large meta-analysis (Balliet, Wu, & De Dreu, 2013) that indicate that parochial altruism is driven primarily by in-group love, and far less by out-group hate.
- 2. Parochial altruism bears some resemblance with what behavioral economists refer to as otherregarding preferences, and psychologists call pro-social value orientations. I present evidence, from my own laboratory (De Dreu, 2010) and those of others (Abbink et al., 2012), suggesting that it pro-social rather than selfish individuals display parochial altruism in intergroup competition.
- **3.** Because parochial altruism has strong fitness functionality and may have been critical to survival in ancestral times (Choi & Bowles, 2007), parochial altruism may have become hard-wired, intuitive, and automatic. I present evidence that indeed, lowering impulse-control and the ability to deliberate amplifies the tendency towards parochial altruism (De Dreu, Dussel & Ten Velden, 2013).
- 4. I explore the neurobiological bases of parochial altruism by focusing on the hypothalamic neuro¬peptide oxytocin. Known for its role in reproduction and social bonding in animals, I present evidence that oxytocin is intimately involved in motivating parochial altruism in humans (De Dreu, Greer et al., 2010).
- 5. I examine possible implications for representative negotiation, a form of dispute resolution where opposing groups delegate to representatives the process of negotiating a mutually acceptable, or perhaps even beneficial solution (Aaldering, Greer, Van Kleef, & De Dreu, 2013).

## Parochial Altruism: In-group Love versus Out-group Hate

Balliet, Wu, and De Dreu (2013) applied meta-analytic techniques to harness the relatively recent explosion of research on intergroup discrimination in cooperative decision making. Firstly, we find support that intergroup discrimination in cooperation is the result of in-group favoritism rather than out-group derogation. Second, we forward and test predictions about the conditions that moderate in-group favoritism from two influential perspectives – a social identity approach and bounded generalized reciprocity perspective. While there is a slight tendency for in-group favoritism through categorization with no mutual interdependence between group members (e.g., dictator games, d = 0.20), situations that contain interdependence result in stronger in-group favoritism (e.g., prisoner's dilemmas, d = 0.43). We also find that in-group favoritism is stronger when there is common (versus unilateral) knowledge of group membership and during simultaneous (versus sequential) exchanges. In all, these results fit a bounded generalized reciprocity perspective on in-group love, suggesting that parochial altruism develops and emerges because individuals expect to benefit, in the long run, from in-group cooperation, and therefore are willing to contribute to their in-group at a personal cost.

## Parochial Altruism: Pro-social versus Pro-self Values

De Dreu (2010b; also see De Dreu, Greer et al., 2010) used an Intergroup Prisoner's Dilemma-Maximizing Differences Game (Halevy, Bornstein, & Sagiv, 2008) to model intergroup conflict, and compared individuals with a chronic pro-self orientation, to those with a chronic pro-social orientation. The experiment showed that pro-social compared to pro-self individuals display stronger in-group trust and ingroup love – they self-sacrifice to benefit their in-group – but not more or less out-group distrust and out-group hate. Path analyses suggest that effects of social value orientation on in-group love are mediated by in-group trust and not by fairness considerations. This experiment thus indicates that parochial altruism emerges especially in pro-social individuals, and is driven by their enhanced in-group love (and not out-group hate). Related work by Abbink, Brandts et al. (2012) obtained similar findings, and additionally showed that especially pro-social individuals escalated intergroup conflict by increasing their contributions to the in-group. Their study thus clarifies that parochial altruism not only strengthens the in-group, but also intensifies intergroup competition and conflict.

# Parochial Altruism: Intuitive versus Calculated

Contradicting that humans are rational and self-interested, cooperation-benefitting others at a cost to oneself-may be the intuitive response to social dilemmas where personal interest conflict with those of the collective (Rand, Greene, & Nowak, 2012). De Dreu, Dussel, and Ten Velden (2013) examined the possibility that because humans tend towards parochial rather than universal altruism, intuitive cooperation may be geared towards (i) strengthening the in-group ("in-group love"), and/or (ii) fighting out-groups ("out-group hate"). An experiment using an incentivized Intergroup Prisoner's Dilemma—Maximizing Differences Game (IPD-MD) with ninety-five pro-social or pro-self subjects randomly allocated to high vs. low impulse-control conditions showed that self-sacrificial decisions were faster, and that lowering impulse-control increased both in-group love and out-group hate. Replicating De Dreu (2010b), pro-social individuals were parochial rather than universal cooperators, regardless of their ability to control impulses.

# Parochial Altruism Resides in Oxytonergic Circuitry

Parochial altruism figures prominently in evolutionary explanations of human social behavior. As noted by Darwin (1873; p. 156), "groups with a greater number of courageous, sympathetic and faithful members, who were always ready to warn each other of danger, to aid and defend each other ... would spread and be victorious over other tribes." The pivotal implication is that the human brain evolved to sustain motivated cognition and behavior critical to the survival of one's own group, to facilitate contributions to in-group welfare and to defend against outside threats including competing groups. De Dreu, Greer et al., (2010) examined whether parochial altruism has its biological basis in brain oxytocin—a peptide of nine amino acids that is produced in the hypothalamus and released into both the brain and the blood stream (Donaldson & Young, 2008).

Functioning as both a neurotransmitter and hormone, oxytocin's targets are widespread and include the amygdala, hippocampus, brainstem, and regions of the spinal cord that regulate the autonomic nervous system. Its manifold effects include the promotion of trust and cooperation (e.g., Kosfeld et al., 2005). De Dreu et al. (2010) hypothesized that when humans are organized in in-groups and competing out-groups, oxytocin modulates parochial altruism. It increases in-group love and, perhaps, out-group hate to increase relative standing, and/or defend the in-group against possible out-group aggression (e.g., pre-emptive strike). Hypotheses were tested in three experiments using double-blind placebo-controlled designs. Male participants self-administered oxytocin or placebo and made decisions with financial consequences to themselves, their in-group, and a competing out-group. Results showed that oxytocin drives a "tend and defend" response in that it promoted in-group trust and cooperation, and defensive, but not offensive, aggression towards competing out-groups.

# Parochial Altruism as Barrier in Representative Negotiation

To reduce inter-group tension and conflict, competing groups often engage representatives who negotiate on their behalf. These representatives may be core members of the group, but can also be external agents with specific skills, knowledge or expertise in the relevant negotiation domain. A potential problem arises when the interests of the representative are not unequivocally aligned with the interests of the represented party. Such a conflict of interest exists, for example, among investment bankers representing bidding firms during merger negotiations: They receive compensation based on the premium paid for target firms. While it is in the target firms' interest to reach a maximum possible premium, the bidding firm strives for a premium as low as possible, potentially resulting in lower compensation for the investment banker.

The problem of interest (mis)alignment is often referred to as the principal-agent problem, in which the agent (representative) has other preferences than the principal (represented group or organization) (Eisenhardt, 1989; Jensen & Meckling, 1976) and may even have personal preferences more aligned with the opposing group. This may lead the representative to negotiate agreements that benefit him- or herself at the expense of the group he or she represents (Bazerman, Neale, Valley, Zajac, & Kim, 1992). In two experiments, Aaldering et al. (2012) examined how representative's negotiation varies as a function of interest alignment between the representative, the constituency represented, and the opposing negotiator (henceforth: adversary). Importantly, they investigated whether representatives' willingness to sacrifice their self-interest to benefit their constituency (parochial altruism) is contingent upon their interpersonal motivation. Experiment 1 revealed that both representatives with a pro-social and a pro-self value

orientation were reluctant to accommodate the negotiation adversary at a cost to themselves and their constituency, while pro-social representatives were more willing to sacrifice self-interest to benefit constituency and adversary combined. Experiment 2 replicated this finding, and clarified that pro-social representatives were more willing to self-sacrifice when this served their constituency only than when it indirectly served the adversary too. Such parochial altruism demonstrates the discriminatory nature of pro-socials' cooperation and reveals the potential dark side of a pro-social orientation in constructive intergroup negotiations. Put differently, parochial altruism may be an important barrier to constructive intergroup negotiation.

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# 'Joined-up' Policy-making: Group Decision and Negotiation practice

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Abstract: Creating public value is problematic in a world of austerity. Joint private and public, and public-public, projects are now an established way of creating public value. Establishing joint goals within a context of different 'own goals' is important and difficult. A particular issue facing many organisations in seeking to negotiate joint goals in a collaborative project is that of getting all the key managers from both organisations together over enough of a sequence of meetings for agreements to be meaningful and owned by those who will deliver the project. The development of such goals can be significantly enhanced by i) using a Group Decision Support System (GDSS) and ii) using a powerful conceptualisation of a goals framework comprising: a goals system; 'core goals'; 'meta-goals'; 'negative' goals; and 'above and beyond' goals. In the case of negotiating joint goals the use of a GDSS has increased productivity to such an extent that powerful negotiated agreements can be achieved with all key managers in the room in as little as one meeting. The combination of high productivity, anonymity, and the structuring of the data has also facilitated the uncovering of 'negative goals', and the development of 'meta-goals' and 'above and beyond' goals. This paper uses three real cases to illustrate the significance of a Group Support System's contribution and to illustrate the different types of goals. In doing so the paper suggests that facilitating such outcomes requires a carefully designed strategic conversation necessarily supported by a Group Decision Support System to enable group decision and negotiation in practice. Two of the cases are from public-public collaboration in the health field, and the other from a private-public setting.

### Introduction

We have worked with the top management teams of over 100 not-for profit and public sector, as well as private sector, organizations over the past twenty years. In all of these cases the process has been supported by the use of a Group Decision Support System (GDSS) to facilitate group decision and negotiation. The use of the GDSS was expected to facilitate enough consensus for the avoidance of a 'false consensus', and so create politically feasible agreements that will be implemented. The specific GDSS used has been designed to focus on the usual aims of most group support systems (eg 'Group Systems' – Nunamaker et al. (1991)) of high group productivity (Nunamaker et al. (1991)) and the appropriate use of anonymity (Connolly et al. (1990)), but also, and most significantly, on the facility for the group to have power over the structuring of multiple perspectives through the use of causal mapping (Ackermann and Eden (2011)). Thus, the interventions have been about helping the teams develop for themselves a deliverable strategy (Eden and Ackermann (1998), Ackermann and Eden (2011)b)).

Recently our experiences have extended to working with public-private 'forced' partnerships - for example, where regulation, to protect the public/public value, creates the need for a private organization and the public regulatory body to work together to avoid a dysfunctional relationship. In developing strategies for managing this relationship, these organizations have realised, during project negotiations and as a result of using a GDSS, that there is a real possibility of going above and beyond their own core goals, and creating additional (often public) value together, without harming the attainment of their own core goals. However, in public-public partnerships, both parties have come to believe that working together can help each of them achieve their mandates better than if they work alone. For example, working in the Health area, partnerships between hospitals, community workers, community homes, local doctors, and so on have come together to help ensure better patient pathways (a common goal) as well as more efficient use of resources and increased services. However, both these types of ventures are fraught with concerns over whether the exercise is legitimate, potentially demanding more of the very finite resources available, and whether both sides will deal fairly. The role of a GDSS to support this work towards multi-organizational working has, as far as the 'client' groups are concerned, been crucial.

A particular problem for management teams, and particularly for collaborations, is that of getting the key managers together on enough occasions for them to be able to reach meaningful agreements that are made by those with the power to implement those agreements. Each meeting has different participants. Thus, if the productivity of such meetings can be increased so that agreements can be reached in one meeting (albeit, on some occasions, evening sessions) then there can be significant increases in the probability of agreements becoming implemented. However, powerful ways of facilitating both process and content are needed to cope with the increased complexity that derives from higher productivity. The GDSS, as a support system, is expected to help manage process complexity, but managing content complexity depends upon appropriate conceptualisations of the content structuring. Structuring content to reflect a means-ends hierarchy – causality – is an important way of structuring content, whilst also experiencing that the categorization of content helps manage complexity.

In this paper we concentrate on the process of helping multi-organizational teams agree joint goals, and so we discuss a categorization of goals that depends on conceptualizing a goals framework comprising core goals' – goals that are crucial for one organisation, 'meta-goals' – goals that could not easily be attained by either organization on their own, 'above and beyond goals' – goals that deliver additional outcomes without harming the achievement of core goals or meta-goals, and 'negative goals' - outcomes that are not wanted, but are possible.

Facilitating effective collaborations in times of austerity, for both formal and informal collaborations of public-public and public- private organizations, is even more important. Indeed, Fisher (2012) talks about the inclusion of different stakeholders to unleash creativity and conceive new solutions – an important expressed aim of a GDSS. However, public-private collaborations are perhaps particularly interesting because they bring the private sector into play in delivering public value. This resonates with Bowie's (2012) discussion of Friedman's separation of private and public as being a false distinction, and Bozeman's Bozeman (2012) call for organizations to work in sets of interdependent relationships.

We also discuss the significance of the role of principles of group decision and negotiation as expressed through a designed Group Decision Support System (GDSS) in facilitating the effective development of collaborative goals – agreeing collaborative purpose. We shall illustrate this role of the GDSS by using real cases. These cases reflect our work within several different project collaborations within the health field in both the UK and Australia, and our work with a multinational energy organization and regulator. Through two cases we explain how the partnerships can be explicated through the generation of a system of goals (an hierarchical network) - and therefore explore and introduce the important categories of goal: 'core goals', 'meta-goals', 'negative goals' and 'above-and-beyond goals'.

# Group Decision and Negotiation facilitated: The Group Decision Support System

The Group Support System software is called 'Group Explorer' and is the product of an effort to synthesise research from a range of apposite disciplines to examine the system's applicability in theory and practice. The system has been under continual research and development over the past ten years. The application of the GDSS has sought to extend the theories underlying problem construction in the field of 'soft-OR' (Eden et al. (2009); Shaw et al. (2009); Ackermann et al. (2011)) and in the field of strategic management (Ackermann and Eden (2011)b). The design of the GDSS is based dominantly on an understanding of how individuals change their mind through a process of social and psychological negotiation (Ackermann and Eden (2011)). It also recognises that developing, researching, and using group support designs, is expected to support a social process as well as effective analysis – each of these concepts are seen as fundamental to enabling the implementation of agreements based on the resolution of complex situations. Thus, the two key concepts that underlie the group support system are those of procedural justice and group-think.

Procedural Justice (Kim and Mauborgne (1996); Colquitt et al. (2005)) relates to the way that decisions are made and participants are treated during decision making. Research suggests that an environment where participants feel a sense of fairness will encourage cooperation, trust, and engagement with the group's aims. In the case of the particular contribution outlined here, the use of procedural justice is distinctive in that it is applied to group situations. The underlying research therefore focuses on how groups work, rather than how individuals behave in isolation, and on how those groups arrive at commitments to act. This is an important distinction as it is used to facilitate the development of effective agreements. This becomes

particularly significant when working across organizations as the development of trust and so equality of participation is paramount.

The design of the system also recognised that, in group work, there exists the significant danger of 'groupthink' (Janis (1972); Janis (1989); Harvey (1988)) which manifests through groups taking irrational decisions, suppressing dissent or ignoring alternatives due to a psychological drive for consensus. This means that there exists the danger of organisations being blinkered to strategically important new opportunities such as the potential for agreeing meta-goals and 'above and beyond' goals. Hence, the research sought to counter the phenomenon of group-think by developing a mechanism for increasing the chances of productive enquiry and associated creativity. Such a system would provide participants a greater opportunity to genuinely change their mind (Ackermann and Eden (2011)) and develop new rewarding relationships.

In addition the group support system drew upon research investigating the role of anonymity (Valacich et al. (1992)) and face-saving features important for supporting crucial stages of negotiations (Fisher and Ury (1982)). Recent developments of the system enable the facilitator to see the ways in which the representatives of the different organisations in the group are moving apart or coming together in their definition of the situation and agreements through colour coding the representatives of each organization. This is achieved by enabling a facilitator to see easily (on a chauffeur screen only accessible by the facilitator), for example, the extent to which statements linked causally belong to one organisation or are a mix of views. As agreements are negotiated the extent of a developing consensus can also be 'measured' by the clustering, or not, of the colours representing different organisations.

Additionally, the system is designed to provide high levels of group productivity, recognising that bringing participants together is challenging, as is ensuring focus and commitment to implementation –rapid progress also helps sustain attention and energy. Thus, an important aspect of the GSS process is that of creating deliverables at regular and short time intervals (a deliverable – 'take away' of agreements - at least once every 1.5hrs) (Ackermann et al. (2011)).

Finally, the system is also importantly based on enabling a group, rather than the facilitator, to create a causal map - a mean-ends structure that represents a way of both understanding and changing the world participants inhabit. The causal map represents options and agreed actions to deliver agreed outcomes or goals. The system provides participants with the ability to jointly negotiate a group view of their world - a network of beliefs about how their world works, and subsequently negotiate agreements about how to change that world - and does so by managing, and working with, complexity (rather than reducing it).But, the system cannot be powerful without ways of managing the complexity that arises as multiple views are 'knitted' together. We now go on to present the conceptualisation of collaborative purpose that is the result of the extensive action research programme undertaken with a wide range of management teams.

## A Goals System as a Goals Hierarchy

Usually a system of goals portrays broad based and fairly generic goals at the top of a hierarchy (Eden and Ackermann (2013)). In the for-profit sector these generic goals will be statements such as 'increase revenue', 'better control of costs', 'increase motivation of all staff', 'higher sales turnover'. And, for a private sector organisation the ultimate top of the hierarchy is likely to be 'increase profitability', 'increase profit', or 'increase shareholder value' – each of which are goals common to all for-profit organizations. In the not-for-profit organizations, the super ordinate goal is often the mandate from government, the funder, or, in the case of a charity, the raison d'être for the creation of the organization. These generic goals do not distinguish one organization from another organization in the same sector. For example, "confidence in the ability of the police" is likely to be a goal common to all police forces, and yet the way in which this is delivered will vary for different police forces. These generic goals are easy to negotiate because they do not 'direct' action. It is the more specific goals that deliver the generic goals that define the purpose of an organization and provide the framework for action. Thus these provide clear illustrations of distinctiveness. That framework for action is provided not just by the statement itself but the means-ends network of 'what for?' and 'how?' (see examples in Eden and Ackermann (2010)).

Without the graphical means-ends network set out as a causal map and hierarchy it would be unclear how and what a specific goal is expected to deliver, or how it is to be delivered. As Keeney has commented with respect to public goals, "it is natural to structure a set of objectives, or equivalently value criteria, into a hierarchy" (Keeney (1988): 398). Thus, in figure 1, "provide a more HOLISTIC & PERSON CENTRED approach to meeting integrated care needs" helps achieve the goals of "respond and manage the needs and impact of patients with dementia in general & community hospitals" and, "availability of good and varied dementia care in the ----"; and is delivered by "increase feeling of shared responsibility for range of services between SWD [Social Work Department] and NHS", "overcome culture differences across different dementia providers" and "meet increased User/Carer expectations". It is this means-ends structure that determines the meaning of a goal, rather than just the wording of the goal.

The GDSS, thus, not only helps elicit these goals and refine their language, but it also helps participants move from their own personal views about single goals to an elaborated shared understanding. Thus, the negotiation is about goal statements and their means-ends structure and the creation of this goals network is significantly aided by the GDSS as the structure (map) acts as a 'transition object' or 'boundary object' (Carlisle (2002); Carlisle (2004); de Geus (1988); Star and Griesemer (1989); Winnicott (1953); Zagonel (2002)) where participants can 'play' with ideas easily and quickly and anonymously. Thus, by taking individual contributions that have been made anonymously (thus supporting creativity and diversity) and allowing them to be explored, adapted, it is possible to move gradually to an agreed group formulation.

The group mapping process thus facilitates the capture and exploration of the systemicity of goals. Additionally it is worth noting the ability to display reinforcing relationships as shown by a two-headed arrow between the two goals. For example, overcome culture differences across different dementia providers and increase feeling of shared responsibility for range of services between SWD and NHS. Thus, sometimes what appear to be generic goals are in fact specific because of the particular, and differentiated, means-ends context, and so goal differentiation becomes possible.

The goals system in figure 1 also reveals a number of other structural properties: for example, showing how relatively central is the goal of STOP inadequate choice of a variety of good quality long term care homes in all areas.

# The nature of collaborative purpose

The use of partnerships often enables organizations to deliver existing strategic goals by reducing the extent of the problems they would otherwise face – namely, reducing the workload and keeping costs in control. Thus, for example, when working with the police we have seen them reduce crime by working in partnership with public housing authorities in the design of the buildings. Often such partnerships have not been formalised, or even jointly agreed, rather they have been designed through the strategizing of one organization and implemented through the management of relationships.

Moreover, when collaborations are effective, can i) achieve goals that neither party could achieve on their own, and ii) more unusually, formulate new ways of achieving additional value through finding ways to extend their organization's goals or agree to new goals – delivering more. However, eof these outcomes are not straightforward to achieve - developing effective collaborations and negotiating collaborative goals are known to be difficult activities (Huxham and Vangen (2005); Vangen and Huxham C. (2011)). Nevertheless, many of the collaborations/partnerships we have worked with have argued that without using the theories and practice of group decision and negotiation expressed through a GDSS they would either never have achieved these outcomes, or it would have taken 3-10 times more time. That said, whilst the GDSS, as a system that enables anonymity and the representation of causality by a group, can be effective, the success of collaboratives depends also on a particular conceptualisation of causality and categories of goals statement.

#### **Core Goals**

Are those goals that are expected to drive (or focus the efforts of) one organisation – the organisation expects their performance measures and critical success factors to be related to these goals. They are at the core of success for the organisation and are expected to influence behaviour across the whole organisation. Often these goals are embedded in mission and vision statements – although such statements, particularly in the public sector, are ridiculed as being 'business-speak', and so do not drive behaviour.

#### **Meta-Goals**

Meta-goals are the essence of collaborative success: they are 'wished-for' core goals for all organizations in the collaboration that cannot be achieved by without an effective working collaboration. Thus, often these meta-goals would not be expressed as core goals by any single organisation for fear they could not be delivered successfully. Additionally, sometimes meta-goals represent core goals that can be attained much more extensively through working collaboratively. Thus, when expressed as a part of core goals they would be less ambitious.

The implementation of agreed strategies to deliver the meta-goals, by members of the collaboration, creates the potential for what is known as 'collaborative advantage' (Eden and Huxham (2001); and see also Ackermann et al. (2005); Bryson (1995): 377-378).

Furthermore, in some cases, particularly private-public settings, a 'collaboration' is forced on the parties – such as where a government regulator and private sector contractor are legally obliged to interact. In such cases the 'forced marriage' can be dysfunctional and combative (it is recognised that a health tension is inevitable). In such 'forced marriages', where no party has any alternative to working together, an ability to achieve meta-goals, as a result of working together, typically comes as a pleasant surprise to the parties. Instead of avoiding a dysfunctional relationship they manage to create a joint goals system that recognizes each other's unique goals and reveals how they could work together to achieve much more (Ackermann and Eden (2010)).

Needless to say, there are frequently some end-goals (at the top of the goal hierarchy – representing the broad generic goals mentioned earlier in the paper) that belong only to one of the parties. Figure 2 shows a goals system developed by a group of Chief Executives of Hospitals, medical consultants, social work senior managers, and senior civil servants responsible for health policy. In this goals system two obvious meta-goals are shown (in ovals) where the group believed that these could not be achieved without collaboration. And yet, it would also be possible to suggest that all of the other goals were also meta-goals as they could only be met effectively and efficiently through collaboration – a characteristic typical of health and possible other governmental sectors.

#### **Negative Goals**

Negative goals express the realities of organisational life – where much time is devoted to avoiding disasters, rather than creating a positive future (Mintzberg (1973);Mintzberg (1975)).

Figure 1 shows a negative goal that has been given a pseudo-positive wording by simply adding the word 'STOP'. The goals system shown by figure 2 is dominated at the top of the hierarchy by negative goals that been edited to produce pseudo-positive wording, but reflect absolutely significance of gaols that are about avoiding disasters! The goals system

#### 'Above and Beyond Goals'

This type of goal is not a goal that the organization can adopt without the help of others in its achievement as well as not being a core goal for the organization. Thus, an organization may actively support the goal but not adopt it as its own performance indicators because it is not prepared to be held accountable for it (also referred to as "not-our-goals" - see Ackermann and Eden (2011): 120), and Eden and Ackermann (2013)).

This category of goal is particularly useful in conceptualising a goals system for a not-for-profit or public sector organization. For example, in one of our cases, "leave a skills legacy" was accepted as a goal for the collaboration, but was not regarded as a goal that either organization wished to be held responsible and accountable for (the goal would not be a part of their performance indicators); rather they wished to make a contribution to its attainment, along with other organizations.

In the case discussed below we explore further the negotiation of 'meta-goals' and 'above-and-beyond goals' within the context of an enforced relationship between public and private organizations. As we shall demonstrate, the opportunity for an organization to go above and beyond their core mandate may possibly be easier in circumstances of forced marriage between two or more organisations and particularly when supported by a GDSS. Forced marriages are not unusual when regulators have an active role in controlling the activity of a large private organization. In the case recorded below the private organization is a power

generator ('Utility Co') and subject to regular inspection and involvement from the regulator both with respect to existing plants and the development of new plants.

# Multi-organisational Collaboration: the case of a Private-Public 'Forced Marriage'

In this illustrative case of a 'forced marriage' we had been involved with each organization over a number of years, as well as being involved with them together, in developing strategies to reduce what each saw as a dysfunctional relationship between them. As such a collaborative relationship had developed. This is contradictory to what some researchers have posited namely that collaboration is easier when not mandated (Bryson et al. (2006): 48). Nevertheless we shall suggest through the below illustration, that leveraging 'forced marriages' is both possible and a promising avenue for developing 'above and beyond' goals.

Several years ago each of the organisations requested our involvement in facilitating a negotiation designed to enable each organization to deliver their own goals and yet work more constructively together. Unfortunately at the time there was considerable tension between the parties. Moreover, it had to be noted that the intention was not to subsume one party's direction within the other but work effectively together retaining their own individual objectives. "In working more closely together, organizations need not, and should not, abandon their central missions" (Sagawa and Segal (2000):114). Following this initial involvement and support, and over a period of three years of further support, their relationship with one another changed in fundamental ways: mutual trust had developed, ways of working changed, and most importantly they reached a high level of appreciation that each organization had to meet specific core goals that were often apparently in conflict with one another. These involvements had all utilised the Group Support System, and its contribution had been regarded as crucial to the success of the interventions and so to the request for a continuing involvement (Ackermann and Eden (2010)).

Thus they had become neither collaborators nor partners, but rather organizations able to work together productively in a situation where there was no choice about their involvement with each other. In addition, important public values were recognised to be at stake by both organizations: safety of the public, and security of supply.

However, more recently, a massive (€16B), and "first of a kind" project emerged (significant new power generation facilities) and, following their experiences with the GSS previously, both organizations believed that it was crucial for them to develop a strategy for effective joint working on the project. The success of the new facilities was of great financial significance to the Utility Co and of crucial significance to the Government of the country in which they were to be built. Given each party's experience in negotiating an appreciation of both their own and shared goals when looking at existing operations, they suggested that it would be appropriate to use the GDSS to help each of them separately develop goals systems for the new project. Their agreed objective was to develop a shared perspective through a designed conversation that would permit high levels of individual air time, in recognition that each participant brought particular expertise 'to the table'.

In the first instance they each wanted to 'get their own thinking together' with respect to the project, and so separate workshops were to be the starting point. In each of the two separate workshops with the management team of each organisation a very simple question was asked: "what should be the purpose of your organization, with respect to the successful creation of the new facilities and with respect to the necessary relationship between the Regulator and Utility Co?" This would allow each organization to express their own view about what they wanted to achieve – their 'core goals'. A third, collaborative, workshop subsequently was undertaken within one week of the other workshops to ensure that the content was still fresh in memory and was regarded as critical by both parties. To facilitate this third workshop additional preparation was carried out. The first stage of this preparation involved examining each of the two goals systems to identify where there was either duplication (and so the two could be merged) or possible causal link relationships enabling linking a goal in one system to a goal in the other.

This work resulted in a 'merged' goals system comprising 39 goals which was used as the introduction to the joint workshop. Whilst for the majority of the goals, it was obvious which organization would have generated them; there were surprises to both teams, both in terms of their support for the other organization and also discovery of conditions from either side that elaborated apparently common goals. For example, a

key common goal that emerged was "build safe, secure and reliable facilities over its entire life". This key goal sounds obvious but involved considerable negotiation – the portfolio of the words 'safe', 'secure', 'reliable' and 'entire life' was significant. This was not only an (almost) common goal, expressed with important and different emphases, but also at the centre/core of the draft merged goals system: the statement had many other goals supporting it, and also it supported many others (namely 5 goals supporting it from Utility Co, and it supporting 2 Regulator goals and 9 Utility goals). As a result of its centrality within the structure and its importance to both parties, this statement was inevitably the starting point for negotiating the combined goals system.

The combined goals system also comprised some meta-goals as well as goals that were core to each of the organizations. However, additionally a number of the six end-goals from the Utility Co initial workshop appeared to be public value goals that might be regarded as 'above-and-beyond goals' in the sense that they were not core goals for the organization itself, and did not in any way attack core goals, but did deliver public value above and beyond the core goals. One such example was "have at the end (of the project) people skilled, proud and keen on doing more, leaving a skills legacy". Notably all of the possible public value goals that were 'above-and-beyond goals' were developed by the Utility Co, even though the Regulator, as a quasi-public/not-for-profit organization might have been expected to identify such goals more readily. This may reflect the degree of autonomy or freedom that a private sector commands.

As the workshop progressed it became clear that many of the potential public value/'above-and-beyond goals' whilst being generated by the utility co were goals that the Regulator team felt very comfortable supporting but they were, to some extent, possibly 'taken-for-granted' goals and so not ones explicitly stated, despite being able to agree to such goals in the workshop. This might have been due to the fact that as with many public sector organizations, the regulator team were particularly keen to have their performance measured against goals that they felt they had a high degree of control over, rather than be pilloried for not meeting goals that they could only, possibly, make a contribution towards. It might also have been the case that the culture wasn't one that encouraged thinking beyond the boundaries of their organization.

The final system of goals acknowledges that the Regulator had an interest in the "profitable operation of the facility" – a core goal for the Utility Co - as having a financially healthy industry would ensure a continued commitment to the country. However, the Regulator also realised that there are opportunities for helping in the achievement of general societal goals (goals that do not lever core goals of either organization but do offer public value) – combining the energies/competences of private/ public and not-for-profit to create something that is of value to all (Fisher (2012)) and that "stitches together coalitions geared to achieving shared gains" (Jacobs (2012): 15).

#### "Joined-up" Thinking?

As far as the participants, in this case, were concerned, they had expected that there would be two well separated goals systems with a few links between them. However, there were more causal links than anticipated and the presence of these showed an impact between the Regulator and Utility Co which revealed how working together could both help each achieve their remit as well as provide public value. Thus, even though, goals statements surfaced in each of the separate workshops differed, the links revealed similar meanings – where meaning derived from the support and supported goal statements.

The possible 'above-and-beyond goals' identified by the Utility Co were ultimately enthusiastically adopted by both organizations, except for the Regulator it was crucially important that they were acknowledged as 'above-and-beyond goals' that would not interfere with their ability to deliver core goals. Perhaps it is more difficult for public value goals to be acknowledged by not-for-profit than for-profit organizations, given the likelihood of their being ridiculed by the popular press and politicians for achieving stated goals? But, it is all very well for two or more management teams reaching agreement about a system of goals that include going above and beyond – but do they mean it, will they actually deliver, or are these just words? Over the years we have developed a number of indicators and techniques for testing the possibility that the agreements are just simply espoused goals rather than goals in action (to steal the spirit of Argyris and Schon (1974)). These indicators are i) what is revealed through strategic risk assessment, ii) the meanings as revealed by the means-ends network, and iii) the nature of the performance indicators developed by group.

How do we know that meta-goals and particularly above-and-beyond goals will be goals-in-action rather than the typically very broad and vague (hard to disagree with goals) which are agreeable to all parties? They

may be nice sounding goals that are nice to talk about but are unlikely to be delivered – but nevertheless become part of a public rhetoric (Bozeman (2002)). Ambiguous values become less ambiguous through providing or realising their means-ends context (Jorgensen and Bozeman (2007): 357). Thus, the development of goals statements in the context of means-ends adds more realism than simply pronouncing nice sounding aspirations without a meaning context. The creation of a network of goals gave an action-oriented meaning to each of the goals. The systemic structure also helps ensure coherency rather than the typical list of goals which often results in perceived or real conflict.

However, in addition, the authors as facilitators had consideration experience of both teams in both a group and one-to-one setting and therefore knew something of the meanings of non-verbal behaviours. Consequently we were able to gain some sense of the levels of commitment. The sincerity—or lack of it demonstrated by a business in supporting a cause is often evident to its partners, employees, and the public at large. The strength of a social sector partner, and its ability to help a business meet its needs, is derived from its effectiveness in achieving its social mission. We were seeking to get a measure of sincerity.

Also, as we noted above, the use of the group decision support system enabled anonymous expressions of commitment and veto of potential agreements.

### **Engendering Strategic Conversations**

As illustrated above, a designed strategic conversation has been fundamental to the likelihood of a management team and multi-organizational teams reaching practical agreements. It has been clear from our experiences that the 'rules of behaviour' in top management teams frequently work against creativity, promote tentativeness, and inhibit open ways of thinking about what can be achieved. Thus, facilitating the consideration of 'above-and-beyond' goals is difficult. The legitimate focus of the group is on debate about core goals although this is rarely considered as a system, and therefore even this discussion is itself problematic. Typically each team member believes their own view of organizational goals is also taken for granted by other team members in their own organization. But, each member of the management team has their own view of the goals of their own organization. Their view derives from the perspective of their own role, expertise, and aspirations. Thus, any process of negotiation must allow for the surfacing of all possible goals – that is, each team members view must be heard and not evaluated until every possible draft goal has been gathered and set in the context of other draft goals (Ackermann and Eden (2011)a)). Early evaluation discourages others in proposing goals, and not seeing them in the context of other goals can miss their possible significance in relation to other goals: the means-ends relationships. The use of the GDSS means that suggestions/contributions to the conversation are NOT evaluated immediately, or early, in the process, rather they are evaluated later in the context of other contributions that are causally related.

Techniques, tools and concepts that facilitate conversations that promote joined up thinking and agreements are undoubtedly needed in both public-public and private-public collaborations – in times of government austerity the efficiency and effectiveness of such collaborations are crucial. In our experience the use of a computer based GDSS (Group Explorer), where anonymity is provided during the early stages of a workshop, means that creativity and tentativeness has been more likely, and so the probability of possible meta-goals, recognition of the necessary reality and importance of 'negative' goals, and 'above-and-beyond goals' being developed is greater. Indeed, even the process of negotiating realistic 'core' goals has been significantly enhanced through the use of a GDSS designed from key GDN principles and theories.

Notwithstanding the important role of the group support system in the cases reported here the workshops were run by facilitators that were trusted and so the participants did not have any need to play up to the 'external' audience of external people.

The group support system electronic log (that records all GDSS activity), and comments from participants, showed that anonymity led to blunter statements about possible goals than would normally have been expected from a typical management team meeting. The ability of the system to continually check consensus, and similarity and differences of perspective, and for these to be carefully checked through the system log, protected against 'false consensus' (Ackermann and Eden (2011)) – notwithstanding that complete consensus is not expected and can be a worrying example of 'group-think'.

We have suggested that an important driving force is that of taking seriously the goal categories of metagoals and above-and-beyond goals and introducing them in practice through workshops designed to agree purpose. However, although this conceptualisation is a necessary condition it is not sufficient. Unless managers in both organisations are prepared to move beyond their standard scripts then the chances of success are negligible. In such circumstances recourse to the apparent requirements for 'real managers' to talk of measurable (SMART – Doran (1981)) goals, positive goals rather than the real goals that actually drive behaviour and views of managers.

# **Concluding Remarks**

In this paper we have sought to argue that there are ways of bringing public and private organizations together to deliver public value that derives from establishing 'above-and-beyond' goals, and that doing so is significantly dependent on the use of a facilitated GDSS supported designed conversations about strategic purpose.

The following, typical, unprompted comments from participants give a flavour of their view of the role of the GDSS with respect to anonymity, productivity, and causal mapping for structuring. In order to demonstrate that these comments are not a particular selection of only positive comments, those shown are from all of the randomly selected participants in one workshop:

- the model helped catch people up and develop a sort of common understanding. We learnt a lot more about each other. .... the mapping was very successful in deciding what needs to be done.
- structure of the [workshop] the format takes out the negative elements... very different from traditional meetings it [the GDSS] provided a mechanism for honest discussion.
- liked the spider diagrams [causal maps] as they were interesting and sparked a lot of discussion. It was a good way of surfacing a lot of issues and good to be able to link thoughts and be able to present the data... we could talk about topics that were sensitive really get in to them it allowed people to talk ... good to get a balance between heads down and talking to one another's.
- really good in bringing the ideas of two different sides together.
- felt both sides went away more positive about the future; it was a very productive session. The maps were road maps to go and do. People seemed more willing to engage on issues rather than sweep issues under the carpet they were willing to talk about issues. ... lots now on the table to go do that wouldn't have got to otherwise. People went into the room with an intense dislike of each other ... We were able to avoid dancing around things but get them out into the open.
- the software [GDSS] was incredibly useful setting preferences and getting everything out in the open. It would have been much slower if everyone had to speak (and we wouldn't have got that much on paper). ... good conflict resolution session with positive outcomes re attitudes and solid deliverables.
- it [the GDSS] helped diffuse the tension (which was historically in existence). ... a good cathartic experience both sides were being honest and noting both organizations are imperfect. ... helped avoid people getting bogged down ... got through far more than I thought possible
- process made us engage, we were able to compose stuff, prioritise, and it was well structured and encouraged people to reflect
- common goals we can sort it out and stop the bickering ... Actions in place.
- astonished by the capability of the system ... would have taken us weeks to get where we got to ... behaviours seem to have changed during the workshop: a more roundtable approach being taken, and joint things coming up by the end of the day
- the system shows views for all to read shows barriers and issues on the screen allowing for reflection and discussion rather than talking at each other. ... System focuses the mind more effectively everybody can put stuff in and then discuss ... The system means we stand a chance of getting the strategy right

• amazing way to get a lot done in a quick way .... Good to be able to say it anonymously and then work on it ... Didn't sense we lost any important input

The client for the Health workshop presented through figure 2 commented:

- it would have taken us months to get to where we got to in 5 hours: difficult to get such a group together over the several sessions, whereas here we had them together for all of one session and achieved what we needed. Anyway, some of the participants would have continued to be too dominant the democratization the system gave us meant there was none of the usual 'out-gunning'.
- it was interesting that, even though there were NHS consultants in the group, we were still able to tackle a big, and important, issue that was about them. The 'uncontrollable' and important issues became controllable. The ability for the system to build from one another's contributions was particularly useful in achieving these outcomes.

A variety of different types of GDSS's and Group Support Systems (Lewis (2010)) – such as Group Systems, Hi-View, MeetingWorks (Lewis et al. (2007)), Dialogue Mapping (Conklin (2006)) - have already demonstrated benefits to organizations through supporting strategy development, problem structuring, and risk management. This paper has sought to show, through examples, that they can also be used to great effect in helping collaborations, and 'forced marriages', work more efficiently and effectively.



Figure 1: The agreed Goals System for the multi-organisation (public-private collaboration among health sector organisations)



Figure 2: The goals system developed in a workshop exploring strategic problems in health delivery (goals in square boxes are core goals for different organisations, and the goals in ovals are meta-goals) – note that the material has been edited for reasons of confidentiality, but the figure represents the spirit of the outcome

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### Tackling Climate Change: A System of Systems Engineering Perspective

#### Winner of the INFORMS Group Decision and Negotiation Award

#### Stockholm, Sweden

#### Abstract

An integrative and adaptive approach to Responsible Governance is put forward for addressing climate change based on a System of Systems (SoS) Engineering framework that reflects the values of stakeholders using a participatory approach and achieves desirable systems goals such as resilience, sustainability and fairness. Currently, the world is suffering from an "Atmospheric Tragedy of the Commons" in which every nation is knowingly releasing deadly greenhouse gases in order to selfishly maximize its own economic benefits at the expense of destroying the "Atmospheric Commons" and thereby causing severe climate change which will adversely affect all countries around the globe.

To overcome this strategically unwise type of individual behavior, a cooperative approach to good governance is suggested which will benefit every nation economically in the long term and, more importantly, satisfy ethical systems objectives. More specifically, the "Fee and Dividend" concept devised by James Hansen and others is suggested as a truly insightful, yet simple, method for solving the tough strategic decision-making aspects of climate change via: (1) Taxing carbon at its source or point of first sale (Fee). (2) Distributing 100% of this tax uniformly to all citizens (Dividend). (3) Negotiating a level of tax for each nation (Liability). (4) Increasing the tax over time in combination with stricter regulations to bring atmospheric carbon accumulation to a stipulated level (Survival).

When compared to other alternatives, such as Cap and Trade, the "Fee and Dividend" idea may form the basis of a feasible and sensible method for handling climate change in the same way that the 1987 "Montreal Protocol on Substances that Deplete the Ozone Layer", and its extended versions thereof, constitute exceptional international agreements for cooperatively controlling the size of the ozone hole before it reached the point of no return. Indeed, the citizens of the world are most grateful to the truly remarkable scientists, consisting of Mario Molina, Paul Crutzen and Frank Rowland, who received the 1995 Nobel Prize for Chemistry for explaining how CFCs created the ozone hole. In fact, responsible governance is not only needed in proactively combating climate change and the ozone hole but in many other highly interconnected complex SoS problems such as the failed American financial system, growing gap between the rich and poor, unfair medical systems, irresponsible energy production and usage, widespread pollution of both natural and societal systems, and unreliable aging infrastructure. Accordingly, extensive research is urgently needed for developing a comprehensive theoretical structure for System of Systems Science and Engineering for suitably solving current and emerging complex systems problems.

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# PART II

# CONFLICT RESOLUTION IN ENERGY AND ENVIRONMENTAL MANAGEMENT

30

### Oil Export Pipeline Conflict between North and South Sudan

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**Abstract**: The conflict between North and South Sudan over shipping South Sudanese oil through North Sudan's export pipeline to Port Sudan is studied using the Graph Model for Conflict Resolution to attain greater insight into the dispute. The possible equilibrium states are determined to ascertain if North and South Sudan would solve their oil problem according to the agreements or not. The analytical results reveal that both North and South Sudan are forced to resolve the conflict and start producing oil.

Keywords: Graph Model for Conflict Resolution, Port Sudan, Oil pipeline, South Sudan, North Sudan, Comprehensive peace agreement, Cooperative peace agreement

#### Introduction

The conflict between North and South Sudan over shipping South Sudan oil through North Sudan export pipeline to Port Sudan, commenced after South Sudan gained its independence in July 2011. The dispute is studied using the Graph Model for Conflict Resolution (Fang et al., 1993) to explain the effect of a third party on the outcomes of the conflict. To explain the conflict, North Sudan controls all export pipeline because it passes through the north region. Due to this fact, North Sudan requested South Sudan to pay a fee which was 200% higher than what used to be paid by the oil companies before independence to use the shipping pipeline to Port Sudan (Oil and Energy Trends, 2011). South Sudan rejected the higher fee because it was more than the international standard price. The conflict between North and South Sudan evolved over time at three distinct stages: (1) September 2011 dispute: after South Sudan won independence in July 2011, North Sudan started imposing higher oil export charges on South Sudan to ship the oil from the south region to Port Sudan (Sudan Tribune, 2011a; Oil and Energy Trends, 2011); (2) December 2011 conflict: North Sudan started to appropriate 23% of the oil coming from South Sudan to Port Sudan (Uma, 2011). As a consequence of North Sudan's action, South Sudan stopped pumping the crude oil into the shipping pipeline to Port Sudan in January 2012 (Pflanz, 2012; Sudan Tribune, 2011b); and (3) September 2012 conflict: third parties from the United Nations (UN), African Union, United Nations Security Council and US forced both North and South Sudan to resolve the conflict under the threat of sanctions on both of them (BBC News Africa, 2012a, b; Laessing, 2012). The main cause of the conflict was the Comprehensive Peace Agreement (CPA) that was signed in 2005 between the Republic of Sudan (the original name of the country before South Sudan won its independence) and the Sudanese movement "the liberation army" (Comprehensive Peace Agreement, 2005).

CPA is considered to be one of the most important settlements in Sudan. That is because it helped in resolving the civil war and gave people living in the south region of Sudan the democratic right in choosing their destiny. People in the south region of Sudan can choose to establish a new independent country or to remain within Sudan. Thus, CPA was the foundation for South Sudan's independence that took place on July 9, 2011. However, the agreement failed to provide clear terms regarding the sharing of the Sudanese oil between North and South Sudan. Due to this lack of clarity, conflicts over the oil resources between North Sudan and South Sudan began in 2011 and the dispute is expected to continue evolving in the future.

#### **Oil Conflict Overview**

Three types of oil resources are impacting the division between North and South Sudan. First, 80% of the oil fields are located in the south region and 20% are situated in the north region. Second, all oil export pipeline passes through the north region to Port Sudan. Lastly, most of the oil refineries are located in north region. Because of this division, conflict over the oil wealth between North and South Sudan occurred in 2011 and 2012 (based on BBC News Africa (2012a) and Oil and Energy Trends (2011))

The CPA signed in 2005 divided the oil from the south region between North and South Sudan at 48% and 50%, respectively (Comprehensive Peace Agreement, 2005). The remaining 2% would be given to the specific location from which the oil came. However, both the South and the North were unhappy with that arrangement. According to Oil and Energy Trends (2011), South Sudan tried to renegotiate the share of oil from the south region that would be sent to North Sudan from 48% to 25%. North Sudan rejected the South Sudan proposal and asked for more than a 50% share. In addition, North Sudan imposed a fluctuating charge for the use of the export pipeline to Port Sudan (Oil and Energy Trends, 2011). South Sudan refused to pay the higher charge and kept producing the oil by using the North Sudan pipeline to Port Sudan, while North Sudan kept negotiating oil export fee with the government of South Sudan Tribune, 2011a).

South Sudan wants to build a pipeline with a capacity of 450,000 barrels per day (bpd) to Kenya and link it with the Kenyan pipeline to Port Mombassa. In order for South Sudan to fund this project, it needs to have a sustainable oil production (Oil and Energy Trends, 2011). Figure 1 shows the existing pipeline in North Sudan and South Sudan alternative pipeline route.



Fig. 1. North Sudan export pipeline and South Sudan alternative export pipeline (based on DeHaemer, 2011)

#### Historical Evolution for the Oil Export Pipeline Fee Conflict

Table 1 shows the historical evolution of the conflict from September 2011 on the left to January 2013 on the right. DMs are listed using the following symbols: South Sudan (SS), North Sudan (NS) and third party (TP). The letter (Y/N) indicates whether the DM took the option opposite to the letter or not.

The single equilibrium calculated for the September 2011 conflict is shown as a column of Y's and N's above state number 2. This equilibrium constitutes a possible resolution to the conflict for September 2011. In fact, state 2 in which North Sudan requested South Sudan to pay a higher fee for using the oil shipping pipeline and South Sudan ignored the higher charge for using it was the actual outcome that happened in September 2011. For this situation North Sudan kept tabulating the unpaid export charge, while South Sudan continued exporting oil without paying the oil shipping cost. The equilibrium remained valid because it assumed that North and South Sudan would make an agreement regarding the higher cost of using the oil-shipping pipeline. The arrow between states 1 and 2 shows the change in the option selection that led to the equilibrium from the status quo for September 2011.

However, from October 2011 to November 2011 China acted as a third party to help solve the dispute between North and South Sudan over the higher charge for shipping oil via pipeline. State 3 in which North Sudan requested a higher oil-shipping price based on the Chinese proposal and South Sudan refused the proposal while China acted as a third party, was the transitional state that led to the actual equilibrium. State 4 in which South Sudan refused China proposal, North Sudan compensated for the unpaid charge by taking 23% of the oil coming from South Sudan, and, the situation in which South Sudan stopped producing the oil was the actual equilibrium that happened in December 2011 (Uma, 2011).

Furthermore, the international agency consisting of the UN, UN Security Council, African Union and US, acted as a third party to force both North and South Sudan to solve the conflict and start producing oil. State 5, in which the North requested a reasonable price for using the oil-shipping pipeline based on the international standard price and South Sudan accepted paying it while the third party was forcing both North and South to reach a resolution, was the actual equilibrium to the dispute.

Currently, the conflict is at state 6. This is because North Sudan added a new option to the game that put a condition on the Cooperative Peace Agreement, which was signed in September 2012 between North and South Sudan. The condition stressed that the government of South Sudan must disarm the liberation army. So without agreeing to the security condition that was imposed by North Sudan, South Sudan cannot start producing oil using the North Sudan export pipeline to transfer the oil to Port Sudan (Sudan Tribune, 2012).

		S	ept, 2011	Oct, 2011 to Nov,	Dec, 2011	Sept, 2012	Jan, 2013
				2011			
DM	Options	Status	Equilibrium	Transitional State	Equilibrium	Equilibrium	Transitional
		Quo					State
NS	Higher charge	N	→ Y	Y	Y	Y	Y
	Compensate	Ν	Ν	N	► Y	→ N	Ν
	Security condition	Ν	Ν	N	N	Ν	Y
SS	Accept the charge	Ν	Ν	Ν	N	→ Y	Y
	Alternative pipeline	Ν	Ν	Ν	Ν	Ν	Ν
	Stop	Ν	Ν	<u>N</u>	• Y	→ N	Y
	Security condition	Ν	Ν	Ν	Ν	Ν	Ν
TP	Act	Ν	N	→ Y	Y	Y	Ν
State		1	2	3	4	5	6

Table 1. Historical Evolution of the Conflict from September 2011 on the Left to January 2013 on the Right

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### Identifying a Decision Maker's Fuzzy Satisficing Threshold in a Fuzzy Graph Model

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Keywords: Graph Model, Fuzzy preference, Preferable moves, Fuzzy satisficing threshold.

#### Introduction

The fuzzy satisficing threshold of a decision maker (DM) is an important parameter utilized in the fuzzy stability determination within the fuzzy Graph Model for Conflict Resolution methodology (Bashar et al., 2010, 2012; Hipel et al., 2011). The Graph Model for Conflict Resolution is a comprehensive methodology for resolving conflicts observed in multiple participant-multiple objective decisions arising in many areas including engineering, environmental management, social and political sciences, law, and economics (Fang et al., 1993; Kilgour et al., 1987). A fuzzy Graph Model is a Graph Model in which one or more DMs have fuzzy preferences that generalize crisp or ordinary preference by considering preference uncertainty. A number of fuzzy stability definitions is put forward to capture various forms of human behavior under conflict. The four fuzzy stability definitions integrated into the fuzzy Graph Model methodology are fuzzy Nash stability or fuzzy rationality, fuzzy general metarationality, fuzzy symmetric metarationality, and fuzzy sequential stability. A state or scenario is fuzzy stable for a DM if a move to another state, determined according to the specific fuzzy stability definition, does not meet the fuzzy satisficing threshold of that DM. Therefore, the fuzzy satisficing threshold of a DM is his or her criterion to identify an advantageous move. A state that is fuzzy stable for all DMs under a fuzzy stability definition is a fuzzy equilibrium under that definition, and is interpreted as a possible resolution of the conflict (Bashar et al., 2010, 2012; Hipel et al., 2011).

In a crisp Graph Model, a state is either preferred, indifferent, or less preferred to another state by a DM (Fang et al., 1993). Therefore, if a preference relation over the set of feasible states is developed for a DM, then he or she is well-aware of which states are advantageous. In a fuzzy Graph Model, however, a DM's preference for any state over any other is represented by a preference degree (Bashar et al., 2010, 2012; Orlovsky, 1978; Xu, 2007). Hence, the DM may prefer a particular state over another with a certain degree but that may not be enough for him to identify the state as advantageous. Thus, a parameter was essential to resolve this problem, and the concept of fuzzy satisficing threshold was introduced (Bashar et al., 2010, 2012; Hipel et al., 2011). But determining the fuzzy satisficing threshold of a DM was another challenge, as until now there is no suitable technique to identify it. In this paper, a guideline is proposed to determine an appropriate fuzzy satisficing threshold for a DM.

#### Fundamentals of a Fuzzy Graph Model

Let  $N = \{1, 2, ..., n\}, n > 1$ , denote the set of DMs, and  $S = \{s_1, s_2, ..., s_m\}, m > 1$ , the set of feasible states. For  $k \in N$ , the k-th DM's reachable list from a state  $s \in S$  is the record of all the states that DM k can reach in one step, denoted  $R_k(s)$  (Fang et al., 1993). In the Graph Model methodology, a DM does not always choose to move to a reachable state from an initial state. The DM's preferable moves ("improvements") are distinguished from the available moves according to the preferences over feasible states. In the case of a DM's preference uncertainty, his or her preferable moves are identified by utilizing the fuzzy preferences over feasible states.

A fuzzy preference (Orlovsky, 1978) over S is a fuzzy relation on S, represented by a matrix  $\mathcal{R} = (r_{ij})_{m \times m}$ , with membership function (Zadeh, 1965, 1973)  $\mu_{\mathcal{R}} : S \times S \longrightarrow [0, 1]$ , where for  $s_i, s_j \in S$ ,  $\mu_{\mathcal{R}}(s_i, s_j) = r_{ij}$ represents the degree of preference for state  $s_i$  over  $s_j$ , satisfying

 $r_{ij} + r_{ji} = 1$  and  $r_{ii} = 0.5$ , for all i, j = 1, 2, ..., m.

The condition  $r_{ij} + r_{ji} = 1$  is referred to as the additive reciprocity.

 $r_{ij} = 1$  indicates that state  $s_i$  is definitely preferred to state  $s_j$ ;  $r_{ij} = 0.5$  means that state  $s_i$  is likely to be indifferent to  $s_j$ ;  $r_{ij} = 0$  implies that state  $s_j$  is definitely preferred to  $s_i$ . The interpretations of other preference degrees in [0, 1] follow accordingly.

Let  $r_{ij}^k$  denote the fuzzy preference degree of state  $s_i$  over  $s_j$  for DM  $k \in N$ . The k-th DM's fuzzy relative certainty of preference for state  $s_i$  over  $s_j$  is defined to be  $\alpha^k(s_i, s_j) = r_{ij}^k - r_{ji}^k$  (Bashar et al., 2010, 2012; Hipel et al., 2011).

In the case of a fuzzy preference, where a DM's choices are represented as degrees of preference, the DM may have flexibility in determining preferable moves, referred to as the fuzzy unilateral improvements. In other words, every DM in a fuzzy Graph Model (a Graph Model with DMs' fuzzy preferences) may have a different criterion to select his or her preferable moves. To incorporate this flexibility into the fuzzy Graph Model methodology, a parameter, fuzzy satisficing threshold, was introduced (Bashar et al., 2010, 2012; Hipel et al., 2011).

The fuzzy satisficing threshold of a DM is a number that characterizes the level of fuzzy relative certainty of preference required for the DM to find an advantageous state. Mathematically, if  $\gamma_k \in (0, 1]$  is the smallest number such that for any  $s_i, s \in S$ ,  $\alpha^k(s_i, s) \ge \gamma_k$  implies that  $s_i$  is advantageous from s for DM k, then it is the *fuzzy satisficing threshold* of DM k.

#### Guidelines for Finding the Fuzzy Satisficing Threshold of a Decision Maker

Let  $C_k$  denote the set of all positive values of fuzzy relative certainty of preference for DM  $k \in N$  over the set of feasible states S. Then there are two cases to consider: (i)  $C_k$  is empty and (ii)  $C_k$  is non-empty.

**Case I -**  $C_k$  is empty: This indicates that the fuzzy relative certainty of preference for every state over another is 0 for DM k. In other words, DM k is likely to be indifferent between any two states in S. Thus, it does not matter which number DM k chooses as a fuzzy satisficing threshold. Hence, any number in the open-closed unit interval (0, 1] represents a fuzzy satisficing threshold for DM k.

But if DM k has at least one non-zero fuzzy relative certainty of preference, then  $C_k$  must be non-empty. That is, the values of fuzzy relative certainty of preference over the set S cannot all be non-positive. More specifically, if there is a negative fuzzy relative certainty of preference for one state over another, then there must be a positive fuzzy relative certainty of preference between some states. In particular, for DM k, if  $\alpha^k(s_i, s_i) < 0$  for some  $s_i, s_i \in S$ , then  $\alpha^k(s_i, s_i) = -\alpha^k(s_i, s_i) > 0$ .

**Case II -** *C<sub>k</sub>* **is non-empty:** This case will be discussed in the following two steps.

Step 1: Since  $C_k$  is non-empty, DM k must have at least one positive fuzzy relative certainty of preference. Choose  $\gamma_k^1 = \min C_k$ . Then there exist  $s_i^1, s_j^1 \in S$  such that  $\alpha^k(s_i^1, s_j^1) = \gamma_k^1$ . If DM k is convinced that  $s_i^1$  is more advantageous than  $s_j^1$ , then his or her fuzzy satisficing threshold is  $\gamma_k^1$ . If  $s_i^1$  is not more advantageous than  $s_i^1$  for DM k, then proceed to Step 2.

Step 2: Denote  $C_k^1 = C_k - \{\gamma_k^1\}$ . Choose  $\gamma_k^2 = \min C_k^1$ , and repeat Step 1. If  $\gamma_k^2$  is the fuzzy satisficing threshold for DM k, then stop; otherwise, denote  $C_k^2 = C_k^1 - \{\gamma_k^2\}$ , and repeat Step 1.

Since  $C_k$  is finite, this process must end. If there exists a q such that  $C_k^q$  is empty but  $\gamma_k^q$  is not the fuzzy satisficing threshold of DM k, then any number in the interval  $(\gamma_k^q, 1]$  can represent the fuzzy satisficing threshold of the DM. In such a case, all the feasible states are likely indifferent to DM k, because no state is advantageous over another for that DM.

#### Conclusions

A systematic guideline is developed to find the fuzzy satisficing threshold of a DM in a fuzzy Graph Model. The steps associated with this technique are simple and easy to follow. Note that, in the past, there were no

straightforward rules, and the fuzzy satisficing threshold of a DM was identified by analyzing historical data about the DM.

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### Evolution of Cities and Urban Resilience through Complex Adaptation and Conflict Resolution

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Abstract: A city, as a complex adaptive system, evolves. As a non-equilibrium system, its components rely on exchanges of energy and wastes with its environment to sustain its inhabitants and systems. As a system of systems, its agents must work through conflicts among its systems, resolutions to which affect its evolution. Integrating these systems perspectives, the authors propose a framework on the evolution of cities and a methodology to study urban resilience.

Keywords: Graph Model for Conflict Resolution; Sustainable Cities; Urban Resilience; Urban Energy Systems; Adaptive Cycle

#### Introduction

Cities are home to most people, and are projected to house nearly 75% of the global population by 2050 (UN, 2011); they use most of the energy and drive most of the global greenhouse gas emissions (Ash et al., 2008). A myriad of energy and environmental issues, including transportation congestion, degrading water supply infrastructure (Asnaashari et al., 2013) and air pollution (Mage et al., 1996), are born in cities. Simultaneously, however, cities are locations that breed great innovators and problem solvers. For example, cities have been among the leaders in making progress towards climate change mitigation, as exemplified by the worldwide Cities for Climate Protection network involving over 1,000 communities voluntarily acting to address climate change (FCM, 2013; ICLEI, 2012). Hence, sustainable developments of cities are of global concern in terms of global environmental impacts and as locales for both technological and social innovations. Understanding how cities evolve, the goals of cities, and mechanisms of achieving its goals is important for steering change along desirable pathways.

A city can be conceptualized simultaneously as a complex adaptive system and a non-equilibrium open system, as well as a system of systems. As a complex adaptive system, a city's evolution follows, at least partially, an undirected trajectory with inherent unpredictability in its exact future states, though it would be expected to invoke an adaptive cycle (Gunderson and Holling, 2001; Holling, 1973). As a complex adaptive system follows its adaptive cycle, its resilience changes heuristically. How its resilience changes, however, depends on the variables of interest mapped onto the phases of the adaptive cycle. For example, a regional economy's adaptive cycle demonstrates high resilience during reorganization and exploitation phases and low resilience during conservation and release phases based on connectedness (Simmie and Martin, 2010). In another example, the resilient regime of an urban center is during phase transitions from exploitation to conservation and from release to reorganization based on agency of social capital and social structure/institutional forms (Pelling and Manuel-Navarrete, 2011). Hence, it is possible to invoke the adaptive cycle with different variables to infer heuristics about urban resilience and its many dimensions.

Knowing where a city is in its adaptive cycle and to which phase it will transition requires information about the city's dynamics and structure. More specifically, external interactions between the city and its environment can be understood via non-equilibrium open systems, and internal interactions among its systems and agents can be examined via system of systems thinking methodologies. While strides have been made in recent years in understanding the general properties of cities (Batty, 2012, 2008; Bettencourt et al., 2007), the suite of details that define the courses followed by cities remains uncertain and unknown though it would be useful in order to make timely course corrections (Bettencourt and West, 2010). Determining the evolutionary trajectory of a city requires an understanding of the type of thing that a city is. Jacobs (1961) defined cities as a thing of organized complexity, whereby a large number of factors are integrated, necessitating in-situ consideration of the parts relative to the whole. Furthermore, a city can be thought of as a socio-ecological system (Moffatt and Kohler, 2008) that exists in non-equilibrium and open to exchanges with its environment (Bristow and Kennedy, 2013a; Rees, 2012). Moreover, a city can be modeled

as a system of systems in which there are multiple participants with multiple objectives, complex interactions and risk management needs (Hipel and Fang, 2005; Hipel et al., 2010).

The overall research objective is to merge these systems lenses and to obtain a rigorous, operational and dynamic model of urban resilience that deals with both endogenous factors (such as internal decision making and internal structure) and exogenous factors (such as resource availability and climate variations). In Section 2, the authors propose a framework that integrates literatures on complex adaptive systems, non-equilibrium open systems and system of systems thinking to study the evolution of a city and its resulting urban resilience in its many dimensions. Finally, Section 3 concludes this paper with future work on connecting adaptive cycles with conflict models through a real-world urban study.

#### Framework Overview

Understanding the evolution of a city requires a socio-ecological perspective that is inherently systems based (Coelho and Ruth, 2006): Ecologically, a city 1) must take from and emit to its surroundings resource inputs and waste outputs, respectively, which involves interdependence with ecosystems and the environment, and 2) forms higher level patterns, such as adaptability, from interactions at the lower level. The first point captures the qualities of the city that drive and maintain it far from equilibrium while the second represents the complex adaptive nature of the city. Societally, the organizational and strategic relationships at various levels in the city are represented well from a system of systems perspective (Hipel et al., 2008). Cities are inhabited by a variety of people, organizations, and institutions that have multiple and possibly conflicting objectives. These inhabitants are often operationally and managerially independent systems (transportation modes, water supply, food distribution, waste management, etc.). As a system of systems, agents in a city work through conflicts among individual objectives to achieve system goals. These complementary views of cities are presented in Table 1.

Complex Adaptive System	Open Non-Equilibrium System,	System of Systems		
(Coelho and Ruth, 2006; Pelling and Manuel-Navarrete, 2011)	(Bristow and Kennedy, 2013a; Rees, 2012)	(Bristow et al., 2012a; Hipel et al., 2008; Maier, 1998; Sage and Biemer, 2007; Sage and Cuppan, 2001)		
<ul> <li>Emergent higher level patterns from lower level activity</li> <li>Large number of interacting elements</li> <li>Adaptation</li> <li>Self-organizes</li> </ul>	<ul> <li>Open to exchanges of matter, energy, and information with the environment</li> <li>Driven to dissipate high quality resources and produce entropy</li> <li>Pursues structuration as a means to dissipation</li> <li>Self-organizes</li> </ul>	<ul> <li>Operational independence</li> <li>Managerial independence</li> <li>Unexpected emergent behavior</li> <li>Self-organization</li> <li>Adaptation</li> </ul>		

Table 1. Characteristics of cities as complex adaptive systems, open non-equilibrium systems, and as systems of systems.

By integrating these systems perspectives, we propose a socio-ecological system framework for studying the evolution of cities and urban resilience, shown in Fig. 1. It entails four stages. The first stage involves careful selection of variables that demonstrate the adaptive cycles of a city. Potential variables are the connectedness of infrastructure networks and the exergy stored in the city. The second stage requires hard thinking on the formulation of resiliency definitions for regions of the adaptive cycles. We say "hard thinking" because these definitions must rigorously delineate who is resilient to what, and where quantifiable, by how much. As there may be many different adaptive cycles within a city, there may also be multiple dimensions of urban resilience. In the third stage, empirical investigations are needed to assess where in the adaptive cycles the city is located, and thus measures of resilience are obtained. Finally, in the fourth stage, conflict models are employed to determine evolutionary trajectories wherein the evolution of the conflict model states are mapped to the dynamics of selected variables of interest. The goal of this work is to look at strategic interactions between the elements of the city to see whether overall the city can and will evolve to more resilient regions in its adaptive cycles.



Fig. 1. Socio-ecological system framework for studying the evolution of cities and their resilience.

# Connecting Adaptive Cycles with Conflict Models: The Case of Urban Energy Systems

Testing and implementation of the proposed conceptual framework can build on existing work through case study applications in the area of urban energy use. Bristow and Kennedy (2013b) illustrate how the energy use of cities follows a sigmoid trajectory characteristic of systems undergoing an adaptive cycle (Fath et al., 2004). Furthermore, Bristow and Kennedy (2013a) provide a methodology for assessing the network structure of urban energy flows and transformations, which allows for assessment of the connectedness of the energy system. The nodes within this network include the various industries, and infrastructure systems that comprise a city. Together, these two works represent the necessary foundations for the first three stages of the proposed conceptual framework above.

The fourth stage is established by extending the network model into a system of systems conflict model. Operationally and managerially, many of the nodes of the network are independent of the others (such as unrelated industries), while other nodes are only managerially independent (e.g., industries and the electrical system). The decision makers (DMs) are the agents managing and operating the nodes. Each DM has its own set of objectives that often varies from those of other DMs. The Graph Model for Conflict Resolution (GMCR) is a powerful tool suitable for analyzing this conflict. It is useful for 1) predicting evolution of conflicts (Xu et al., 2010); and 2) steering negotiations to desirable outcomes (Fang et al., 1993); and 3) in its expanded form within an agent-based modelling and simulation platform can determine attractor states of dynamic non-equilibrium systems with heterogeneous agents (Bristow et al., 2012b).

The next stage of the research program is a synthesis of the first stages to develop a rigorous urban resiliency definition, which will build on Bristow and Kennedy (2012) and lead into a formal definition and analysis of dynamic conflict models of agents within a city with respect to energy.

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### Hierarchical Water Diversion Conflict in China

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**Abstract**: The water diversion conflicts in China caused by the South North Water Diversion Project (SNWDP) are systematically investigated in a hierarchical structure. The hierarchical conflicts are defined and studied within the paradigm of the Graph Model for Conflict Resolution (GMCR). The stability results are compared with the findings analyzed in each subconflict. Comprehensive resolutions that are discovered from the results provide possible courses of action for decision makers to follow.

Keywords: Water Diversion, Hierarchical Conflict, Graph Model, Conflict Resolution

#### Introduction

The water diversion conflicts in China resulting from the South North Water Diversion Project (SNWDP) are systematically investigated in a hierarchical structure. The hierarchical conflicts are defined and constructed within the paradigm of the Graph Model for Conflict Resolution (GMCR). Potential resolutions that are discovered provide possible courses of action for decision makers to follow.

China has the world's largest population and appears to have abundant water supplies. In particular, China's total fresh water storage is about 2800 billion m3, and is ranked 6th in the world, the top three being Brazil, Russia, and Canada (Wikipedia 2013). However, with 19% of the world's population but just 7% of its potable water, China suffers from water shortages (Barron's 2012). Water availability per capita in China amounts to only 1/5 of the world average. In the North China Plain, where 20% of the population lives, severe droughts have been reported recently, as precipitation has been decreasing. The increasing demand of water in industry and agriculture in the North China Plain attributes to these water storages.

Plans for water diversions in China can be traced back to around the 7th Century A.D.. Since the 1950s, water diversions have been a major government strategy to better allocate water in China. The South-North Water Diversion Project is the main infrastructure project designed to better utilize China's water resources. Specifically, water is diverted from the frequently flooded Yangtze River Basin to the dry North China Plain. This huge project consists of three main routes – Eastern, Central, and Western – as shown in Fig.1.



*Fig. 1.* The three routes of the South-North Water Diversion Project (Source: http://francistopia.edublogs.org/2011/06/03/"south-north-water-diversion-project"/, 2011)

This megaproject could have significant impacts on local societies and their environment. Provincial governments, residents, and other stakeholders are involved and their interests and rights may be dramatically affected. Disputes among stakeholder groups are arising along all three routes. Water diversion is a global issue and is the subject of research from various perspectives. Interbasin water transfers in Brazil are compared with two international cases: the Colorado-Big Tompson Project in the US and an Australian water diversion project (de Andrade et al. 2011). Their studies revealed the environmental, political, and economic complexities associated with these large water diversion projects. When possible water diversions from the North American Great Lakes were analyzed within a game theory framework (Becker and Easter 1995), states and provinces along the lakes were found to divert water even when it is not necessary, thereby producing a Tragedy of the Commons situation. Many studies have focused on issues and conflicts related to the SNWDP in China. The risk of water shortages caused by SNWDP in areas around the Danjiangkou Reservoir was determined and evaluated (Gu et al. 2012). Monthly flow data in the reservoir were simulated for optimized operation at minimum risk; a case study in the Yellow River Basin provides approaches to allocate water resources taking into account a flexible limit to water storage (Shao et al. 2009).

To strategically investigate these conflicts, the GMCR is a useful systems thinking approach to provide decision makers with a systematic understanding and guidance for potential courses of action to follow. GMCR has been successfully applied to the water diversion conflict in the Danjiangkou area (He et al. 2012), where an important reservoir on the central route of the project is located. To obtain an overall view on the entire project, conflicts are considered as being hierarchical and are studied by defining a hierarchical model based on GMCR.

#### Identification of the Hierarchical Water Diversion Conflicts in China

Strategic conflicts arise in areas along the three routes, depicted in Fig.1. Disputes over water usage on the eastern route are between Beijing and eastern provinces along the Yangtze and Huai Rivers, for example in Jiangsu and Anhui provinces. Frequent droughts reported in some eastern provinces are blamed to be the consequence of the ongoing project. Eastern provincial governments, on behalf of all regional stakeholders affected by the water diversion, would like to bargain with the Central Government over water usage, such as water pricing and the amount of water diverted.

The construction on the central route is changing the local landscape, resulting in many residents to be relocated. These residents are greatly concerned since they are reluctant to change their ways of living. Compensation has been provided by the Central Government in terms of providing subsidies, new residences, and job opportunities.

Neighboring countries will be affected by the western route, as water will be diverted from some international rivers in the Tibetan Plateau. Officials in Bangladesh and India have expressed grave concerns over this project. They would protest this project and seek negotiations with Beijing. The western route is still under discussion and its construction is currently suspended.

#### **Definition of the Hierarchical Water Diversion Conflict**

These water diversion conflicts can be defined as being hierarchical, consisting of single conflicts on three routes, each of which must deal with a central government authority in Beijing. Sub-conflicts, which are the elements of the overall water diversion conflict, are defined. China Central Government (CG) acts as the only dominant decision maker (domDM) participating in all of three routes. Other DMs, who only take part in one route, are referred to as subDMs. Eastern Provincial Governments (EPGs) are the subDMs having disputes with CG on the eastern route. Relocated Residents (RRs) and the Central Provincial Governments (CPGs) are two subDMs on the central route. The Neighboring Countries (NCs) bargain with CG as the subDMs on the western route. CG, the domDM, and each subDM have their own options and preferences. Except for preferences over its options, the DM has preferences over different routes, which significantly affect the outcomes of the overall conflict. These priorities are defined and their impact on the final outcomes is presented.

#### **Stability Analyses**

Following the GMCR methodology, a separate graph model, consisting of DMs, options or courses of action available to each DM, the set of feasible states and relative preferences for each DM, is constructed for each of the three subconflicts as well as the overall conflict containing the three subconflicts. A stability analysis is then executed for each of these three subconflict models in order to determine what equilibria these models predict for the overall conflict. These equilibria are then compared to the equilibria calculated for the overall conflict. The intersection of these two sets of equilibria, if it exists, constitutes common equilibria which are of particular interest since they indicate resolutions in which some type of common ground is present.

#### Conclusions

In this paper, the Graph Model for Conflict Resolution is extended into a hierarchical model consisting of subconflicts on three routes. A stability analyses is carried out in each subconflict which represents a given route. The results are compared with the findings calculated in the overall conflict containing the three subconflicts. Intersection of these two sets of equilibria is examined to indicate the common interest for DMs. A general model with subgraphs containing more than one domDMs should be investigated. Properties regarding common equilibria for different types of stability definition will be studied.

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### Strategic Modeling Approach for Third Party Intervention

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Keywords: Third Party, Conflict Resolution, Graph Model, Mediation

#### Introduction

An inverse approach to the Graph Model for Conflict Resolution (GMCR) is investigated and applied to a historical water conflict along the Euphrates River in the Middle East. The objective of the inverse approach is to enrich mediators with strategic information that will allow them to influence one or more decision makers in a dispute to bring about a more desired resolution.

The current GMCR framework, which forms the basis for the inverse approach, requires preference ranking information that is not easy to obtain. To overcome this issue, the inverse approach introduces a modeling approach that does not require preference ranking information up front. Instead, the desired resolution, or equilibria, is decided and preference ranking information leading to the resolution is generated. The inverse approach modeling utilizes GMCR as a negotiation tool rather than a prediction tool.

#### **Third Party Intervention**

The motivation for this research is the observation that mediation is vital for successful conflict resolution (Kinsara et al., 2012a,b). Seventy percent of international conflicts since 1945 involved third party intervention (Bercovitch and Gartner, 2006). Moreover, mediation and third party roles and strategies have been widely researched and investigated in the literature (Kinsara et al., 2012a,b).

#### **Inverse Approach**

The inverse approach was introduced by an earlier paper as an optimality approach within the framework of GMCR (Kinsara et al., 2012a). The main difference between the inverse approach and the standard GMCR procedure is in the order of steps. Figure 1 illustrates the current application of GMCR in the real world (adapted from Fang et al., 1993). A modified version of the graph, shown in Figure 2, illustrates the application of the inverse approach to GMCR in the real world. The original procedure requires the following inputs for a conflict to be analyzed: (1) decision makers (DMs), (2) options for each DM, and (3) preference rankings of the states for each DM (Fang et al., 1989;1993). On the other hand, the inverse approach will not require the ranking of states for all DMs. The inverse approach requirements are: (1) DMs, (2) options for each DM, and (3) desired equilibria. The result will be a list of possible state rankings that will make the desired resolution stable. It is believed that this kind of strategic information will help mediators to influence the DMs involved in the conflict. The following section presents an example which implements the inverse approach.



Fig. 1. The current application of GMCR in the real world (adapted from Fang et al., 1993)



Fig. 2. The application of inverse approach to GMCR in the real world (modified from Fang et al., 1993)

#### Case Study

The water conflict that will be discussed occurred along the Euphrates River in 1975 between Iraq and Syria. This conflict, in addition to other two connected conflicts along the Euphrates River, was investigated and analyzed by Hipel et al. (2013). The Middle East frequently encounters escalating water disputes mainly because of its arid nature. In 1974, Turkey finished the construction of the Keban dam and began filling the lake behind it. Turkey agreed with the downstream countries, Syria and Iraq, to maintain a discharge of 450m3/s (Inan, 2000). In 1975, Syria unilaterally began filling the lake behind its Thawra dam at the time that a significant drought hit the area (Kalpakian, 2004). The flow of the Euphrates entering Iraq had dropped from 920 m<sup>3</sup>/sec to only 197 m<sup>3</sup>/sec (Jerome and Wolf, 2009). The two countries were about to go to war, but Saudi Arabia and the Soviet Union intervened (Morris, 1997). The conflict was resolved on June 3, 1975 with an agreement that stipulated that Syria would release extra amounts of water to Iraq (Akanda et al., 2007).

This conflict has two main decision makers: Syria and Iraq. The two available options for Syria are: (1) to release the water to Iraq or not; and (2) to further escalate the situation. On the other hand, Iraq has a single option of attacking Syria or not. Table 1 below outlines the DMs and options for the conflict. The feasible states of the conflict are outlined in Table 2 below.

DM	Option		Description
Syria	1. Release Water	Y	Syria agrees to halt the filling of Thawra Dam and let the Euphrates flow into Iraq
		Ν	Syria continues to fill its dam
	2. Escalate	Y	This could be done by cutting relations with Iraq, sending troops to the shared border, closing the air space to Iraqi aircraft, or any combination of these actions
		Ν	Syria does not undertake any of the escalating options
Iraq 3. Attack Y This includes b		Y	This includes bombing of the dam and going to war with Syria
		Ν	Iraq does not act and accepts the situation

Table 1. DMs, options and descriptions for the Syria-Iraq conflict.

DM	Option	States					
Syria	1.Release Water	N	Y	N	N	Y	N
	2.Escalate	Ν	Ν	Y	Ν	Ν	Y
Iraq	3.Attack	Ν	Ν	Ν	Y	Y	Y
Label		1	2	3	4	5	6

Table 2. DMs, options and states for the Syria-Iraq conflict.

In order to model the Syria-Iraq conflict using the inverse approach, a desired state is chosen to be the resolution of the conflict. The desired state to be achieved in this conflict is state 2, in which both Syria and Iraq stop escalating and water is released to Iraq. A decision support system code based on the matrix representation of GMCR (Xu et al., 2007; 2009) was developed. The ranking for Iraq was fixed, and the objective is to assist the third party at influencing Syria. To execute the inverse approach, the desired equilibrium as well as the DMs and options will be entered into the decision support system. The inverse approach yielded 240 possible state rankings. The 240 rankings were further classified into two meaningful patterns: (1) state 2 is the most preferred state; (2) state 2 is the most preferred not to escalate with Iraq or be attacked by Iraq. Knowing this strategic information could be vital to the mediators as they can focus their efforts to influence Syria to change its preference rankings. Consequently, the final outcome of the conflict will change.

#### Conclusions

The inverse approach to GMCR brings about a strategic perspective to guide third party intervention. Furthermore, this approach overcomes the requirement of prior preference rankings of the DMs. More analysis and modifications are being investigated to further enhance the inverse approach method to handle specific preference ranking ranges for a DM rather than examining the full preference ranking range. Finally, housing the inverse approach methodology under the framework of GMCR gives it the flexibility and capability to accommodate other extensions that were developed for GMCR.

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### Grey Preference in the Graph Model for Conflict Resolution

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**Abstract**: A grey-based preference approach is put forward within the framework of the graph model for conflict resolution. In this research, the authors attempt to employ and customize grey systems theory to produce new and improved techniques for measuring uncertain preferences of decision makers in group decision making. The graph model is a methodology for conflict resolution that structures the decision problem, and provides possible equilibria (solutions) for decision makers through stability definitions. Research on four basic stability definitions under uncertainty by means of the grey-based preference approach is reported in this paper.

Keywords: Grey-based Preference, Graph Model, Conflict Analysis, Group Decision.

#### Introduction

Decision making usually aims to select a best option from a set of alternatives. When two or more decision makers (DMs) are involved in a decision problem, a conflict may arise as the DMs may interact with one another because of their different interests (Hipel, 2009; Kilgour and Eden, 2010). Strategic conflicts are joint, interactive problems in group decision making, in which each DM controls two or more options and attempts to achieve the most preferable situation for himself or herself. At the same time, an option of one DM may benefit or harm another DM. Therefore, cooperative or compromise solutions (equilibria) may be reached (Kilgour, 2005). In practice, these phenomena arise frequently in military strategies, business negotiation, environmental protection, and sustainable development (Kilgour and Hipel, 1987; Hipel and Obeidi, 2005; Kassab et al., 2006).

The graph model is accepted as a simple and flexible methodology to model strategic conflicts. Much valuable research has been conducted on different aspects of this topic. Fang et al. (1993) focused on solution concepts and their interrelationship in theory and practice for conflict models in graph form. Hipel et al. (1999) explained the roles of the graph model for conflict resolution and other operational research tools to solve problems within a systems engineering context. Kilgour and Hipel (2005) reviewed various initiatives in graph modelling for conflict resolution and suggested developments were soon to be implemented.

The main purpose of the graph model is to describe the main characteristics of a conflict based on preferences of DMs. Within the graph model paradigm, a conflict involves four main components: (1) a set of DMs, (2) a set of feasible states, (3) possible movements controlled by the DMs, (4) each DM's relative preference among the feasible states (Fang et al., 1993; Hamouda et al., 2004). Usually, if a DM has no incentive to move from a present state to another, this state is stable for the DM. If a state is stable for all DMs, this state constitutes equilibrium for the conflict. The main stability definitions are Nash stability (R), general metarationality (GMR), symmetric metarationality (SMR), and sequential stability (SEQ) (Fraser and Hipel, 1984; Fang et al., 1993; Basher et al., 2012). These stability definitions have straightforward characterizations to make them easy to calculate.

Preference information is a key component of a graph model, based on which one can determine the movements and stabilities states for DMs. The graph model requires each DM's relative preference, which is expressed by binary relations, "is (strictly) preferred to" and "is indifferent to". In other words, a DM has a ranked list of all states from most preferred to least preferred when transitivity is assumed. However, along with limited understanding of human cognition, incomplete information, interplay of DMs and the complexity of real application, a DM may be unclear or uncertain about his/her preference. Ben-Haim and Hipel (2002) used information-gap model to estimate uncertain degree of preference for a DM. Li et al. (2004) put forward a new relation of "unknown" in modelling preference uncertainty in the graph model, Basher et al. (2012) developed fuzzy preference methodology to analyze conflict behaviour and identify possible resolutions under uncertainty.

#### Grey-based model for uncertainty in preferences of decision makers

The authors develop a grey-based approach to capture uncertain preferences of DMs in group decision. In practice, the preference information may be not precisely known, and the DMs may have vague knowledge about the preference degrees of on a state over another. In some specific situations, it may be hard for DMs to express their preferences of one state over another with an exact numerical value, but an interval preference may be more convincing. The grey-based approach may constitute a valuable alternative for representing preference under uncertainty.

Grey Systems Theory (GST) originally put forward by Julong Deng in 1982 (Deng, 1982), is a methodology that focuses on problems with imperfect information, which may be discrete or continuous. Grey Numbers, a main definition in GST can represent not only a number of discrete values but also intervals of numbers, depending on the DMs' opinion. Furthermore, GST uses the concept of degree of greyness to estimate the uncertainty of grey numbers, rather than a typical distribution of their values. The methodology of GST can effectively handle representation and processing of vague or uncertain information, and it can give insights into operational features of systems and their evolution.

This research, using grey numbers to express interval preference, aims to extend the graph model for conflict resolution with uncertain preference given by DMs. Meaningful equilibrium information will be extracted based on generalized stability definitions, and new stabilities under uncertainty may be defined. Within the framework of the graph model, this approach permits DMs to describe interval preference with a clear lower bound and upper bound, as well as strict preference and indifferent preference. This approach will be constructed according to the following three steps:

#### • Structuring the conflict

Structuring a conflict problem includes identification of DMs and feasible states, determination of relative preference.

#### • Articulating and modeling DMs' uncertain preferences

The grey definitions of grey numbers and degree of greyness are included to describe interval preferences. A grey-based aggregation method is used to incorporate uncertain preference into the graph model. After that, the stability definitions under uncertainty for Nash, GMR, SMR, and SEQ in the context of two-DM will be put forward.

#### • Case study

An illustrative case study is provided to show the feasibility of this methodology, to demonstrate how the new definitions can be applied to conflicts, and to identify aspects that may be improved.

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### **Robustness of Equilibrium in Conflict Resolution**

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Keywords: Robustness of equilibrium, conflict resolution

#### Introduction

Since Nash (1951) proposed the definition of equilibrium in game theory, many refinements have been introduced to further enhance this concept. Refinements of equilibrium definitions are important in game theory setting, where strategies are directly impacted by the defined equilibrium.

This may be the first time that robustness of equilibrium is analyzed in a conflict resolution setting. In conflict resolution, the analyst often wishes to find a resolution, so having a set of equilibria is not considered a problem, as long as the conflict is resolved at one of them. Moreover, Li et al., (2005) provided a method called status quo analysis to find which equilibrium is likely to arise, by checking if it is reachable from a given status quo, without referring to its robustness. On the other hand, many conflicts seem to evolve over time, even after reaching an equilibrium in the first round. The objective of this research is to provide a measure of robustness of equilibria in a conflict in order to define which equilibria are likely to be stable, and which could be disturbed in another round of the conflict. Such a measure will provide insights into the sustainability of a resolution of any given conflict. More specifically, a methodology proposed within the framework of the Graph Model for Conflict Resolution (GMCR) is presented after a background survey of the literature on robustness of equilibrium in a game theory setting.

#### Background

Since GMCR utlizes stability definitions similar to those in game theory, it is relevant to look at the robustness of equilibrium in game theory. GMCR is a methodology in which decision makers (DMs) and their moves and counter-moves are assumed, based on relative preference for the various positions produced by different combinations of DMs' options. The outcome states represent a round of conflict taking place at a single point in time. Conflicts evolving over other stages are analyzed separately, or jointly as one conflict over an extended time period.

In game theory, the analyst may reject certain Nash equilibria because they are counter intuitive (Fudenberg et al., 1988). It is acceptable that, for any given game, agreement over which equilibria are more stable is "a matter of taste" (Kohlberg and Mertens, 1986). More formalized methodologies to investigate or further restrict equilibrium are proposed, including perfect equilibrium, proper equilibrium, strategically stable equilibrium, and robust equilibria of potential games, by Selten (1975), Myerson (1977), Kohlberg and Mertens (1986), and Ui (2001), respectively. The focus of equilibrium refinement and robustness in game theory is to find the most stable, robust, or likely equilibria.

#### Methodology

Robustness of an equilibrium in conflict resolution refers to the tendency of the equilibrium to be resilient against deviation. An equilibrium may provide a temporary resolution, but a robust equilibrium is an equilibrium that is most likely to be sustained, as DMs abstain from re-engaging in further rounds of the conflict. However, whether an equilibrium is robust is not a deterministic fact, but a degree that varies across different equilibria. Some equilibria may be more robust than others, and some may be more acceptable to certain players. Since in GMCR relative preferences are used rather than utility values, the equilibrium states in any conflict model provide various degrees of resolution of a conflict, based on the preferences of the DMs. The equilibrium that is most preferred by DMs can be considered to be the most robust.

Therefore, one way to assess equilibrium robustness is to rank all equilibria based on each DMs relative preferences. Then find the highest ranked among all DMs to find the most robust, and least robust, and those in between. But different DMs rankings of equilibria may be inconsistent.

As well, ranking among all DMs may not predicts the most sensible equilibrium. Starting a conflict may require a certain degree of dissatisfaction and realization. The first round provides important baseline information. Such as the status quo. The first DM to initiate a move to improve over the status quo may be the player who is most motivated to engage in the conflict. Assessing the robustness of equilibrium from the point of view of the player who makes the first move of the conflict is one way to resolved the inconsistent rankings of different DMs. So in this situation the equilibrium states are ranked in terms of robustness against the preferences of the player who first deviated from the status quo. Because if the first round of the conflict resulted in less than an improvement over status quo for the DMs who started the conflict. In this case, all equilibrium states ranked less than or equal to the status quo, with respect to the preferences of the first DM to move, are considered unstable or unsustainable.

Moreover, the status quo point is a baseline not only for the DM who made the first move, but also for all other DMs. All DMs in a conflict will desire to either improve, or at least maintain their positions. Any equilibrium that is less preferred than the status quo will put the conflict at risk of re-starting.

Another way to assess equilibrium robustness-since the goal is to sustain the resolution-is to look at the motivation of DMs to deviate from the equilibrium. A player in a conflict is motivated toward achieving some goals. The relationship between the goal and the motive is measured by the goal gradient, which Galtung (2008) defines as the distance between the goal and the degree of realization of the goal. Then the more a player is motivated to deviate from equilibrium, the less stable it becomes.

In addition, a general methodology could be developed to estimate the risk of deviation from equilibrium. Such a risk factor could be estimated using Bayesian probability theory. Building on previous experience of conflicts with similar structure or objectives, equilibria can be assessed using this risk measure. The higher the risk of deviating from an equilibrium, the lower the robustness.

Finally, a fuzzy approach could combine the aforementioned methodologies, to assess robustness of equilibrium, in a way that takes into account all possible factors for a more comprehensive robustness assessment. In such an approach, different methodologies adding to the risk factor can be used as inputs to a fuzzy inference system, where the output is generated based on ranking and risk factors across all DMs.

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### Applying the Graph Model to Strategic Conflicts Arising over the Keystone XL Pipeline Project between Canada and the USA

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**Abstract**: The Keystone XL pipeline is under construction to transfer unrefined bitumen from the Alberta Oil Sands in Canada to oil refineries located in the Gulf Coast of the United States (US). However, largely because of environmental issues surrounding the project, a complex conflict has arisen. Using the Graph Model for Conflict Resolution (GMCR) technique, the conflict over the Keystone XL pipeline project is formally investigated, modeled and analyzed in this ongoing study to gain strategic insights into its resolution.

Keywords: Keystone XL pipeline project, Graph Model for Conflict Resolution (GMCR) technique.

#### Introduction

The Keystone XL project is causing a political discord among US states, the Obama Administration, influential prominent Republicans, the Canadian Federal government, and environmentalists and concerned citizens. Each party is using the project to score political or economic gains by taking nonconforming positions. Hence, the Graph Model for Conflict Resolution (GMCR) technique is used to study and gain strategic insights into this brewing dynamic conflict at the local and international levels in Canada and the United States. Since the US President has not yet made a final decision regarding the approval or rejection of the newly submitted proposal, this study would contribute to testing the reliability of the GMCR technique. Other practical and research applications of this ongoing dispute are being studied.

#### Background of the Keystone XL Pipeline Project

The Keystone XL project has created complex circumstances leading to disputes between two neighboring countries, the US and Canada. The pipeline is planned to pass through the Sand Hills region of Nebraska, which is home to the Ogallala Aquifer—the largest aquifer in the world that has a very sensitive ecosystem (Hayden, 2011). The process used to extract bitumen from the oil sands and transferring it to the US via pipelines, requires large quantities of water and energy, and threatens the natural environment. Moreover, green house gas emission (GHG), and global warming are other negative consequences of conducting the project. (Parfomak et al., 2011). Due to the potential environmental threats, in addition to frequent environmentalist protests, multiple rounds of lobbying and negotiations on environmental issues took place between the Canadian Federal and US administration, and between the White House and the states affected by the project (Gerken, 2011).

In addition to the environmental drawbacks of this project, other issues such as political and economic challenges have also contributed to turning this conflict into a struggle for TransCanada, the corporation proposing the construction of the pipeline. For example, although the project is not yet approved overall, the construction of the pipeline has been completed in some of the US states. This means that TransCanada should pay for the pipeline tax and maintenance costs in those states (Moore, 2012). Moreover, uncertainty in the economic gains and the extent of potential environmental degradation, catalyzed by the political bickering between Republicans and Democrats contributed to creating mistrust and miscommunication among various stakeholders.

In January 2012, President Obama rejected the Keystone XL pipeline project, based on the US Department of State's recommendation. According to the State Department's announcement, "the rushed and arbitrary - 60 days - deadline insisted on by Congressional Republicans prevented a full assessment of the pipeline's impact" (The White House, 2012), especially the possible negative environmental effects, and therefore it suggested rejecting the proposal. The Republicans on the other hand appreciate many positive outcomes

such as economic benefits, less dependence on the Middle East, and job creation for this project and, thus strongly support it. In addition to these, political intentions played a role in setting the imposed deadline, by putting pressure on the US President before the elections (Cohen, 2012).

In order to avoid building the pipeline through the Sand Hills of Nebraska and based on evaluation reports provided by Nebraska's Department of Environmental Quality (NDEQ), which sides with the environmentalists and concerned citizens, TransCanada rerouted the pipelines and in May 2012, applied for the Presidential permit again. The White House is committed to release the final response regarding the new proposal in the first quarter of 2013 (TransCanada web, 2012). This added more complexity to the conflict since the US presidential election was supposed to take place in November 2012 and several controversial debates were raised among environmentalists, Republican and Democratic parties about the intentions of delaying the decision regarding this project.

#### Modeling Methodology

After exploring key factors underlying this conflict, the evolution of the decision making procedure is modeled and analyzed using the GMCR technique (Hipel et al., 1997). The examination of the Keystone XL pipeline case study using the aforementioned technique requires listing the main (President Obama, and Canada) and influential DMs (Congressional Republicans, and NDEQ), their options (summarized in Table 1), and their relative preferences among the possible states in the conflict (e.g. Republicans prefer that the project gets accepted under any condition). As of September 2012 when the model was developed, there were six options for the DMs, resulting in 26 states, which represent all the combinations that may occur.

According to DMs' preferences and a systematic elimination of states that are deemed to be unreasonable to occur, many infeasible states were dropped from the model and only twenty-four feasible states remained. Subsequently, a stability analysis was conducted to determine stable and unstable states based on a set of solutions concepts. According to the results of this comprehensive study, two of the identified feasible states were satisfied by Nash, General Metarational (GMR), Symmetric Metarational (SMR), and Sequential (SEQ) stabilities. These two states are considered to be equilibrium states, which are stable for all the DMs. For example, in Table 2, State 21 (one of the equilibrium states) describes the situation where despite NDEQ's insistence for the elimination of environmental impacts, President Obama has approved the construction of Keystone XL pipeline. This situation is appeasing to both Canada and Congressional Republicans who have always supported the project.

DMs	Options		
President Obama	1- Accept the proposal		
	2- Request modifications		
	Note: When President Obama does not choose options 1 or 2, it means that he has rejected the proposal		
Canada	3- Deal with US		
	4- Accept modification		
	Note: When Canada does not choose options 3 or 4, it means that the project is canceled		
Republicans	5- Pressure the President to accept the proposal		
NDEQ	6-Pressure to stop the project, otherwise reduce and even eliminate all environmental impacts		

Table 1. DMs and their options

DM	Option	Status Quo	Transitional State	Sample Equilibrium state
President Obama	1	N	$\implies$ Y	Y
	2	Y	N	
Canada	3	Ν	N	Y
	4	Y	Y	Ν
Republicans	5	Y	Y	Y
NDEQ	6	Y	Y	Y
State number	-	24	23	21

**Table 2.** Current situation and its transition to one of the equilibrium states. Note that Y means yes and indicates the situation in which the DM has chosen the option.

#### **Insights and Conclusions**

The projected economic benefits of the Keystone XL are in contradiction with the environmental preservation that the world currently needs. Using GMCR technique, the current analysis aims to study and provide a wise balance between these two extreme sides. Based on thorough documentation, classification, mathematical models, and analyses of the various aspects of the conflict, a more realistic perspective is provided. Therefore, in addition to facilitating communication and cooperation between the DMs, the quality of understanding, negotiation and mediation between them would be enhanced and the probability of a win/win solution would be increased (Hipel and Obeidi, 2005).

Moreover, most of the main and influential DMs of the studied conflict are local, governmental or multiemployee organizations. Also, some of the DMs consist of two or more organizations working together to make decisions. Therefore, this research can also be useful in understanding the dynamics of the multiparticipant decision making process and how each party plays a role in the final made decision.

One of the important contributions of applying the GMCR technique to the Keystone XL project is helping policy makers to develop and enhance the current local, national and international laws. Based on the findings of this study, these regulations would be more suited to support environmental sustainability, in addition to meeting social and economic demands from the society and the stakeholders.

The US President has yet to decide about the approval or rejection of the Keystone XL pipeline. If the final result of this conflict is in accordance with the results obtained from the GMCR analysis, this ongoing case study would further contribute to the literature and practical real world applications since the credibility of the GMCR technique would be validated. Other complex conflicts can also be investigated through this method, knowing that this method create valid, and reliable equilibrium states. Moreover, comparison between these real world results with the predicted results can also yield to interesting discussions regarding the implementation of the GMCR technique and interpretation of its findings.

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### Negotiation and Conflict Resolution in Systems Engineering: A Prescriptive Approach

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**Abstract**: The Graph Model for Conflict Resolution is a methodology for the modeling and analysis of strategic conflicts. Project development in systems engineering involves interaction among multiple disciplines, each one having a more or less vague understanding of the others. Development of such projects is concerned with the elicitation of user needs and preferences across this multi-disciplinary crowd of stakeholders and decision makers. Often, these decision makers are confronted with conflicts which need to be resolved for ensuring the success of a project. We present here a prescriptive methodology which derives motivation from graph-model and rank order centroid based process for conflict resolution problems in systems engineering projects.

Keywords: Systems Design, preference modeling, Graph Model for Conflict Resolution, negotiation, stakeholder satisfaction, rank order centroid, prescriptive approach

#### Introduction

The primary goal of systems engineering is the creation of a set of high quality products and services that enable the accomplishment of desired tasks and needs of the clients or user groups. Typical systems engineering projects can be divided into three phases: definition, development, and deployment (Sage and Armstrong, 2000). The definition phase involves the activities of requirement elicitation and refinement. By the end of the system definition phase, we have all the system functional and non-functional requirements. The system development phase involves the activities of conceptual architecture or behavior definition, design activity, and detail design activity, production and testing. There are numerous issues to be sorted out during the various phases of a project life cycle to ensure a smooth and successful product development.

The project development process often encounters conflicts, which can emerge during any of the project cycle phases: user/customer requirements elicitation, system requirement definition, architecture analysis, detailed design, implementation, testing, verification & validation, etc. During the user/customer requirements elicitation phase, conflicts occur among stakeholders for prioritization of the needs. Similarly, in the system requirements definition phase, conflicts may occur during finalizing of the system requirements metrics precision.

In this paper, we are concerned with a generic conflict resolution technique which can be used extensively throughout the project life cycle. We propose a solution to carry out the analysis of the decision-making process for the systems design activities. The proposed technique is partially based on the Graph Model for Conflict Resolution (Kilgour et al., 1987; Fang et al., 1993). The earlier graph models for conflict resolution were widely used in investigating interactive decision-making conflicts in environmental engineering, water resources management, energy, and other kinds of disputes. In this paper, we show how already existing graph model based game theory techniques can be improved and augmented with suitable vocabulary in order to be able to depict conflicts arising in systems and software engineering projects.

In this paper the two terms "decision maker" ("DM") and "stakeholder" are often employed. The term "DMs" refers to the entities that are together responsible for choosing an overall course of action. All DMs are stakeholders, but not all stakeholders are DMs.

In this paper, we bring forward one important contribution for conflict resolution: a prescriptive approach for modeling the systems engineering conflict and resolution, using classical preferences and surrogate rank to weight generation technique.

This paper is organized as follows: Section 2 presents the conflicts in requirement negotiation and systems design, Section 3 presents an overview of the Graph Model for Conflict Resolution (GMCR), Section 4

introduces the prescriptive approach, Section 5 presents an example of our approach, and Section 6 presents the conclusion.

#### **Requirement Negotiation and Conflict Resolution**

After the customer needs are properly elicited, they are transformed into requirements, and are negotiated with the various stakeholders. The negotiation process itself asks for every stakeholder to provide a ranking for requirements under consideration. The earlier descriptions of requirement negotiation processes in the literature clearly mention that one needs to prioritize the requirements, but do not explain how to do it. They rely on the assumption that the stakeholders know how to decide upon their priorities. In our previous work (Shukla et al, 2012), we tried to provide a systems theory by partially using non-conventional preference modeling (Roy and Vincke, 1984), which is itself derived from classical preference, as mentioned by Arrow (1953) and later by Fishburn (1982), and game theory (Nash 1950; Nash, 1951) to solve decision making problems for systems design. Previous attempts to design systems using traditional game theory were not so encouraging (Mahajan et al., 2004) as they were using the principles of the classical non-cooperative games. In representing the systems design process like a game, it seems to be much more effective to represent it as a game, in which DMs are participating without playing mean or strategic moves.

Conflict resolution problems may sometimes seem trivial, and the usual solutions may result in the most highly weighted DM's choice accepted as the final solution. Other approaches sometimes use genetic algorithms for resolving conflicts, but they seldom augment DMs' satisfaction. The existing approaches may lead to a vast difference between the degrees of satisfaction among the various stakeholders. The previously proposed conflict resolution approaches are far from perfect. There is still no holistic way to determine the weights of the DMs, or criteria weights, which drive the conflict resolution decisions in the majority of cases. The AHP approach and its derivatives, which are popular approaches to decision making in systems design engineering, assume that their DMs actually know their preference ratios among the criteria, without really providing any justification. With the recent advances in systems theory, it has become evident that a mechanism is needed to assist the stakeholders in rationalizing their choice of priorities in a formal manner. The contents of this paper constitute an important step in this direction. In this paper, we have used the preference modeling as used in GMCR based conflict resolution techniques and used technique to convert ordinal rankings of each stakeholder to cardinal ranking and retransformed them to ordinal ranking to resolve a conflict occurring between the stakeholders during a SE project.

#### Overview of the Graph Model for Conflict Resolution (GMCR)

Because of its simplicity and realistic structure, GMCR constitutes a suitable medium to represent conflict in systems design. GMCR is described in full by Fang *et al.* (1993). The definition of GMCR is as follows:

- N' is the set of decision makers (DMs) involved in the conflict under study, where 2 ≤ |N| < ∞; within the systems design context these DMs are usually stakeholders of the system under consideration.</li>
- 'S' is the set of distinguishable feasible states, satisfying  $2 \le |S| < \infty$ . One particular state, *so*, is designated as *status quo* state. In the context of systems design, a state S is one of the possible configurations of the system under consideration.
- For each  $i \in N$ , DM *i*'s directed graph G,  $G_i = (S, A_i)$ , the arc set  $A_i \subseteq S \times S$  contains no loops. The entries of  $A_i$  are controlled by DM *i*.
- For each  $i \in \mathbb{N}$ , a complete binary relation,  $\geq_i$ , on S, that specifies DM i's preference over S. If  $s, t \in S$ , then  $s \geq_i t$  means that DM i prefers s to t, or is indifferent between s and t. According to well established conventions, i strictly prefers s over t, is written as  $s \geq_i t$ , iff  $s \geq_i t$  but  $\neg [t \geq_i s]$ . Also, i is indifferent between s and t is written as  $s \sim_i t$ , iff  $s \geq_i t$  and  $t \geq_i s$ .

The above presented graph model was later expanded to handle unknown preferences (Li et al., 2004, 2005), strength of preference (Hamouda et al., 2004, 2006; Xu et al., 2009), fuzzy preferences (Hipel et al., 2011; Bashar et al., 2012), attitudes (Inohara et al., 2007; Walker et al., 2012), and emotions (Obeidi et al., 2009). For

the situation in which unknown preference between two states is taken into account, the preference structure of DM *i* is described as a triplet of relations  $\{>_i, \sim_i, U_i\}$  on S, such that:

- $s >_i t$  represents the strict preference of s over t by DM i.
- $s \sim_i t$  represents the indifference of s over t by DM i.
- $s U_i t$  means that the relative preference of s and t is unknown by DM i.

It is clear that  $>_i$  relation is asymmetric,  $\sim_i$  is symmetric and reflexive and  $U_i$  is symmetric. When strength of preference is taken into account, the preference structure can be represented as a triplet  $\{>>_i, >_i, \sim_i\}$ , such that:

- $s >_i t$  means that s is weakly preferred to t by DM *i*,
- $s >>_i t$  means that s is strongly preferred to t by DM *i*.

The relations >> and > are asymmetric and the triplet  $\{>>_{i}, >_{i}, \sim_{i}\}$  is complete. Based on this preference structure, for any state 's', a DM *i* can identify five subsets of the states set S:

- $\varphi_i + +(s) = \{s_m : s_m >>_i s\}$  —all states that DM *i* strongly prefers to *s*.
- $\varphi_i -(s) = \{s_m : s >>_i s_m\}$  —all states that DM *i* strongly prefers *s* to.
- $\varphi_i = \{s_m : s_m \sim_i s\}$  —all states that are equally preferred to *s* for DM *i*.
- $\varphi_i + (s) = \{s_m : s_m >_i s\}$  —all states that DM *i* weakly prefers to *s*.
- $\varphi_i (s) = \{s_m : s > i s_m\}$  —all states that DM *i* weakly prefers *s* to.

In the graph model, DM i's reachable list  $R_i(s)$  from a given state 's' containing all states that can be reached by DM i from state 's' in one step, specifies DM i's immediate decision possibilities at state s. From the above partition,  $R_i(s)$  can be partitioned into five subsets as follows:

- $R_i + +(s) = R_i(s) \cap \varphi_i + +(s) = \{s_m : s_m \in R_i(s) \text{ and } s_m >>_i s\}$ —all strong unilateral improvements from state 's' for DM *i*.
- $R_i+(s) = R_i(s) \cap \varphi_i+(s) = \{s_m : s_m \in R_i(s) \text{ and } s_m \ge_i s\}$ —all weak unilateral improvements from state 's' for DM *i*.
- $R_i(s) = R_i(s) \cap \varphi_i(s) = \{s_m : s_m \in R_i(s) \text{ and } s >_i s_m\}$ —all weak unilateral disimprovements from state 's' for DM *i*.
- $R_i (s) = R_i(s) \cap \varphi_i (s) = \{s_m : s_m \in R_i(s) \text{ and } s >>_i s_m\}$ —all strong unilateral disimprovements from state 's' for DM *i*.
- $R_i=(s) = R_i(s) \cap \varphi_i=(s) = \{s_m : s_m \in R_i(s) \text{ and } s_m \sim_i s\}$ —all equally preferred states reachable from state 's' by DM *i*.

Option prioritization does not seem to be a good approach for systems design. It is a good approach when the problem consists of decreasing the utility of a state for one DM by another DM, i.e., when the conflict involves sanctioning the opposition for a strategic benefit; however, in systems design the approach is to accept the configuration with the highest utility. In the case of systems engineering, where the decisions are made from a more abstract level towards more precise levels, the more preferred approach would be to use the relative preferences with respect to other subsystems being developed (from more important systems towards less important ones).

#### **Proposed Modifications**

As mentioned in Section 2, a state S is a possible configuration of the system under development. The directed graph Gi = (S, Ai) for any stakeholder i models the preferences among the various configurations
of the system under development. The existing preference structure of the graph model cannot suitably address the needs of the systems design process.

#### **Proposed Negotiation Process**

To facilitate the systems design process in a systematic way, a project management team should extensively identify the stakeholders and assign a weight for each identified stakeholder. This helps the DMs to seek the decisions in a systematic way to produce the system with the required constraints and stakeholder needs. The conflicting design concepts are identified and one to one comparison of each design concept is carried out by every stakeholder to elicit his preference. The preference matrix thus elicited by each stakeholder provides his perceptual ranking of design concepts.

The principle is to gather the ordinal ranking of every design concept from each stakeholder and then transforms the ordinal rankings to cardinal rankings. The achieved cardinal ranking thus implies the ordinal ranking of the design concepts accepted by all the stakeholders. The ordinal ranking are converted using a transformation function which allocates a particular score for a specific ranking. A typical score function is given by Rank Ordering Centroid (ROC) technique used for transforming ordinal rankings to cardinal (Ahn, 2011). Functions resembling to decreasing utility functions are used to generate the cardinal scores from rankings.

#### A. Some Definition

1) Definition of States: A state can be defined as one possible design concept configuration of the system under study. Number of states represents the number of possible design concept configurations for the system under study.

2) Preference modeling: The preference triplet  $\{>>_i, >_i, \sim_i\}$  is used to create preference matrices  $P^i$ , which is skew-symmetric, as shown in Eq.(1):

$$P^{i} = \frac{alt1}{alt2} \begin{bmatrix} 0 & p_{12} & \cdots & altn \\ 0 & p_{12} & \cdots & p_{1n} \\ p_{21} & 0 & \cdots & p_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{n1} & p_{n2} & \cdots & 0 \end{bmatrix}$$
(1)

Matrix  $P^{i}$  represents the preference of the stakeholder 'i' over the set of design concepts, where the value  $p_{ab}$  by a DM 'i' is given by Eq.(2) below:

$$p_{ab} = \begin{cases} 2, & if \ a >> b \\ 1, & if \ a > b, \\ 0, & if \ a \sim b \\ -1, & if \ a > b \\ -2, & if \ a >> b \end{cases}$$
(2)

3) Decision Point: A decision point 'ld' represents the number of times each DM is allowed to play a move before the final decision is taken. To allow to proceed through the decision process rapidly or to limit the number of significant moves, if there are fairly large number of states to be evaluated.

3) Game: A game is proposed, such that, each stakeholders starts from the most favored state and move towards the less favored state till they reach their least favored state. The game is played in 'm' steps, where 'm' is the cardinality of set 'S', i.e., the number of design concepts under evaluation.

4) Scoring of each alternative: The previous step of game provides combined actual ranking of the alternatives under evaluations. This combined ranking for each alternative is transformed to scores using functions based on rank order centroid techniques (ROC).

#### B. Negotiation Process

A usual negotiation process can be summarized in four steps as follows:

- 1. Weight all the DMs: The project manager has to take responsibility to weight the stakeholders participating in the project itself.
- 2. Derive the preferences over the set of alternative design concepts: The stakeholders should provide their preference matrices using the preference structure (triplet) as used by the usual graph model. A design concept which receives highest number of '2', then '1'and then '0' is ranked higher. A design concept which receives highest number of '-2' is rank lowest, followed by one which gets highest number of '-1'.
- 3. Start the negotiation process (game) between the DMs, with every DM starting with the most preferred configuration to the least preferred one.
- 4. *Score Generation:* Individual score of every configuration is calculated and the one with the highest value is selected. If the two design concepts get the same ranks, their scores are equally shared for the ranks they share.

We choose the scoring function as shown below in Eq.(3), which is close to ROC function.

score 
$$(c) = \sum_{i=1,J=1}^{n-1,k} \Psi_{i} * \frac{(k-j)}{k}$$
 (3)

In Eq.(3),  $\Psi_i$  is DM *i*'s weight in conflict, '*n*' is number of stakeholders ranked the design concept, '*k*' and '*j*' are index terms which allow to determine the score for a particular rank. The score function can be suitably calibrated as agreed upon by the DMs to give a curve similar to risk averse, prone or neutral curve.

# Example

To show how to use our technique, we try to model the conflict using an example of a hybrid car propulsion design. Let us suppose there are four DMs: the Design Engineers, Marketing, End-users and safety engineers, i.e.,  $N = \{de, mk, eu, se\}$ , clearly |N|=4, and they need to decide upon a hybrid-propulsion mechanism for their hybrid car but unlikely they cannot decide which design concept should be chosen for implementation in their car.

The four types of propulsions mechanism lead to six possibilities of hybrid-propulsion system, i.e., S={PEE, PDE, PGE, EGE, DGE, DEE} selected for evaluation by the stakeholders shown in Table 1.

Propulsion mechanisms	Possible Configurations for hybrid propulsion system
Petrol Engine, Diesel Engine, Electric Motor, Gas Engine	Petrol-Electric Engine (PEE),Petrol-Diesel Engine (PDE), Petrol-Gas Engine (PGE) Electric-Gas Engine (EGE) Diesel-Gas Engine (DGE)
0	Diesel-Electric Engine (DEE)

Table 1

*Step1:* The decision makers' weights are allocated to them (usually a project manager is responsible for deciding upon the stakeholders' weights), weights available are shown in Table 2.

Table 2						
Decision Makers	Weight					
ds	.3					
mk	.2					
ен	.25					
se	.25					

*Step2:* The decision makers' preferences are modeled using the classical preferences as shown in Figure 1. The preferences thus modeled allow determining the perceptual ranking of the various concepts for each decision maker. The preference modeling also allows stakeholder to reason their preference when they compare each alternative one to one.

	PEE	PDE	PGE	EGE	E DG	E DEE	3	PEE	PDE	PGE	EGE	DG	E DEE
PEE	Ê 0	-1	0	1	-1	1	PEE	Г0	-2	-2	-2	-1	-1]
PDE	1	0	1	2	1	2	PDE	2	0	-2	-2	-1	-1
PGE	0	-1	0	1	-1	1	PGE	2	2	0	1	1	1
EGE	-	1 -2	-1	0	-2	-1	$^{\circ}EGE$	2	2	-1	0	1	1
DGE	1	-1	1	2	0	2	DGE	1	1	-1	-1	0	1
DEE	<b> </b> :	1 -2	-1	1	-2	0	DEE	1	1	-1	-1	-1	0
			ds_nref				, <u> </u>			mk_nre	ef .		
			as prej							nu pre	,		
	PEE	PDE	PGE	EGE	E DG	E DEE	Ξ.	PEE	PDE	PGE	EGE	DG	e dee
PEE	PEE	PDE	$\frac{PGE}{1}$	EGE 2	E DG		PEE	<sub>РЕЕ</sub>	PDE 1	PGE 1	<i>EGE</i>	DG	$\begin{bmatrix} & DEE \\ & -1 \end{bmatrix}$
PEE PDE		PDE 2 2 0	$\frac{PGE}{1}$	еде 2 1	E DG 1 -1	1 - 2	PEE PDE	$\int_{-1}^{PEE}$	<i>PDE</i> 1 0	PGE 1	1 1	<i>DG</i> −1 −1	$\begin{bmatrix} DEE \\ -1 \\ -1 \end{bmatrix}$
PEE PDE PGE		PDE 2 2 0 1 1	$\frac{PGE}{1}$	EGE 2 1 1	E DG 1 -1 0	1 -2 -1	PEE PDE PGE	PEE $0$ $-1$ $-1$	PDE 1 0 -1	PGE 1 1 0	EGE 1 1 -1	-1 -1 -2	$ \begin{array}{c}             E  DEE \\             -1 \\             -1 \\           $
PEE PDE PGE EGE	PEE	$\begin{array}{c} PDE \\ \hline 2 \\ 2 \\ 0 \\ 1 \\ 1 \\ 2 \\ -1 \end{array}$	$\begin{array}{c} \begin{array}{c} PGE \\ \hline 1 \\ -1 \\ 0 \\ -1 \end{array}$	EGE 2 1 1 0		1 -2 -1 -2	PEE PDE PGE 'EGE	$\begin{bmatrix} 0 \\ -1 \\ -1 \\ -1 \end{bmatrix}$	PDE 1 0 -1 -1	PGE 1 1 0 1	1 1 -1 0	-1 -1 -2 -2	$\begin{bmatrix} & DEE \\ -1 \\ -1 \\ -2 \\ -2 \end{bmatrix}$
PEE PDE PGE EGE DGE		$     \begin{array}{r} PDE \\       2 \\       2 \\       0 \\       1 \\       1 \\       2 \\       -1 \\       1 \\       1 \\       1   \end{array} $	$\frac{PGE}{1}$ $-1$ $0$ $-1$ $0$	EGH 2 1 1 0 1	$\begin{array}{c} \overline{} & DG \\ \hline 1 \\ -1 \\ 0 \\ -1 \\ 0 \end{array}$	$\begin{bmatrix} e & DEE \\ 1 \\ -2 \\ -1 \\ -2 \\ -1 \\ -1 \end{bmatrix}$	PEE PDE PGE 'EGE DGE	$ \begin{array}{c} PEE \\ \hline 0 \\ -1 \\ -1 \\ -1 \\ 1 \end{array} $	PDE 1 0 -1 -1 1	PGE 1 1 0 1 2	EGE 1 1 -1 0 2	$\begin{array}{c} DG \\ -1 \\ -1 \\ -2 \\ -2 \\ 0 \end{array}$	$\begin{bmatrix} & DEE \\ -1 \\ -1 \\ -2 \\ -2 \\ -1 \end{bmatrix}$
PEE PDE PGE EGE DGE DEE	PEE	$     \begin{array}{r}         PDE \\             \hline             2 & 0 \\             2 & 0 \\             1 & 1 \\             2 & -1 \\             1 & 1 \\             1 & 2 \\             \hline         $	$\begin{array}{c} PGE \\ \hline 1 \\ -1 \\ 0 \\ -1 \\ 0 \\ 1 \end{array}$	EGE 2 1 1 0 1 2	$\begin{array}{c} \overline{} & DG \\ \hline 1 \\ -1 \\ 0 \\ -1 \\ 0 \\ 1 \end{array}$	$\begin{bmatrix} e & DEE \\ 1 \\ -2 \\ -1 \\ -2 \\ -1 \\ 0 \end{bmatrix}$	PEE PDE PGE 'EGE DGE DEE	$ \begin{array}{c} PEE \\ \hline 0 \\ -1 \\ -1 \\ -1 \\ 1 \\ 1 \end{array} $	PDE 1 0 -1 -1 1 1	PGE 1 1 0 1 2 2	EGE 1 1 -1 0 2 2	$\begin{array}{c} DG \\ -1 \\ -1 \\ -2 \\ -2 \\ 0 \\ 1 \end{array}$	$\begin{bmatrix} & DEE \\ -1 \\ -1 \\ -2 \\ -2 \\ -1 \\ 0 \end{bmatrix}$

Fig 1.Preference Matrix for the four configurations by the four DMs

*Step 3:* Once the preferences are modeled the ranking of each design concept is available and the negotiation game is played as shown in Figure 2 below. Rank orders for eu, ds, mk, and se are PFE<DFE<PGE=DGE<EGE, PDE<DGE<PEE=PGE<EGE<DEE,

PGE<EGE<DEE<PDE, and DGE<DEE<PDE<EGE<PGE respectively. Every DM starts with the most preferred design concept towards the least preferred as shown below in Figure 2.

	PEE	PDE	PGE	EGE	DGE	DEE
1	eu	ds	mk	•	se	•
2	•	٠	•	mk	ds	eu, se
3	ds, se	٠	ds , eu	•	еи	mk
4	ds	se	ds , eu	•	eu, mk	•
5	mk	еи	•	ds, se	•	•
6	•	mk	se	еи	•	ds

#### Fig 2: Negotiation Process

*Step 4:*The scores are calculated using different index valuess of 'k'and 'j'to generate the scores in risk neutral, risk averse and risk prone form. Figure 3, shows the curves representing the five types of scoring patterns for each rank. Below Eq.(4), shows the score calculations for each of the design concepts using the values of index terms 'k'=6 and 'j'=1. The scores for the five types of curves and ROC based scores are shown in Table 3 and Table 4, with 'ld' values 6 and 4 respectively.

$$score(PFE) = .25 + \frac{1}{2} \left( \frac{4}{6} \times .3 + \frac{3}{6} \times .3 \right) + \frac{4}{6} \times .25 + \frac{2}{6} \times .2 = .6583$$

$$score(PDE) = (.3) + \frac{3}{6} \times .25 + \frac{2}{6} \times .25 + \frac{1}{6} \times .2 = .5417$$
(4)
$$score(PGE) = .25 + \frac{1}{2} \left( \frac{4}{6} \times (.3 + .25) + \frac{3}{6} \times (.3 + .25) \right) + \frac{1}{6} \times (.25) = .6125$$

$$score(EGE) = \frac{5}{6} \times .2 + \frac{2}{6} \times .55 + \frac{1}{6} \times .25 = .3916$$

$$score(DGE) = .25 + \frac{5}{6} \times .3 + \frac{1}{2} \left( \frac{4}{6} \times .25 + \frac{3}{6} \times .25 \right) + \frac{3}{6} \times .2 = .7458$$

$$score(DEE) = \frac{5}{6} \times (.25 + .25) + \frac{3}{6} \times .2 + \frac{1}{6} \times .3 = .5667$$



Figure 3: Scoring Funtions of Score vs Rank

Design Concept	Algorithms (score-normalized score) ld=6						
Concept	Risk Averse	Risk Neutral-1	Risk Prone	ROC	Risk Neutral-2	Risk Neutral- 3	
PEE	110.7 <b>-</b> 0.18667	93.75 <b>-</b> 0.1820	83.5-0.1847	0.193177	0.6583 <b>-</b> 0.1872	135-0.19	
PDE	92-0.1551	80.75 <b>-</b> 0.1567	74.5-0.1648	0.169009	0.5417 <b>-</b> 0.154	111.25 <b>-</b> 0.1567	
PGE	95.95 <b>-</b> 0.1618	82.75 <b>-</b> 0.16067	73.125 <b>-</b> 0.1617	0,1603935	0.6125 <b>-</b> 0.1742	108.875 <b>-</b> 0.1533	
EGE	79–0.1332	66 <b>-</b> 0.12815	56.5-0.125	0.0888689	0.3916 <b>-</b> 0.1113	80 <b>-</b> 0.1127	
DGE	117.25 <b>-</b> 0.1977	103.25 <b>-</b> 0.2004	89.875 <b>-</b> 0.1988	0.22277741	0.7458 <b>-</b> 0.2121	152.625 <b>-</b> 0.215	
DEE	98.1 <b>–</b> 0.16543	88.5 <b>-</b> 0.17184	74.5 <b>-</b> 0.16482	0.1608095	0.5667 <b>-</b> 0.1611	122 <b>-</b> .0.1718	

#### Table 3

#### Table 4

Design	Algorithms (score-normalized score) ld=4						
Concept	Risk Averse	Risk Neutral-1	Risk Prone	ROC	Risk Neutral-2	Risk Neutral- 3	
PEE	94.7-0.2002	81.75 <b>-</b> 0.1792	73.5-0.2044	0.193177	0.5916 <b>-</b> 0.19084	121.75 <b>-</b> 0.1994	
PDE	64-0.1353	80.75 <b>-</b> 0.1770	51.5-0.1432	0.169009	0.4250 <b>-</b> 0.1371	87.75 <b>-</b> 0.1437	
PGE	85.95 <b>-</b> 0.1817	57.75 <b>-</b> 0.1266	63.125 <b>-</b> 0.1755	0,1603935	0.5708 <b>-</b> 0.1841	101.375 <b>-</b> 0.1660	
EGE	25-0.0528	56-0.1228	19 <b>-</b> 0.0528	0.0888689	0.25-0.0806	34 <b>-</b> 0.05569	
DGE	117.25 <b>-</b> 0.24788	103.25 <b>-</b> 0.22642	89.875 <b>-</b> 0.25	0.22277741	0.7458 <b>-</b> 0.2405	152.625 <b>-</b> 0.25	
DEE	86.1 <b>-</b> 0.18202	76.5 <b>–</b> 0.1677	62.5 <b>-</b> 0.1738	0.1608095	0.5167 <b>-</b> 0.1666	113 <b>-</b> 0.18509	

The scores shown above in table 3 and 4 clearly show that the design concept DGE is unanimous choice resolution choice for all the stakeholders. The results when 'ld'=4 are much more pronounced then when 'ld'= 6. Interestingly, comparing the normalized scores to the ROC technique, indicates that scores are much more evenly distributed and superior scoring is achieved for the various design concepts.

## Conclusions

In this paper we used the preference modeling of the existing Graph Model for Conflict Resolution to resolve the conflicting scenarios in the systems engineering process. We showed how ordinal ranking can be obtained using the binary preferences. We show through a toy problem how to model a propulsion

system of the hybrid car. The objective of our research work is to provide a systems theory of how transparent decisions can be taken in a systems engineering project with maximum satisfaction to the stakeholders. We look forward to.

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# Graph Model for Conflict Resolution with Stochastic Preferences

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**Abstract**: We present a generalization of the graph model for conflict resolution, introduc- ing the possibility of decision makers express their preferences among the possible scenarios through stochastic preferences. In this new model, four definitions of stability (solution con- cepts) are proposed:  $\alpha$ -Nash stability (R), ( $\alpha$ ,  $\beta$ )-metarationality (GMR), ( $\alpha$ ,  $\beta$ ) symmetric metarationality (SMR), and ( $\alpha$ ,  $\beta$ ,  $\gamma$ )-sequential stability (SEQ). Relations between these def- initions are demonstrated, as well as an analysis of how the values of the parameters  $\alpha$ ,  $\beta$  and  $\gamma$  influence the set of stable states is made. An application of this proposed model to an environmental conflict is presented. The analysis of their preferences expressed probabilis- tically.

Keywords: Graph Model for Conflict Resolution, Solution Concepts, Strength of Preference, Probabilistic Preferences.

#### Introduction

Decision making and negotiation in conflict situations are inherent to human and institutional relations. They are present when two individuals are deciding on how to split a bill and also in a negotiation to end a war between various countries. Moreover, there are situations involving information systems, engineering design, program evaluation, marketing, therapeutic procedures, etc., that involve complex choice problems (Campello, 2000). Considering the costs that can result from an unresolved conflict, finding solutions or equilibrium concepts is of key importance. For that, the development of models that are flexible enough to capture important aspects of real world conflict situations and, consequently, of more appropriate solution concepts is a major challenge.

A model of conflict analysis tries to capture important characteristics of the conflict, such as the actions available to those involved in the conflict and the possible strategic interactions among them. Once a model is established, an important step to do is stability analysis to characterize what are the possible equilibria of the conflict. Many techniques, based on some important concepts of game theory, have been used to model interactions in conflict situations. In 1950, Nash introduced the important concept of stability, known as Nash equilibrium (Nash, 1950, 1951). Since then, several conflict situations have been studied in game theory using this concept. To get closer to conflict situations in the real world the graph model for conflict resolution (GMCR) was presented by Kilgour et al. (1987), which is based on classical concepts of game theory (von Neumann and Morgenstern, 1953) and is an enhancement of the conflict analysis of Fraser and Hipel (1984) and metagames analysis (Howard, 1971). In this model, individuals involved in a conflict, called Decision Makers, or DMs have preferences over possible states. States represent the scenarios that can happen during the course of the conflict (Hipel et al., 2012). For example, suppose a negotiation process where individuals are deciding how much to invest in a particular business in which they are partners. One possible scenario occurs when both partners choose not to invest anything and another one occurs when only one decides to invest all his available resources and the other one decides not to invest. In the graph model for conflict resolution, each graph represents the possible movements for an individual involved in the conflict and the collection of graphs models the conflict.

The analysis of possible movements controlled by the DMs in the course of a conflict and the determinations of the likely conflict resolutions is the role of the stability analysis. Such analysis examines which state is stable for a given DM according to some particular notion. When a certain state is stable for all DMs, such state is presented as a possible solution of the conflict.

Different solution concepts describe possible DM's strategic behaviors in a conflict. A state may be stable according to some notion and unstable according to a different notion. For example, one notion of stability

can analyze the possibility of DM i moving from one state to another one seeking an immediate gain, that is, if he can improve his situation by changing the current state to one that is possible for him at a certain given moment in the conflict, or according to another solution concept it can be analyzed not only if i improves his situation by changing from one state to another, but also takes into account the likely responses of other decision makers that move after i and how i compares the possible states that results from such responses to the current state where it is located. Many solution concepts have been developed to represent various possibilities of strategic interactions like these. These solutions include the concept of Nash stability (Nash 1950, 1951), general metarationality (GMR) (Howard 1971), symmetric metarationality (SMR) (Howard 1971), and sequential stability (SEQ) (Fraser and Hipel, 1984).

The stability analysis in GMCR model can be applied in many contexts. Such tools may be useful to the participants of the conflict that can better understand what their role in the conflict is and make assessments as the conflict unfolds. They are also helpful for a mediator, because the technique allows the identification of what are the scenarios that are good for everyone. For an analyst who wants to study the conflict for various purposes, for example, he can use such model to understand how individual preferences lead the conflict to a particular resolution or to study how the conflict affects human behavior and from that develop better ways to manage conflicts in the future (Hipel et al., 2012).

The stability analysis is based primarily on the study of the players' preferences. Knowledge about which states are preferred over others for a DM reveals about his chances of making the transition from one state to another. There exist new offsprings to the original GMCR that try to capture different preference features. For example, the intensity of preferences of decision makers. In Hamouda, Kilgour and Hipel (2004), in addition to identifying a ranking among the states, the degree of preference is modeled, i.e., a DM may strongly prefer a state over another or simply prefer one state to another in the usual sense. This new preference structure implies new solution concepts to the conflict.

When modeling a conflict, normally one assumes that all components of the situation are totally known, i.e., all decision makers, the actions available to each one of them, including the preferences of each one over these actions. However, it is not always the case that these preferences are clear or accurate. Several models try to capture preference features that can better model real world situations. For example, probabilistic models have been used to describe individuals making choices. The intention is cover the descriptive psychological and rationality aspects present in the preference patterns. The basic idea of such models is to define a preference structure capable of capturing the difficulty that the decision maker has in perceiving the differences of value between the alternatives available to him, and his vacillations as to which aspects of the alternatives he thinks are more important and so manage to accommodate via stochastic preferences the fluctuations of behavior in the choices of individuals (Campello, 2000).

As described before, one of the stages of conflict modeling, under the graph model, is to identify decision makers's preferences. Models that admit uncertainty on preferences are quite useful either because the DMs may not have certainty about his own preferences or because it is difficult to obtain accurate information about preferences in practical problems (XU, 2010).

In our model, we study conflict situations using GMCR, but considering a preference structure that was never applied in such context. As already mentioned, some models consider that individ- uals can express their preference with a certain intensity, allowing an individual, for example, to prefer a state a to b more than he prefers another state c to d. Here, we propose that such intensity of preference is captured by a probability distribution. Thus, individuals do not simply prefer one state to another, but do it according to a certain probability. Our model catches different levels of preference's intensity. We allow that the DMs not only have a strong preference for one state over another, but our DMs are able to quantify such level of preference thought a probabilistic statement. As we have seen, it is reasonable to assume that when faced with a choice an individual prefers one scenario over another in a non-deterministic way.

Our goal is to develop a graph model for conflict resolution using the concept of stochastic preference and define new solutions to conflicts based on such preference structure. The use of such model allows a more realistic modeling of conflict resolution and gives a more detailed information regarding the stability of the possible conflict scenarios. In Section 2, we review GMCR model, the probabilistic preference structure we propose to apply in GMCR, propose GMCR with stochastic preferences and define new solution concepts

for the model. In Section 3, we present results about the relations between the proposed solution concepts and, in Section 4, we present an application of this model to an environmental conflict.

# **Review of the Literature**

A model for conflict situations involves individuals or groups with different interests, called decision makers (DMs) and incorporates the main features of the conflict. In this section, we formally review GMCR which was introduced by Kilgour et al. (1987).

In GMCR, the conflict representation is based on how and why decision makers decide to switch from one state to another. Such states are determined by the possible actions that can be taken by the DMs involved in the conflict; each state determines exactly one action for each DM in the conflict. Therefore, by switching his own actions a DM can switch among some states. In GMCR there is a collection of graphs, one for each DM, where all the graphs have the same set of vertices or nodes representing the possible states of the conflict. The arcs of a particular graph represent the possible transitions that a particular DM can make. GMCR consists of this collection of graphs together with a set of preference relations over the set of states; one preference relation for each DM. The set of DMs is denoted by  $N = \{1, 2, 3, \ldots, n\}$  and  $S = \{1, 2, \ldots, s\}$  is the set of possible states or scenarios of conflict. A collection of directed graphs Di =  $(S, Ai), i \in N$ , is used to model the ongoing conflict. The vertices of each of these graphs, as already said, are the possible states of conflicts and therefore S, is common to all graphs. If DM i in a state sp can move to a possibly different state sq , then there is a direct arc from sp to sq in Ai (Hipel et al., 2012). All states available in a single step for a specific DM i from a state s are elements of a set Ri(s), i.e.,  $Ri(s) = \{t \in S : (s, t) \in Ai\}$ . Thus, Ri(s) is the set of states achievable for DM i when the current states is s.

Most models in game theory and also in GMCR models a preference relation, denoted by >-, which is asymmetric and negative transitive binary relation, is considered and interpreted as follows:

x > -y, if the object x is strictly preferred to the object y for a particular DM.

From such preference relation, two other binary relations can be derived: (Kreps, 1988), the non-strict preference relation,

$$x C: y \Leftrightarrow y > x$$
,

and the indifference relation,

 $x \sim y \Leftrightarrow x > y \text{ and } y > x.$ 

Recently, some GMCR models have extended such notion of preference to better represent some real world conflicts. For example, Hamouda, Kilgour and Hipel (2004) proposed a model in which the DMs can have preference with two different levels of intensity. A DM can strongly prefer a state over the other or simply prefer one over the other. Allowing this extra flexibility, the authors define new stability concepts. The new preference structure is a triple  $\{>>, >, \sim\}$ , where a > b implies that a is preferred over b, while a >> b implies that a is strongly preferred over b.

In some contexts, it may be interesting to extend the concept of preference strength or pref- erence intensity by allowing more levels of intensity. It is reasonable to consider that in some real world situations, individuals may express a stochastic preference rather than deterministic one as presented here. A preference represented by a number between 0 and 1 would indicate the likelihood a DM would prefer a certain state (or an available option) over another one.

Probabilistic models of preferences have a long history. Luce (1958) develops a probabilistic utility model proposing a model to capture the intuition that when a DM is offered a pair of objects in some set S he must choose the alternative that he judges superior according to a probabilistic choice over the criterion used to make the choice which is dependent on a particular empirical context. Thus, P (a, b) represents the probability that the DM strictly prefers the alternative a over b when presented to choose one of them. For example, when asked to choose between a chocolate and a vanilla ice cream the DM may say that he prefers the first one with probability.

Thus, such DM very often chooses the chocolate ice cream, but approximately 20% of the times chooses the vanilla ice cream, the criteria and mechanisms used by the DM to choose between these two options are too complex to be modeled explicit, but it is assumed that they exhibit some kind of regularity that enable such preference to be modeled by a probability distribution. Such probability whose domain is  $S \times S$  must satisfy:

P (a, b)  $\ge 0$  for each a, b  $\in$  S,

 $P(a, b) + P(b, a) \le 1$  for each  $a, b \in S$ ,

Our objective is to propose an extension for GMCR model by allowing the DMs to have stochastic preference over states. Such probabilistic preference may arise either from the modeling of a single DM who vacillates in a probabilistic fashion when choosing between states or can be used to represent a part in a conflict which is not monolitic. For example, a country which can be represented by different diplomats each one of them having a possibly different ranking over the states. In the next section, we formally present GMCR with stochastic preferences and redefine standard notions of stability in this new model.

# **GMCR** with Stochastic Preferences and Stability Analysis

GMCR with stochastic preferences involves exactly the same components of the described GMCR, with the exception that DMs now are considered to have stochastic preference over states. Thus, it is assumed that every DM in a conflict is able to indicate the probability P (a, b) that he prefers state a over state b, for every pair of states a and b in a conflict. The intuition of this idea is that individuals can use empirical data to establish a probability distribution over the states. Or, in some conflict situations, decision makers, who may be individuals, but also institutions or countries, may have more than one representant and each representant has the possibility of being chosen the actual DM representant in a particular conflict with a certain probability. Whereas each representant may have a standard deterministic preference relation over the stated over the states preference relation over the states at a standard preference relation, but we could use an stochastic preference relation defining that the probability that the DM prefers state a over b as the sum of the probabilities of the representants that prefer a over b. Consider the following example that illustrate this situation.

#### Example 3.1.

We present a modified version of a hypothetical conflict proposed by Hipel (2001) that illustrates the usefulness of the proposed GMCR with stochastic preferences. In this conflict there are two DMs: Environmentalists E and Developers D. Environmentalists can choose to be proactive P in promoting environmental responsibility or not, in which case they are called reactive.

R. Developers can choose between being sustainable S or not, which is represented by U. Since there are only two options, there are  $2^2 = 4$  possible combinations: (P, S), (P, U), (R, U) and (R, S), which are the possible states of the conflict. If DM E, for example, is in state (P, S), he can either stay in (P, S) or change to (R, S), while DM D, in the same state, can stay in (P, S) or change to (P, U). The conflict is modeled as having an initial state and evolves depending on whether the DMs change actions and therefore states.

The original example assumes that preferences are deterministic and E's preferences are such that (P, S) > E(R, S) > E(P, U) > E(R, U) and considers that there are two types of DM D: one

gives low priority to environmentalism and the other is more responsible in this sense than the first one. The preferences of the first type,  $D_U$ , are  $(R, U) \ge D_U(P, U) \ge D_U(R, S) \ge D_U(P, S)$  and second,  $D_S$ , are such that  $(R, S) \ge D_S(P, S) \ge D_S(R, U) \ge D_S(P, U)$ .

We modify the original example by considering that if a DM i deterministically prefers one state sp to another sq, then we say that Pi(sp, sq) = 1. Otherwise, we say that the probability is zero. According to this definition, the likelihood that E prefers one state to another are shown in Table 1. Each cell expresses the probability that DM E prefers the line state to the column state.

Е	(P,S)	(R,S)	(P,U)	(R,U)
(P,S)	0.00	1.00	1.00	1.00
(R,S)	0.00	0.00	1.00	1.00
(P,U)	0.00	0.00	0.00	1.00
(R,U)	0.00	0.00	0.00	0.00

Table 1: Stochastic Preferences for DM E

Consider now that DM j can be of several different types and each type has a possibly different preference order. Let us also assume that there is a probability distribution over the set of types that represent DM j in the conflict. In this case, we say that DM j has a stochastic preference for state sp over state sq that is given by the sum of the probabilities of the types of DM j that prefer sp over sq. Thus, for example, consider the probability distribution in which P (D =  $D_s$ ) = 0.30 and P (D =  $D_U$ ) = 0.70. Thus, the stochastic preferences of DM D are as shown in Table 2, where each cell indicates the likelihood that DM D prefers the line state to the column state. For example, PD ((R, S), (P, S)) = 0.30 + 0.70 = 1, since the two possible types of DM D prefer (R, S) over (P, S), while PD ((P, U), (P, S)) = 0.70, because the likelihood of the type of DM D that prefers (P, U) over (P, S) is 0.70, i.e., the probability of the type being  $D_U$  is 0.70.

Table 2: Stochastic Preferences for DM D

D	(P,S)	(R,S)	(P,U)	(R,U)
(P,S)	0.00	0.00	0.30	0.30
(R,S)	1.00	0.00	0.30	0.30
(P,U)	0.70	0.70	0.00	0.00
(R,U)	0.70	0.70	1.00	0.00

GMCR model contains a set of DMs, N. Each DM has a set of actions available. From this set, each DM must choose one action and this choice affects the current state of the conflict. The set of states that DM *i* can achieve when the current state of the conflict is s is denoted by  $R_i(s)$ .

Let us consider now that the DMs participating in the conflict prefer a state over the other

according to a probability distribution, so that given any two states  $s_p$  and  $s_q$ , any DM *i* has a probability that expresses the chance he prefers state  $s_p$  over  $s_q$  which is denoted by Pi( $s_p$ ,  $s_q$ ).

Thus, considering the new preference structure that allows each DM to have stochastic prefer- ence over states, we can define new concepts of stability that makes use of this extra information revealed by the preference structure. We propose notions of stability which are based on the standard notions of Nash stability, Metarationality and Sequential Stability.

#### Notions of Stability in GMCR with Stochastic Preferences

In this section, consider parameters  $\alpha$ ,  $\beta$  and  $\gamma$  lying in the interval [0, 1].

 $\alpha$ -Nash Stability. In the original GMCR model, a state being Nash stable means that none of the DMs could move to a state that is better than the equilibrium one. In the present model, we want to have a stability notion that captures the intuition that no DM can move to a state which is preferred over the equilibrium state with a sufficiently high probability. The following definition formalizes this idea:

**Definition 3.2.:** Let  $i \in N$ . A state  $s \in S$  is  $\alpha$ -Nash stable for DM *i*, if for every state  $s_1 \in R_i(s), P_i(s_1, s) \le 1 - \alpha$ .

Thus, a state s is  $\alpha$ -Nash stable for DM *i* if among all the states that i can achieve when he is in s there is no state that he prefers to s with probability greater than  $1 - \alpha$ . For example, a state s that is 0.9-Nash stable for DM *i* is such that among all the states that i can achieve from s there is none that i prefers to s with probability greater than 0.10. As another example, a state is 1.0-Nash stable for DM *i* if among all the states that i can achieve from s there is none that i prefers to s with probability greater than 0.10. As another example, a state is 1.0-Nash stable for DM *i* if among all the states that i can achieve from s there is none that zero.

As we show in the next section, the set of  $\alpha$ -Nash stable states monotonically decreases as one increases  $\alpha$ . Thus, for each state there exists an interval of values of  $\alpha$  for which such state satisfies  $\alpha$ -Nash stability. The supremum of such interval characterizes the intensity of Nash stability of the corresponding state. In order to guarantee that each state can be associated with such a number, there must be at least one  $\alpha$  such that the state satisfies  $\alpha$ -Nash stability. This is the reason why we allow  $\alpha$  to be equal to zero, since every state is obviously 0-Nash stable.

 $(\alpha, \beta)$ -Metarationality. In the original GMCR model, a state being metarational stable means that even if one DM could move to a more preferred state there would be a counter move from another DM that would lead the conflict to a state worse than the equilibrium one for the first DM. In the present model, we want to have a stability notion that captures the intuition that even if one DM can move to a state which is preferred over the equilibrium state with a sufficiently high probability, there would be a counter move from another DM leading to a state which is not much more preferred than the equilibrium one by the first DM. The following definition formalizes this idea:

**Definition 3.3.:** Let  $i \in N$ . A state  $s \in S$  is  $(\alpha, \beta)$ -Metarational for DM *i* if for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_j(s_1)$  such that  $P_i(s_2, s) \le 1 - \beta$ .

Thus, a state s is  $(\alpha, \beta)$ -Metarational stable for DM *i* if for every state that i can achieve from *s* and he prefers to s with probability greater than  $1-\alpha$ , then there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that i does not prefer s<sub>2</sub> over s with probability greater than  $1 - \beta$ . For example, a state s that is (0.9, 0.7)-Metarational stable for DM *i* is such that for every state that i can achieve from s and that he prefers over *s* with probability greater than 0.10, there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that i does not prefer s<sub>2</sub> over s with probability greater than 0.3. As another example, a state is (1, 1)-Metarational stable for DM *i* if for every state that *i* can achieve from s and that he prefers over *s* with positive probability, there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that *i* does not prefer s<sub>2</sub> over s with probability greater than 0.3. As another example, a state is (1, 1)-Metarational stable for DM *i* if for every state that *i* can achieve from s and that he prefers over *s* with positive probability, there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that *i* does not prefer s<sub>2</sub> over s with positive probability.

As we show in the next section, the set of  $(\alpha, \beta)$ -Metarational stable states monotonically decreases as one increases either  $\alpha$  or  $\beta$ . Thus, for each state there exists a region of  $(\alpha, \beta)$  values for which such state satisfies  $(\alpha, \beta)$ -Metarational stability. Such region characterizes the intensity of Metarational stability of the corresponding state. In some contexts, it may make sense to add a restriction that  $\alpha = \beta$ , but since we do not see any compelling reason to do so in general we add such parameter to give more flexibility. In this case,  $\alpha$  defines the threshold for the preference when we are analyzing moves of a DM that is considering moving away from an equilibrium state and  $\beta$  defines the threshold for the preference when we analyze the counter move of a different DM.

 $(\alpha, \beta)$ -Symmetric Metarationality. In the original GMCR model, a state being symmetric metarational stable means that even if one DM could move to a more preferred state there would be a counter move from another DM that would lead the conflict to a state worse than the equilibrium one for the first DM and, moreover, the first DM can not move away from such latter state to another one that is preferred to the equilibrium state. In the present model, we want to have a stability notion that captures the intuition that even if one DM can move to a state which is preferred over the equilibrium state with a sufficiently high probability, there would be a counter move from another DM leading to a state which is not much more preferred than the equilibrium one by the first DM and, moreover, the first DM can not move away from such latter state to another one that is preferred over the equilibrium state which is not much more preferred than the equilibrium one by the first DM and, moreover, the first DM can not move away from such latter state to another one that is preferred over the equilibrium state with sufficiently high probability. The following definition formalizes this idea:

**Definition 3.4.:** Let  $i \in N$ . A state  $s \in S$  is  $(\alpha, \beta)$ -Symmetric Metarational for DM i if for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_j$   $(s_1)$  such that  $P_i(s_2, s) \le 1 - \beta$  and there is no  $s_3 \in R_i(s_2)$  such that  $P_i(s_3, s) > 1 - \alpha$ .

Thus, a state s is  $(\alpha, \beta)$ -Symmetric Metarational stable for DM *i* if for every state that i can achieve from s and he prefers to s with probability greater than  $1 - \alpha$ , then there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that *i* does not prefer s<sub>2</sub> over s with probability greater than  $1 - \beta$  and, moreover, there is no counter response that i can make from s<sub>2</sub> leading to a state s<sub>3</sub> such that i prefers s<sub>3</sub> over *s* with probability greater than  $1 - \alpha$ .

For example, a state s that is (0.9, 0.7)-Symmetric Metarational stable for DM i is such that for every state that i can achieve from s and that he prefers over s with probability greater than 0.10, there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that i does not prefer s<sub>2</sub> over s with probability greater than 0.30 and, moreover, there is no counter response that i can make from s<sub>2</sub> leading to a state s<sub>3</sub> such that i prefers s<sup>3</sup> over s with probability greater than 0.10. As another example, a state is (1, 1)-Symmetric Metarational stable for DM *i* if for every state that *i* can achieve from *s* that he prefers over *s* with positive probability, there is a response moving to a state s<sub>2</sub> that some other DM *j* can make such that i does not prefer s<sub>2</sub> over s with positive probability and, moreover, there is no counter response that i can make from s<sub>2</sub> leading to a state s<sub>3</sub> such that i prefers s<sub>3</sub> over s with positive probability and, moreover, there is no counter response that i can make from s<sub>2</sub> leading to a state s<sub>3</sub> such that i prefers s<sub>3</sub> over s with positive probability and, moreover, there is no counter response that i can make from s<sub>2</sub> leading to a state s<sub>3</sub> such that i prefers s<sub>3</sub> over s with positive probability.

As we show in the next section, the set of  $(\alpha, \beta)$ -Symmetric Metarational stable states monotonically decreases as one increases either  $\alpha$  or  $\beta$ . Thus, as in the case of metarationality, for each state there exists a region of  $(\alpha, \beta)$  values for which such state satisfies  $(\alpha, \beta)$ -Symmetric Metara- tional stability. Such region characterizes the intensity of Symmetric Metarational stability of the corresponding state. We also do not see any compelling reason to require that in general  $\alpha = \beta$  and such parameters have exactly the same interpretation as in the previous case.

 $(\alpha, \beta, \gamma)$ -Sequential Stability. In the original GMCR model, a state being sequentially stable means that even if one DM could move to a more preferred state there would be a counter move from another DM that would lead the conflict to a state worse than the equilibrium one for the first DM and, moreover, such counter move is not harming to the second DM. In the present model, we want to have a stability notion that captures the intuition that even if one DM can move to a state which is preferred over the equilibrium state with a sufficiently high probability, there would be a counter move from another DM leading to a state which is not much more preferred than the equilibrium one by the first DM and, moreover, such counter move of the second DM leads him to a state that is preferred over the current state with a sufficiently high probability. The following definition formalizes this idea:

**Definition 3.5.:** Let  $i \in N$ . A state  $s \in S$  is  $(\alpha, \beta, \gamma)$ -Sequentially Stable for DM *i* if for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_i(s_1)$  such that  $P_i(s_2, s_1) \ge \gamma$  and  $P_i(s_2, s) \le 1 - \beta$ .

Thus, a state s is  $(\alpha, \beta, \gamma)$ -Sequentially Stable for DM *i* if for every state that *i* can achieve from *s* and he prefers with probability greater than  $1 - \alpha$ , then there is a response moving to a state s<sub>2</sub> that some other DM j can make such that j prefers s<sub>2</sub> over s<sub>1</sub> with probability greater than or equal to  $\gamma$  and i does not prefer s<sub>2</sub> over s with probability greater than  $1 - \beta$ .

For example, a state s that is (0.9, 0.8, 0.7)-Sequentially Stable for DM i is such that for every state  $s_1$  that I can achieve from s and that he prefers over s with probability greater than 0.1, there is a response moving to a state  $s_2$  that some other DM *j* can make such that j prefers  $s_2$  over  $s_1$  with probability greater than or equal to 0.7 and i does not prefer  $s_2$  over s with probability greater than 0.2. As another example, a state is (1, 1, 1)-Sequentially Stable for DM *i* if for every state  $s_1$  that i can achieve from s that he prefers with prositive probability, there is a response moving to a state  $s_2$  that some other DM *j* can make such that *j* prefers  $s_2$  over s  $s_1$  with probability one and i does not prefer so that some other DM *j* can make such that *j* prefers  $s_2$  over  $s_1$  with probability one and i does not prefer  $s_2$  over s with positive probability.

As we show in the next section, the set of  $(\alpha, \beta, \gamma)$ -Sequentially stable states monotonically decreases as one increases either  $\alpha$ ,  $\beta$  or  $\gamma$ . Thus, for each state there exists a region of  $(\alpha, \beta, \gamma)$  values for which such state satisfies  $(\alpha, \beta, \gamma)$ -Sequential stability. Such region characterizes the intensity of Symmetric Metarational stability of the corresponding state. We also do not see any compelling reason to add any correlation for the values of the parameters  $\alpha$ ,  $\beta$  and  $\gamma$ .  $\alpha$  and  $\beta$  have exactly the same interpretation as in the previous cases while  $\gamma$  is interpreted as the threshold for the preference when we are analyzing moves of the second DM that is considering to make a counter move.

# **Relations Among Different Stability Notions**

There is a well known implication among the standard notions of stability in GMCR model (Fang et al., 1993). It can be easily shown that Nash Stability implies Symmetric Metarational- ity which in turn implies Metarationality. Moreover, Nash Stability implies Sequential Stability which in turn implies Metarationality. In the present model, similar implications remain valid. Besides showing these relationships, we also analyze implications in the solution concepts when the parameters  $\alpha$ ,  $\beta$  and  $\gamma$  are changed.

Theorem 4.1.: The following relationships are valid in GMCR model with stochastic preferences:

- (a) If a state s is  $\alpha$  Nash stable for DM i, then it is ( $\alpha$ ,  $\beta$ )-Metarational stable, ( $\alpha$ ,  $\beta$ )-Symmetric Metarational stable and ( $\alpha$ ,  $\beta$ ,  $\gamma$ )-Sequentially stable for DM i for all  $\alpha$ ,  $\beta$  and  $\gamma$ .
- (b) If a state s is (α, β)-Symmetric Metarational stable for DM i, then it is (α, β)-Metarational stable for DM i for all α and β.
- (c) If a state s is (α, β, γ)-Sequentially stable for DM i, then it is (α, β)-Metarational stable for DM i, for all α, β and γ.
- (d) If a state s is  $\alpha_1$ -Nash stable for DM i, then it is  $\alpha_2$ -Nash stable for DM i for all  $\alpha_1 \ge \alpha_2$ .
- (e) If a state s is  $(\alpha_1, \beta)$ -Metarational stable for DM i, then it is  $(\alpha_2, \beta)$ -Metarational stable for DM i, for all  $\beta$  and  $\alpha_1 \ge \alpha_2$ .
- (f) If a state s is  $(\alpha, \beta_1)$ -Metarational stable for DM i, then it is  $(\alpha, \beta_2)$ -Metarational stable for DM i, for all  $\alpha$  and  $\beta_1 \ge \beta_2$ .
- (g) If a state s is  $(\alpha_1, \beta)$ -Symmetric Metarational stable for DM i, then it is  $(\alpha_2, \beta)$ -Symmetric Metarational stable for DM i, for all  $\beta$  and  $\alpha_1 \ge \alpha_2$ .
- (h) If a state s is  $(\alpha, \beta_1)$ -Symmetric Metarational stable for DM i, then it is  $(\alpha, \beta_2)$ -Symmetric Metarational stable for DM i, for all  $\alpha$  and  $\beta_1 \ge \beta_2$ .
- (i) If a state s is  $(\alpha_1, \beta, \gamma)$ -Sequentially stable for DM i, then it is  $(\alpha_2, \beta, \gamma)$ -Sequentially stable for DM i, for all  $\beta$ ,  $\gamma$  and  $\alpha_1 \ge \alpha_2$ .
- (j) If a state s is  $(\alpha, \beta_1, \gamma)$ -Sequentially stable for DM i, then it is  $(\alpha, \beta 2, \gamma)$ -Sequentially stable for DM i, for all  $\alpha, \gamma$  and  $\beta_1 \ge \beta_2$ .
- (k) If a state s is  $(\alpha, \beta, \gamma_1)$ -Sequentially stable for DM i, then it is  $(\alpha, \beta, \gamma_2)$ -Sequentially stable for DM i, for all  $\alpha, \beta$  and  $\gamma_1 \ge \gamma_2$ .

**Proof:** For (a), note that a state s is  $\alpha$ -Nash stable for DM i if for all  $t \in R_i(s)$ ,  $Pi(t, s) \le 1 - \alpha$ . Thus, since there is no state  $t \in R_i(s)$  such that  $P_i(t, s) > 1 - \alpha$ , all other solution concepts are vacuously satisfied.

For (b), suppose that s is  $(\alpha, \beta)$ -Symmetric Metarational stable for DM i. Thus, for all  $s1 \in Ri(s)$  such that  $Pi(s1, s) > 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that  $Pi(s2, s) \le 1 - \beta$  and there is no  $s3 \in Ri(s2)$  such that  $Pi(s3, s) > 1 - \alpha$ . Therefore, it is true that for all  $s1 \in Ri(s)$  such that  $Pi(s1, s) > 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that  $Pi(s2, s) \le 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that  $Pi(s2, s) \le 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that  $Pi(s2, s) \le 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that  $Pi(s2, s) \le 1 - \beta$ , which implies that s is  $(\alpha, \beta)$ -Metarational stable for DM i.

For (c), suppose that s is  $(\alpha, \beta, \gamma)$ -Sequentially stable for DM i. Thus, for all  $s1 \in Ri(s)$  such that  $Pi(s1, s) > 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that Pj (s2, s1)  $\geq \gamma$  and  $Pi(s2, s) \leq 1 - \beta$ . Therefore, for all  $s1 \in Ri(s)$  such that  $Pi(s1, s) > 1 - \alpha$ , there exists  $s2 \in Rj$  (s1) such that  $Pi(s2, s) \leq 1 - \beta$ , which implies that s is  $(\alpha, \beta)$ -Metarational stable for DM i.

For (d), suppose that s is  $\alpha_1$ -Nash stable for DM i. Thus, for all  $s_1 \in \text{Ri}(s)$ ,  $\text{Pi}(s_1, s) \leq 1-\alpha_1 \leq 1-\alpha_2$ . Therefore, s is  $\alpha_2$ -Nash stable for DM i.

For (e), suppose that s is  $(\alpha_1, \beta)$ -Metarational stable for DM i. Let  $s_1 \in R_i(s)$  be such that  $P_i(s_1, s) > 1 - \alpha_2$ . Thus, since  $\alpha_1 \ge \alpha_2$ , we have that  $P_i(s_1, s) > 1 - \alpha_1$ . Therefore, as s is  $(\alpha_1, \beta)$ -Metarational stable for DM i, there exists  $s_2 \in R_j$  ( $s_1$ ) such that  $P_i(s_2, s) \le 1 - \beta$ , which implies that s is  $(\alpha_2, \beta)$ -Metarational stable for DM i.

For (f), suppose that s is  $(\alpha, \beta_1)$ -Metarational stable for DM i. Thus, for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_j(s_1)$  such that  $P_i(s_2, s) \le 1 - \beta_1 \le 1 - \beta_2$ , which implies that s is  $(\alpha, \beta_2)$ -Metarational stable for DM i.

For (g), suppose that s is  $(\alpha_1, \beta)$ -Symmetric Metarational stable for DM i. Let s1  $\in$  Ri(s) be such that  $P_i(s_1, s) > 1-\alpha_2$ . Thus, since  $\alpha_1 \ge \alpha_2$ , we have that  $P_i(s_1, s) > 1-\alpha_1$ . Therefore, as s is  $(\alpha_1, \beta)$ -Symmetric Metarational

stable for DM i, there exists  $s_2 \in R_j$  ( $s_1$ ) such that  $P_i(s_2, s) \le 1-\beta$  and there is no  $s_3 \in R_i(s_2)$  such that  $P_i(s_3, s) > 1 - \alpha_1$ , which implies that there is no  $s_3 \in R_i(s_2)$  such that  $P_i(s_3, s) > 1 - \alpha_2$ . Thus, s is ( $\alpha_2$ ,  $\beta$ )-Symmetric Metarational stable for DM i.

For (h), suppose that s is  $(\alpha, \beta_1)$ -Symmetric Metarational stable for DM i. Thus, for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_j$  ( $s_1$ ) such that  $P_i(s_2, s) \le 1 - \beta_1 \le 1 - \beta_2$  and there is no  $s_3 \in R_i(s_2$  such that  $P_i(s_3, s) > 1 - \alpha$ , which implies that s is  $(\alpha, \beta_2)$ -Symmetric Metarational stable for DM i.

For (i), suppose that s is  $(\alpha_1, \beta, \gamma)$ -Sequentially stable for DM i. Let  $s_1 \in R_i(s)$  be such that  $P_i(s_1, s) > 1 - \alpha_2$ . Thus, since  $\alpha_1 \ge \alpha_2$ , we have that  $P_i(s_1, s) > 1 - \alpha_1$ . Therefore, as s is  $(\alpha_1, \beta, \gamma)$ -Sequentially stable for DM i, there exists  $s_2 \in R_i$  ( $s_1$ ) such that  $P_i(s_2, s_1) \ge \gamma$  and  $P_i(s_2, s) \le 1 - \beta$ , which implies that s is  $(\alpha_2, \beta, \gamma)$ -Sequentially stable for DM i.

For (j), suppose that s is  $(\alpha, \beta_1, \gamma)$ -Sequentially stable for DM i. Thus, for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_j(s_1)$  such that  $P_j(s_2, s_1) \ge \gamma$  and  $P_i(s_2, s) \le 1 - \beta_1 \le 1 - \beta_2$ , which implies that s is  $(\alpha, \beta_2, \gamma)$ -Sequentially stable for DM i.

For (k), suppose that s is  $(\alpha_1, \beta, \gamma)$ -Sequentially stable for DM i. Thus, for all  $s_1 \in R_i(s)$  such that  $P_i(s_1, s) > 1 - \alpha$ , there exists  $s_2 \in R_j(s_1)$  such that  $P_j(s_2, s_1) \ge \gamma_1 \ge \gamma_2$  and  $P_i(s_2, s) \le 1 - \beta$ , which implies that s is  $(\alpha, \beta, \gamma_2)$ -Sequentially stable for DM i.

# An Application

Consider the stochastic preferences of the DMs are as in Example 3.1. We can now examine the states' stability properties. Tables 3, 4, 5 and 6 show the range of values for the parameters for which the states (P, S), (R, S), (P, U) and (R, U), respectively, satisfy the stochastic notions of stability for each DM. For example, consider that the initial state is (R, U). Analyzing the conflict according to the states that are achievable for DM *D* at (R, U), we have that the available states for this DM are (R, U) (D can choose to stay in same state) and (R, S). We observe in Table 2 that P<sub>D</sub> ((R, U), (R, U)) = 0 and P<sub>D</sub> ((R, S), (R, U)) = 0.3. Thus, to infer about for which values of  $\alpha$ , state (R, U) is  $\alpha$ -Nash stable for DM *D*, we need to verify that the probability that DM *D* prefers each state available in (R, U) to state (R, U) is less than or equal to  $1 - \alpha$ . Therefore, (R, U) is  $\alpha$ -Nash stable for DM D if  $0.0 \le 1 - \alpha$  and  $0.30 \le 1 - \alpha$ . Thus, if  $\alpha \le 0.70$ , then the two previous inequalities are satisfied and therefore (R, U) is  $\alpha$ -Nash stable for DM *D*.

Let us now consider how to analyze the stochastic stability of state (R, U) according to the other notions. First, note that if  $\alpha \leq 0.7$ , then there is no available state for DM *D* at (R, U) such that D prefers such a state to (R, U) with probability greater than  $1 - \alpha$ . Thus, for any  $\beta$ , the concept of Metarationality is satisfied. Indeed, the same argument holds for the remaining concepts, namely, if  $\alpha \leq 0.7$  and  $\beta$  is free, then (R, U) is also ( $\alpha$ ,  $\beta$ )-Symmetric Metarational and if  $\alpha \leq 0.7$ ,  $\beta$  and  $\gamma$  are free, then (R, U) is ( $\alpha$ ,  $\beta$ ,  $\gamma$ )-Sequentially stable. On the other hand, if  $\alpha > 0.7$ , then (R, S) is the unique state s achievable for DM *D* at (R, U) such that P<sub>D</sub> ((s), (R, U)) > 1 -  $\alpha$ .

The next step is to analyze the available states for DM *E* at (R, S) with respect to the stochastic preferences of DM *D* over the initial state (R, U). There are two states available for E at (R, S): (R, S) and (P, S). According to Table 2, P<sub>D</sub> ((R, S), (R, U)) = P<sub>D</sub> ((P, S), (R, U)) = 0.30. To examine for which values of  $\beta$  (R, U) is ( $\alpha$ ,  $\beta$ )-Metarational, we need to verify if  $\beta$  is such that  $0.30 \le 1 - \beta$ , which is true for  $\beta \le 0.70$ . Thus, for  $\alpha > 0.70$  and  $\beta \le 0.70$ , the state (R, U) is ( $\alpha$ ,  $\beta$ )-Metarational for DM *D*.

Note that for  $\alpha > 0.7$ , the unique state s available for DM D in (R, U) such that P<sub>D</sub> (s, (R, U)) > 1 -  $\alpha$  is (R, S). In (R, S), DM E can achieve both (R, S) and (P, S). However, both of these states are preferred by DM D over (R, U) with probability  $0.3 > 1 - \alpha$ . Thus, DM D can choose as a counter-response not to do anything and he will be in a state that is preferred over the original state (R, U) with a probability higher than  $1 - \alpha$ . Therefore, if  $\alpha > 0.7$ , then (R, U) is not symmetric rational stable for DM D.

Finally, let us analyze if it is possible that, for  $\alpha > 0.7$ , the state (R, U) be sequentially rational stable for DM D. Note that as in the previous paragraph, the unique state s available for DM D in (R, U) such that P<sub>D</sub> (s, (R, U)) > 1 -  $\alpha$  is (R, S) and that in (R, S), DM E can achieve both (R, S) and (P, S). (R, U) will be sequentially rational stable for DM D if either P<sub>E</sub> ((R, S), (R, S)) =  $0 \ge \gamma$  and P<sub>D</sub> ((R, S), (R, U)) =  $0.3 \le 1$ 

 $-\beta$  or P<sub>E</sub> ((P, S), (R, S)) =  $1 \ge \gamma$  and P<sub>D</sub> ((P, S), (R, U)) =  $0.3 \le 1 - \beta$ . Thus, (R, U) is sequentially rational stable for DM *D* if  $\alpha > 0.7$ ,  $\beta \le 0.7$  and  $\gamma \le 1$ . The other cells in Tables 3, 4, 5 and 6 can be filled using a similar procedure.

	Table 3: Stochastic Stability for Stat	e (P, S)
able for E	Stable for D	Stat

	Stable for E	Stable for D	Stable
$\alpha$ -Nash	$\forall \alpha$	$\alpha \le 0.3$	$\alpha \le 0.3$
$(\alpha, \beta)$ -GMR	$\forall \alpha, \forall \beta$	$\alpha \le 0.3$ , $\forall \beta$ or $\alpha > 0.3$ , $\beta \le 0.3$	$\alpha \le 0.3$ , $\forall \beta$ or $\alpha > 0.3$ , $\beta \le 0.3$
$(\alpha, \beta)$ -SMR	$\forall \alpha, \forall \beta$	$\alpha \leq 0.3, \forall \beta$	$\alpha \leq 0.3, \forall \beta$
$(\alpha, \beta, \gamma)$ -SEQ	$\forall \alpha, \forall \beta, \forall \gamma$	$\alpha \le 0.3, \forall \beta, \forall \gamma \text{ or } \alpha > 0.3, \beta \le 0.3, \gamma = 0$	$\alpha \leq 0.3, \forall \beta, \forall \gamma \text{ or } \alpha > 0.3, \beta \leq 0.3, \gamma = 0$

-	Stable for E	Stable for D	Stable
$\alpha$ -Nash	$\alpha = 0$	$\alpha \le 0.3$	$\alpha = 0$
$(\alpha,\beta)$ -GMR	$\forall \alpha, \forall \beta$	$\alpha \le 0.3$ , $\forall \beta$ or $\alpha > 0.3$ , $\beta \le 0.3$	$\alpha \le 0.3, \beta \le 1 \text{ or } \alpha > 0.3, \beta \le 0.3$
$(\alpha,\beta)$ -SMR	$\forall a, \forall \beta$	$\alpha \leq 0.3, \forall \beta$	$\alpha \leq 0.3, \forall \beta$
$(\alpha, \beta, \gamma)$ -SEQ	$\alpha = 0, \forall \beta, \forall \gamma \text{ or }$	$\alpha \leq 0.3, \forall \beta, \forall \gamma \text{ or}$	$\alpha = 0, \forall \beta, \forall \gamma \text{ or } \alpha \leq 0.3, \forall \beta, \gamma \leq 0.7 \text{ or}$
	$\alpha > 0, \forall \beta, \gamma \leq 0.7$	$\alpha > 0.3, \beta \leq 0.3, \forall \gamma$	$\alpha > 0.3, \beta \le 0.3, \gamma \le 0.7$

Table 5: Stochastic Stability for State (P, U)

	Stable for E	Stable for D	Stable
$\alpha$ -Nash	$\forall a$	$\alpha \leq 0.7$	$\alpha \le 0.7$
$(\alpha, \beta)$ -GMR	$\forall \alpha, \forall \beta$	$\alpha \leq 0.7, \forall \beta \text{ or } \alpha > 0.7, \beta \leq 0.7$	$\alpha \leq 0.7, \forall \beta \text{ or } \alpha > 0.7, \beta \leq 0.7$
$(\alpha, \beta)$ -SMR	$\forall \alpha, \forall \beta$	$\alpha \leq 0.7, \forall \beta$	$\alpha \leq 0.7, \forall \beta$
$(\alpha, \beta, \gamma)$ -SEQ	$\forall \alpha, \forall \beta, \forall \gamma$	$\alpha \leq 0.7, \forall \beta, \forall \gamma \text{ or } \alpha > 0.7, \beta \leq 0.7, \gamma = 0$	$\alpha \leq 0.7, \forall \beta, \forall \gamma \text{ or } \alpha > 0.7, \beta \leq 0.7, \gamma = 0$

Table 6: Stochastic Stability for State (R, U)

-	Stable for E	Stable for D	Stable
a–Nash	$\alpha = 0$	$\alpha \leq 0.7$	$\alpha = 0$
$(\alpha, \beta)$ -GMR	$\alpha = 0, \forall \beta \text{ or } \alpha > 0, \beta = 0$	$\alpha \leq 0.7, \forall \beta \text{ or } \alpha > 0.7, \beta \leq 0.7$	$\alpha = 0, \forall \beta \text{ or } \forall \alpha, \beta = 0$
$(\alpha,\beta)$ -SMR	$\alpha = 0, \forall \beta$	$\alpha \leq 0.7, \forall \beta$	$\alpha = 0, \forall \beta$
$(\alpha, \beta, \gamma)$ -SEQ	$\alpha = 0, \forall \beta, \forall \gamma \text{ or}$	$\alpha \leq 0.7, \forall \beta, \forall \gamma \text{ or}$	$\alpha = 0, \forall \beta, \forall \gamma \text{ or }$
	$\alpha > 0, \beta = 0, \gamma \le 0.3$	$\alpha > 0.7, \beta \leq 0.7, \forall \gamma$	$\forall \alpha, \beta = 0, \gamma \leq 0.3$

# Conclusion

The stability concepts of GMCR model have been extended to incorporate the extra information included in the stochastic preference structure introduced in the model. Such stochastic preference may be interpreted as some kind of intensity preference.

In this work we presented some results relating such extended stability concepts, showing that essentially the same implications valid among the standard solution concepts remain valid with appropriate modifications in the present model. Other results were added to show some implications that occur when considering different parameters for the same stability concept.

An application of the model was made to a hypothetical conflict situation illustrating how to determine the parameters for which the states are stable according to the proposed solution concepts and also how useful is the addition of stochastic preferences in GMCR models to capture more real-world situations.

Acknowledgements: The authors would like to thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPQ) and the Funda cão de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE) for financial support.

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# Added value of professional mediation in electronic conflict resolution processes

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**Abstract**: Conflicts between dispersed parties are increasingly handled online. Despite the potential of assisted conflict resolution approaches, parties commonly try to resolve conflicts on their own regardless of the complexity and intensity of the conflict. We study the impact of professional mediators interacting with the parties at dispute via an online mediation support system in comparison to traditional online communication on the conflict resolution process. Results of our laboratory experiment indicate that professional mediators equipped with sophisticated support indeed influence substantial aspects of subjective and objective process and outcome dimensions.

Keywords: Online dispute resolution, conflict resolution approaches, online mediation, online negotiation, experimental comparison.

## Motivation

The increasing volume of e-commerce has resulted in a higher number of conflicts rooted in the virtual world. Conflicts based on these or real world transactions are often also handled online. So-called online dispute resolution (ODR) services aim to resolve these conflicts using, for example, e-mail communication, support forums and platforms, community boards etc. These services are conducted synchronously or asynchronously. The latter are typically based on electronic text-based information exchange between the actors, e.g. forums where providers of products and/or services exchange information with their clients or exchange information via e-mails. Consequently, online communication is a prevalent and widely accepted form of conflict resolution processes.

However, these support services focus on simple conflicts in general not characterized by sacred issues at stake or high emotional involvement of actors. Indeed, these impoverished communication media are described as inadequate to handle complex conflicts resulting in lower levels of trust in the process or even escalate the conflict and therefore impede its settlement (Nadler, 2001; Friedman and Currall 2003). Consequently, the use of mediators as one approach of ODR has been proposed to handle the changed characteristics of the online environment and the increasing level of conflict (Nadler 2001). Mediation enables parties at conflict to de-escalate conflicts, increase their emotional awareness, and induce a more conflict resolution oriented behavior (Wall et al. 2001).

Nevertheless, human mediators interacting with parties at conflict in an online environment have not yet experienced their foreseen breakthrough. This indicates that the potential benefits of online mediation do not exist or are not realized by the parties at conflict, probably because they are overshadowed by negative effects of ODR. Possible negative effects might be rooted in the neglected usefulness of the human mediators (Turel et al. 2007). Therefore, we investigate in this paper the value added by professional human mediation assisting parties at conflict in a virtual environment compared to traditional electronic text-based communication.

# **Online Mediation**

Mediation is a conflict resolution approach consisting of three defining elements (i) the assistance of (ii) a neutral third party that (iii) does not have sufficient power to impose an outcome (Wall et al. 2001). The mediation process can be structured into five phases guiding the parties at conflict from a situation characterized inter alia by emotional stalemates to mutually satisfying agreements (Kressel and Pruitt 1989).

Online mediation is defined and implemented as (partial) support of the conflict resolution process either as human mediators communicating via electronic media with the parties at dispute or as an automated component substituting tasks traditionally performed by human mediators (Druckman et al. 2010). Prior research has shown that automated mediation can indeed enrich face-to-face mediations when applied for specific phases only of the process (Druckman et al. 2004). However, in conflicts fully carried out over online media, automated mediation only partly exploits its full potential (Gettinger et al. 2012). Indeed, it is questionable whether purely automated mediation is actually able to provide full support for parties in conflicts with high issues at stake or high emotional involvement. These conflicts based on intangible aspects are best resolved by human mediators (Bercovitch and Jackson 2001), due to their ability to acknowledge emotions of the parties, create mutual understanding between the parties and encourage self-determining behavior (Picard 2002). Services connecting human mediators with the parties at dispute via electronic means need to resolve the challenges of creating the individually needed level of trust and justice (Turel et al. 2008). Indeed, in asynchronous divorce mediations both parties perceived process and outcome aspects equally just (Gramatikov and Klaming 2011).

# **Empirical Study**

To answer our research questions concerning the value added by human mediation assisting parties at conflict during their virtual resolution process compared to traditional electronic text-based communication, we have conducted a laboratory experiment. We recruited 116 participants for the present study from the University of Hohenheim (Germany) as well as volunteers (all of them with academic background) via social media. Recent students followed a negotiation course where they received theoretical insights into mediation. Similarly, also the volunteers received a theoretical lecture about conflict resolution approaches. This was done in order to ensure that all participants had a general understanding of conflict resolution on a theoretical level. Furthermore, we recruited 11 professional mediators with a proper education and practical mediation experience of at least one year.

The case represents a conflict between two members of a student organization. We chose an intraorganizational conflict within a student organization in order to ensure contextual relevance, i.e. all participants could understand and relate to the context of the conflict (Teich et al. 2000). The nature of the conflict is based on different (objective) interests as well as different (subjective) perceptions of issues and the conflict history. The conflict history described in the case represents an emotional case that has already escalated.

Participants were assigned to either of two treatments reflecting our research question. In treatment I parties engaged in a bilateral conflict resolution process via an online platform. The platform enabled users to exchange text-based messages asynchronously in an alternating manner. In treatment II, the conflict resolution process between the parties was assisted by a professional mediator and conducted through an online system. The mediation process followed the five phase model by Kressel and Pruitt (1989) operatively implemented in the system. The communication process was also asynchronously and text-based but managed by the mediator.

Before starting the conflict resolution process, all participants received a theoretical lecture about the webplatform. The professional mediators received a theoretical and practical introduction into the online platform. Furthermore they received test-logins to familiarize with the system. Four days before the start of the experiment, participants representing the parties at conflict received the case study. According to the role of the parties, different pre-questionnaires were sent to the participants two days later. Log-ins were sent out at the day of the start of the experiment. The parties had at max. 18 days to resolve the conflict. However, they were free to leave the virtual bargaining table at any time. After the experiments, parties and mediators were asked to answer a post-questionnaire, again adopted due to their roles in the case.

Our ongoing analysis of the value added by professional mediation includes subjective as well as objective factors of the conflict resolution process and outcome. Among others we consider individual characteristics of the involved parties, process characteristics, e.g. time and effort needed, and several outcome dimensions, e.g. agreement-rate and satisfaction.

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# Dimensional Analysis Model of Conflict Resolution in Everyday Setting

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**Abstract**: This study explores conflict resolutions by applying grounded theory method to 53 cases of real-life conflict experiences. After careful coding, seven categories are created. A dimensional analysis model for conflict resolutions is proposed. It identifies that "preparation for resolving conflict" is the central phenomenon and analyze how conflict origins, casual condition, contextual condition, intervening condition, resolution strategies and consequences are related to the central phenomenon and the dynamics among themselves.

**Keywords**: qualitative study, grounded theory method, conflict resolution, negotiation, conflict context, dimensional analysis model.

#### Introduction

Conflict is a natural, everyday phenomenon which is one of the most important and indispensible parts of our daily life. It results from "the interaction of interdependent people who perceived incompatible goals and interference from each other in achieving those goals" (Hocker and Wilmot, 1985). Conflict tends to occur in a countless variety of ways and owing to various reasons including personal, contextual, and organizational variables. Hence, conflict resolution is a complex process because it is difficult to discriminate what brings about a conflict situation and what the outcomes could be. Moreover, there are also various factors that might influence the conflict resolution process.

Most people initially believe that conflict is bad or dysfunctional (Lewicki et al., 2010). However, conflict also has many productive aspects, such as strengthen relationships, heighten morale, raise awareness of self and others, personal development, psychological development, etc. (Coser, 1956; Deutsch, 1973). The objective of conflict resolution is not to eliminate conflict but to learn how to resolve it in order to control the destructive elements while enjoying the productive aspects. If not managed properly, conflicts can result in bad feelings, high turnover and costly litigation (Hirschman, 2001). At the most serious levels, conflicts can bring teams, departments and sometimes whole organizations to a virtual standstill (Fritchie and Leary, 1998). On the other hand, when conflict is recognized, acknowledged and managed in proper manner, personal and organizational benefits accrue (Darling and Fogliasso, 1999). The key is not to eliminate conflict but to learn how to resolve it to control the destructive elements while enjoying the productive aspects. Hence, conflict resolution skills are important prerequisites (Brewer et al., 2002; Havenga, 2006) and the ability to resolve conflict is a key ingredient of future success (Hignite et al., 2002).

Most studies for conflict resolution are done with data collected from questionnaires or by asking participants to resolve a made-up conflict. In fact, in the vast majority of conflict studies, participants are instructed to negotiate, and the behavioral tactics they use under controlled experimental conditions are then observed. This is problematic because people may not participate in made-up conflict in the same way as they would do if it happens in their real life. Moreover, lab studies may miss the rich context of real-world negotiation or conflict situations. Given such concerns, this study collected data from the real life conflicts that were actually experienced by the participants in the past and the way they attempted to resolve them and the outcomes reached from such resolutions.

Furthermore, instead of first beginning with a theory and then attempting to prove it, this study uses grounded theory method. It is a study that does not begin with a theory and then attempt to prove it but rather begins with an area of study and allows the theory to emerge (Glaser and Strauss, 1967). Grounded theory has advantages which we could not achieve from experiments because there is a gap between experiments and real life situations. Therefore, we take advantage of grounded theory method in this study and apply it to data on real-life conflict experiences. In particular, the main purpose of this study is to obtain and analyze real-life conflict cases by utilizing grounded theory method in order to study, understand, and conceptualize the complex process of conflict resolution in everyday setting. Hopefully, this study can find

a central phenomenon (i.e., core category) and construct a theory by exploring its relationship around different dimensions of the phenomenon.

# **Conceptual Research Framework**

As above-mentioned, it is problematic to study conflict resolution from questionnaires or controlled experiments. We decided to study it by grounded theory. Glaser and Strauss (1967) claimed that grounded theory method is most appropriate -- where researchers found an interesting phenomenon without explanation and from which they seek to "discover theory from data". However, although Glaser and Strauss (1967) were motivated against grand theory, their formulation of grounded theory was never intended to encourage research that ignored existing empirical knowledge.

Hence, Fig. 1 shows a substantive conceptual framework which is created to provide a stimulus to a "good idea" and give an initial direction in developing relevant categories and properties and in choosing possible modes of integration, so that a grounded formal theory could be generated towards the goal of this research study. The framework in Fig. 1 gave us direction to look at the issue of conflict resolution process from six different aspects based on literature review. However, during the coding stages, we did not limit ourselves within these aspects; sometimes we found something outside these aspects.



Fig. 1: Conceptual Research Framework

Conflict exists everywhere and a classification on the basis of conflict types would assist in analyzing the conflict process (Lewicki et al., 2003). Hence, first, we look at the conflict-resolution process from the perspective of what types of conflicts they are because people value different types of conflicts in different ways, and accordingly, they formulate their approaches and strategies for those conflicts. The way to deal with a relational conflict will be very different from the way to deal with a substantive conflict. Therefore, classification of conflicts based on their levels and key sources helps in understanding a particular conflict.

It is also important to learn about the factors that caused the conflicts. Wall and Callister (1995) grouped main causes of conflict as individual characteristics, interpersonal factors, previous interactions, and issues. Having the knowledge of the antecedent conditions is extremely significant because by knowing the root cause of the conflict origins, the parties involved in the conflict could approach and analyze the conflict accordingly.

Conflict resolution style or strategy refers to specific behavioral patterns that one prefers to employ when addressing conflict situation (Moberg, 2001). It is a systematic plan of action presented by behavioral sequence, and a method used to plan and manage the conflict process (Kersten, 2008). Though there are various kinds of strategies proposed by different research studies, distributive (or competitive) and integrative (or co-operative) strategies are two most dominant strategies in most conflict resolution phenomena (Purdy et al., 2000; Lai et al., 2006).

When parties who are directly involved in the conflict are unable to resolve a conflict, a third-party intervention may help. The involvement of impartial third parties has a long and honorable history in the

domain of human social conflict (Rubin and Issues, 1981; Mitchell and Webb, 1988). Three formal types of third-party intervention are: (1) arbitration, (2) mediation, and (3) process consultation (Lewicki et al., 2010). The goal is to find out that in what situation the parties who are directly involved in the conflict approach a third-party for help.

Many research has revealed that communication behavior influences the decision quality, process or outcome satisfaction, perception of the solution, and so on (Kahai and Cooper, 1999, 2003; Yuan et al., 2003). Communication is a critical aspect of conflict resolution process. On the one hand, it could be the very cause of conflict origins, and on the other hand, it could also the action that parties undertake to resolve the conflict. Our goal is to discover the role of communication in conflict resolution process – to find out what type of impact the communication has on the overall conflict resolution process.

According to Kersten (2008), the outcome types can be categorized into six groups (the six categorizations not necessarily being exclusive): (1) substantive vs. relational outcomes, (2) short-term vs. long-term outcomes, (3) objective vs. subjective outcomes, (4) direct vs. indirect outcomes, (5) expected vs. unexpected outcomes, and (6) own vs. others outcomes. On the one hand, conflict had negative connotations (Cetin and Hacifazlioglu, 2004), but on the other hand, conflict can also bring great benefits. Properly managed, it can be a creative force for the business and the individual, because if we regard differences of opinion as valuable sources of cross-fertilization, they begin to enrich our experience (Bagshaw, 1998) and enhance our quality of decisions (Cosier, 1978; Tjosvold, 1985). Hence, we also focus at the conflict resolution process from the view point of conflict outcomes.

In summary, this conceptual research framework of conflict resolution process would serve us as a stimulus to a "good idea" and give an initial direction in developing relevant categories and properties and in choosing possible modes of integration so that a grounded formal theory could be generated towards the goal of this research study.

# Data Collection and Grounded Theory Analysis

The data were collected from an online conflict-sharing system called Conflict and Communication website (See Fig. 2) which was created for people to share their conflict experience in the daily life. The participants were students of an international MBA program in a university. They attended the "International Negotiation" course and it was a requirement of the course. Fig. 3 shows a snapshot of the conflict-sharing page on the website. Each conflict case is divided into four parts: (1) Conflict Content, (2) Resolution, (3) Conflict Outcome, and (4) Suggestion (where each student chooses another student's conflict case to read and provides her suggestion). However, we only analyzed the first three parts without considering the suggestions of others.

#### Data Collection Process – Theoretical Sampling

As this study uses grounded theory method, we have followed the process of theoretical sampling for data collection. Glaser and Strauss (1967) expect the researchers to collect, code, and analyze data simultaneously. This continuous process of data collection is known as theoretical sampling. We applied it to a data set collected in two different semesters from 70 participants. When we almost reached the 53rd conflict case, we finally came to a point when the data of a new additional conflict case fit the categories already devised and we found no more new categories. This indicated the end of the data-collection process (Charmaz, 2000).



Fig. 2: Webpage of Conflict and Communication (Lai, 2012)



Fig. 3: Conflict-sharing page on the website

The final data sample in the study comprised of 27 male students and 26 female students, which is a good representative of both genders appropriately. In addition, the participants were from 20 different nationalities: Austria, French, USA, Slovakia, Honduras, Dutch, Finnish, Russia, Belgian, Indian, Taiwan, Canada, Mexican, Swedish, German, Czech, Thai, Guatemalan, Puerto Rico, and Zimbabwean. This is a good representative of the broader population. As a result, the conflicts shared by these students covered many varieties such as workplace conflicts, school conflicts, personal conflicts, B2B conflicts, and B2C

conflicts. Therefore, the sample has certain type of representative of each setting. The distributions of each of these types of conflict are shown in Fig. 4.



Fig. 4: Distribution of Conflict Types

#### **Grounded Theory Analysis**

After the collection of data, we started the process of grounded theory analysis. There are two fundamental schools for grounded theory: the Glaserian School and the Straussian School. In this study, we adopted the later methodology, that of "Straussian" (Strauss and Corbin, 1990) because their approach is more efficient in terms of its techniques of conducting the analysis and its rigorousness (Stern, 1994). Straussian grounded theory method typically follows a basic four stage procedure: (1) Transcription, (2) Open Coding, (3) Axial Coding, and (4) Selective Coding (Strauss and Corbin, 1990). As the data collected was already in written form, the analysis process directly began with open coding stage. However, the process of open, axial, and selective coding occur simultaneously through constant comparisons and theoretical sampling until theoretical saturation is reached (Strauss and Corbin, 1990).

Open Coding. Initially, open coding was employed. The open coding process first begins with the unitization stage. Based on the research purpose, we adopted "key point" coding at the unitization stage. According to Strauss and Corbin (1990), open coding "fractures the data and allows one to identify some categories, their properties, and dimensional locations". At this stage, the data was examined without any limitations in its scope and without the application of any filters; thus, all data are accepted and none are excluded. Table 1 provides some exemplary open codes.

Conflict Case	ID 1	No.		Key Points	Concepts
I used to share a flat for my studies with a German guy called $XnX^2$ , but we had	16	1	1	I used to share a flat for my studies with a German guy called XnX,	Personal Setting
We shared the same flat, but we had in commun only the living room, the kitchen	16	1	2	But we had completely incompatible personalities.	Incompatible personalities
and me were never agree about who ould clean the sharing parts of the flat. the living room was really untidy. The munication between us was bad	16	1	3	We shared the same flat, but we had in common only the living room, the kitchen and the bathroom, we both had our own room. XnX and me were never agree about who should clean the sharing parts of the flat.	Conflict of needs
because we didn't speak the same	16	1	4	so the living room was really untidy.	Inconvenience
language at all, XnX was able to speak in German and a bit of spanish, but I only spoke french and english, so the communication was barely existant between us. Furthermore, XnX, invited everyday his best friend Thomas to play videogames until 2 A.M, they were	16	1	5	The communication between us was bad because we didn't speak the same language at all, XnX was able to speak in German and a bit of spanish, but I only spoke french and english, so the communication was barely existent between us.	Communication Barrier
playing in the living room and made a lot of noise, so i couldn't concentrate on my studies. We had only one key for both of us, so it was difficult to go out without the other.	16	1	6	Furthermore, XnX, invited everyday his best friend XoX to play videogames until 2 A.M, they were playing in the living room and made a lot of noise, so i couldn't concentrate on my studies. We had only one key for both of us, so it was difficult to go out without the other.	Inconvenience

Table 1: Exemplary	concepts extracted from	Conflict Case No. 16
		./

**Axial Coding.** This stage helped in grouping similar categories into broader categories and much broader categories by explicitly making connections and identifying relationships between a category and its subcategory via a combination of inductive and deductive thinking. In order to simplify the process, researchers emphasize causal relationships, and fit things into a basic frame of generic relationships as Table 2 (Strauss and Corbin 1990). As a result, the number of units to work with was significantly reduced because all the categories were now put together in a more organized and orderly manner. A summary of relationships between all categories and their subcategories are provided in Table 3.

<sup>&</sup>lt;sup>2</sup> In order to protect the involved entities' privacy, their names will be displayed with one letter only in the whole paper.

Relations	Descriptions
Causal conditions	These are the events or variables that lead to the occurrence or development of the phenomenon. They are a set of causes and their properties.
Intervening conditions	They shape, facilitate, or constrain the strategies that take place within a specific context.
Contextual conditions	They are the specific locations (values) of background variables; a set of conditions influencing the action/strategy. Researchers often make a quaint distinction between active variables (causes) and background variables (context). It has more to do with what the researcher finds interesting (causes) and less interesting (context) than with distinctions out in nature.
Phenomena	It is the central idea, event, or happening, or incident. This is what in schema theory might be called the name of the schema or frame. It is the concept that holds the bits together.
Strategies	The purposeful, goal-oriented activities that agents perform in response to the phenomenon and intervening conditions.
Consequences	Outcomes or results of the action, resulting from the strategies.

	<b>e 2:</b> The frame of generic relationships and their descrip.	cripti	desci	their	and	ships	ations	re?	generic	0ţ ;	frame	1 he	ble 2:	1
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Source: Strauss and Corbin (1990)

**Selective Coding.** Selective coding is the integrative process of "selecting the core category, systematically relating it to other categories, validating those relationships (by searching for confirming and disconfirming examples), and filling in categories that need further refinement and development" (Strauss and Corbin, 1990). The criteria for core status are (a) frequency of a category's occurrence in the data, (b) a category's centrality in relation to other categories, (c) its inclusiveness and the ease with which it relates to other categories, and (d) its allowance for maximum variation in terms of dimensions, properties, conditions, consequences, and strategies (Glaser, 1978; Strauss and Corbin, 1990; Morrow and Smith, 1995). To validate how the core category fulfills all the four criteria of a core category status, we adopted the dimensional analysis model, proposed by Strauss and Corbin (1990), which differentiates categories into conditions (contextual, causal, and intervening), phenomena, strategies, and consequences. Table 3 below shows this frame of generic relationships with their descriptions, and the basic features of this model are depicted in Fig. 5.

No.	List of Categories	Fq. <sup>3</sup>	No.	List of Categories	Fq.
1	Settings	55	5.2	Gather Information	30
1.1	General Background Details <sup>4</sup>	XX	5.3	Search for Alternatives	29
1.2	Personal Settings	23	5.4	Prioritize the needs	19
1.2.1	Friends	7	6	Values	52
1.2.2	Family members	5	6.1	Relationship Interests	16
1.2.3	Roommates	3	6.2	Substantive Interests	23
1.2.4	Couples	3	6.3	Concern for Resolving the Conflict	13
1.2.5	Strangers	2	7	Third-Party Intervention	10
1.2.6	Neighbors	1	7.1	Authority	5
1.2.7	Tenant vs. Landlord	2	7.2	Mediator	5
1.3	Workplace Setting	16	8	Low Bargaining Power	9
1.3.1	Employee vs. Supervisor	10	9	Less Confidence	3

Table 3: Summary of Relationships between All Categories and Their Subcategories

<sup>&</sup>lt;sup>3</sup> Fq. stands for frequency of occurrences of the categories in the data

<sup>&</sup>lt;sup>4</sup> The frequency of occurrence (fq.) of this category is not considered because it contains irrelevant information which is insignificant to the overall general phenomena being studied.

1.3.2       Intergroup       3       10       Lack of Trust         1.3.3       Intergroup       2       11       Risk Factor         1.3.4       Intragroup       1       12       Institutional Dynamics         1.4       School Setting       7       13       Unfamiliarity with negotiation proc         1.4.1       Intragroup       6       14       Use Threat         1.4.2       Student & Advisor       1       16       Strategies         1.5       B2C Setting       5       16.1       Collaborate         1.6.1       Intergroup       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Inconvenience       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences			10			1 2 2
1.3.3       Intergroup       2       11       Risk Factor         1.3.4       Intragroup       1       12       Institutional Dynamics         1.4       School Setting       7       13       Unfamiliarity with negotiation proc         1.4.1       Intragroup       6       14       Use Threat         1.4.2       Student & Advisor       1       16       Strategies         1.5       B2C Setting       5       16.1       Collaborate         1.6       B2B Setting       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences         2.7       Unfair Treatment       16       18.1.3       Relational Outcome </td <td>9</td> <td>Lack of Trust</td> <td>10</td> <td>3</td> <td>Internee vs. Supervisor</td> <td>1.3.2</td>	9	Lack of Trust	10	3	Internee vs. Supervisor	1.3.2
1.3.4       Intragroup       1       12       Institutional Dynamics         1.4       School Setting       7       13       Unfamiliarity with negotiation proc         1.4.1       Intragroup       6       14       Use Threat         1.4.2       Student & Advisor       1       16       Strategies         1.5       B2C Setting       5       16.1       Collaborate         1.6.1       Intergroup       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1.1       Unsepticed Positive Effects         3       Main Conflict       91       18.1.2       Positive Co	6	Risk Factor	11	2	Intergroup	1.3.3
1.4       School Setting       7       13       Unfamiliarity with negotiation proc         1.4.1       Intragroup       6       14       Use Threat         1.4.2       Student & Advisor       1       16       Strategies         1.5       B2C Setting       5       16.1       Collaborate         1.6       B2B Setting       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences         2.7       Unfair Treatment       16       18.1.3       Relational Outcome         3.1       Different Needs       39       18.1.5       Solved Outc	3	Institutional Dynamics	12	1	Intragroup	1.3.4
1.4.1       Intragroup       6       14       Use Threat         1.4.2       Student & Advisor       1       16       Strategies         1.5       B2C Setting       5       16.1       Collaborate         1.6       B2B Setting       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences         2.7       Unfair Treatment       16       18.1.1       Unexpected Positive Effects         3       Main Conflict       91       18.1.2       Positive Consequences         3.1       Different Needs       39       18.1.3       Relational Outcome         3.2       Negative Emotions       42       18.1.4	ss 3	Unfamiliarity with negotiation process	13	7	School Setting	1.4
1.4.2       Student & Advisor       1       16       Strategies         1.5       B2C Setting       5       16.1       Collaborate         1.6       B2B Setting       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Unexpected Positive Effects         3       Main Conflict       91       18.1.2       Positive Consequences         3.1       Different Needs       39       18.1.3       Relational Outcome         3.2       Negative Emotions       42       18.1.4       Personal Development         3.3       Split-up Relationship       10       18.1.5	4	Use Threat	14	6	Intragroup	1.4.1
1.5       B2C Setting       5       16.1       Collaborate         1.6       B2B Setting       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences         2.7       Unfair Treatment       16       18.1.1       Unexpected Positive Effects         3       Main Conflict       91       18.1.2       Positive Feelings         3.1       Different Needs       39       18.1.3       Relational Outcome         3.2       Negative Emotions       42       18.1.4       Personal Development         3.3       Split-up Relationship       10       18.1.	76	Strategies	16	1	Student & Advisor	1.4.2
1.6       B2B Setting       4       16.2       Compete         1.6.1       Intergroup       4       16.3       Avoid         2       Conflict Origins       103       16.4       Compromise         2.1       Communication Gap       22       17       Communication Effect         2.2       Misperception       7       17.1       Confrontation         2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences         2.7       Unfair Treatment       16       18.1.1       Unexpected Positive Effects         3       Main Conflict       91       18.1.2       Positive Feelings         3.1       Different Needs       39       18.1.3       Relational Outcome         3.2       Negative Emotions       42       18.1.5       Solved Outcome         4       Personality Effects       78       18.1.6       Substantive Outcome         4.1.1       Principal Entity's Cooperativeness       <	21	Collaborate	16.1	5	B2C Setting	1.5
1.6.1Intergroup416.3Avoid2Conflict Origins10316.4Compromise2.1Communication Gap2217Communication Effect2.2Misperception717.1Confrontation2.3Incompatible Personalities417.2Discussion2.4Unmet Expectation2417.3Communication Avoidance2.5Unclear Job Boundaries318Outcomes2.6Inconvenience2418.1Positive Consequences2.7Unfair Treatment1618.1.1Unexpected Positive Effects3Main Conflict9118.1.2Positive Feelings3.1Different Needs3918.1.3Relational Outcome3.2Negative Emotions4218.1.4Personal Development3.3Split-up Relationship1018.1.5Solved Outcome4Personality Effects7818.1.6Substantive Outcome4.1.1Principal Entity's Cooperativeness918.1.8Integrative Outcome4.1.2Principal Entity's Assertiveness1418.2Negative Consequences4.1.3Principal Entity's Non-Egocentricism618.2.1Unsolved Outcome4.1.4Principal Entity's Non-Egocentricism1318.2.2Negative Feelings'4.2.2Opponent's Personality Effect3518.2.3Split-up Relationship4.2.1Opponent's Personality Effect3518.2.3Split-up Relatio	17	Compete	16.2	4	B2B Setting	1.6
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2.3       Incompatible Personalities       4       17.2       Discussion         2.4       Unmet Expectation       24       17.3       Communication Avoidance         2.5       Unclear Job Boundaries       3       18       Outcomes         2.6       Inconvenience       24       18.1       Positive Consequences         2.7       Unfair Treatment       16       18.1.1       Unexpected Positive Effects         3       Main Conflict       91       18.1.2       Positive Feelings         3.1       Different Needs       39       18.1.3       Relational Outcome         3.2       Negative Emotions       42       18.1.4       Personal Development         3.3       Split-up Relationship       10       18.1.5       Solved Outcome         4.1       Principal Entity's Personality Effect       42       18.1.7       Distributive Outcome         4.1.1       Principal Entity's Cooperativeness       9       18.1.8       Integrative Outcome         4.1.2       Principal Entity's Assertiveness       14       18.2       Negative Consequences         4.1.3       Principal Entity's Non-Egocentricism       6       18.2.1       Unsolved Outcome         4.1.4       Principal Entity's Non-Egocentricism	13	Confrontation	17.1	7	Misperception	2.2
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4.1Principal Entity's Personality Effect4218.1.7Distributive Outcome4.1.1Principal Entity's Cooperativeness918.1.8Integrative Outcome4.1.2Principal Entity's Assertiveness1418.2Negative Consequences4.1.3Principal Entity's Egocentricism618.2.1Unsolved Outcome4.1.4Principal Entity's Non-Egocentricism1318.2.2Negative Feelings <sup>5</sup> 4.2Opponent's Personality Effect3518.2.3Split-up Relationship4.2.1Opponent's Cooperativeness218.3Lesson Learned4.2.2Opponent's Assertiveness2818.3.1Importance of Preparation4.2.3Opponent's Egocentricism518.3.2Importance of Communication	13	Substantive Outcome	18.1.6	78	Personality Effects	4
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4.1.4Principal Entity's Non-Egocentricism1318.2.2Negative Feelings <sup>5</sup> 4.2Opponent's Personality Effect3518.2.3Split-up Relationship4.2.1Opponent's Cooperativeness218.3Lesson Learned4.2.2Opponent's Assertiveness2818.3.1Importance of Preparation4.2.3Opponent's Egocentricism518.3.2Importance of Communication	11	Unsolved Outcome	18.2.1	6	Principal Entity's Egocentricism	4.1.3
4.2Opponent's Personality Effect3518.2.3Split-up Relationship4.2.1Opponent's Cooperativeness218.3Lesson Learned4.2.2Opponent's Assertiveness2818.3.1Importance of Preparation4.2.3Opponent's Egocentricism518.3.2Importance of Communication	20	Negative Feelings <sup>5</sup>	18.2.2	13	Principal Entity's Non-Egocentricism	4.1.4
4.2.1       Opponent's Cooperativeness       2       18.3       Lesson Learned         4.2.2       Opponent's Assertiveness       28       18.3.1       Importance of Preparation         4.2.3       Opponent's Egocentricism       5       18.3.2       Importance of Communication	18	Split-up Relationship	18.2.3	35	Opponent's Personality Effect	4.2
4.2.2       Opponent's Assertiveness       28       18.3.1       Importance of Preparation         4.2.3       Opponent's Egocentricism       5       18.3.2       Importance of Communication	26	Lesson Learned	18.3	2	Opponent's Cooperativeness	4.2.1
4.2.3     Opponent's Egocentricism     5     18.3.2     Importance of Communication	8	Importance of Preparation	18.3.1	28	Opponent's Assertiveness	4.2.2
	9	Importance of Communication	18.3.2	5	Opponent's Egocentricism	4.2.3
5         Preparation for Resolving Conflict         138         18.3.3         Importance of Persistence	3	Importance of Persistence	18.3.3	138	Preparation for Resolving Conflict	5
5.1     Examine the Situation     60     18.3.4     Other Importance	1		1834	60	Examine the Situation	51

<sup>&</sup>lt;sup>5</sup> The category *Negative Feelings* is what people felt after the outcome attained, while the category *Negative Emotions* are the negative feelings people felt in the conflict.



Fig. 5: Basic Features of a Dimensional Analysis Model.

Following the process of grounded theory analysis, we made a minor change to the dimensional analysis model of Strauss and Corbin (1990). Our findings show that causal conditions are main conflicts (such as negative emotions, different needs, and split-up relationship) that occurred and caused the central phenomenon (or core category) which is preparation for resolving conflicts to happen. Further, during the analysis, another active variable was found (titled 'conflict origins') which resulted in the main conflict (this made the causal conditions in the model to function as a mediator variable). Therefore, we made a minor change to the dimensional analysis model by adding a new construct called "conflict origins" before the causal conditions to show that it is the reason why the causal conditions has occurred. Fig. 6 shows the modified dimensional analysis model with Preparation for Resolving Conflict as the central phenomenon because it fulfills all the four criteria of a core status criteria mentioned by Glaser (1978) (Strauss and Corbin, 1990; Morrow and Smith, 1995). That is, it has maximum frequency of occurrence in the data; it has centrality in relation to other categories; it has inclusiveness and it is related to other categories with ease; and finally, it has allowance for maximum variation in terms of dimensions, properties, conditions, consequences, and strategies.



Fig. 6: Preparation for resolving conflict as central phenomenon in modified dimensional analysis model.

Regarding the analysis reliability, the Guetzkow's U is suggested by Srnka and Koeszegi (2007) for measuring the reliability of the number of units identified by two independent coders by using the equation: U=(O1-O2) / (O1+O2). In the equation, the O1 and O2 means the total numbers of units divided by coder 1 and coder 2 separately. Folger et al. (1984) describe scores below .10 on this index as "quite low," indicating acceptable unitizing reliability. The lesser U value reflects the higher reliability between two coders. After the first run, disagreements about unitizing were resolved through further discussion between the two coders by established precise rules for unitizing the text elements. Hence, in the second round, Guetzkow's U = 0.006 was much better. Complete agreement on unitization was reached through discussion and agreement among the coders. Finally, the 53 conflict cases were divided into 981 units.

# Dimensional Analysis Model for Conflict Resolutions in Everyday Setting

In this section, we will describe the resulted in dimension analysis model for conflict resolution in everyday setting. Then, discuss the relationships among every category by giving some examples.

#### **Description of the Model**

After identifying the preparation for resolving conflict as the core category, the final dimensional analysis model is shown in Fig. 7. It constructs a theory by illustrating a detailed picture of conflict resolutions in everyday setting. Firstly, the conflict origins are the reasons or explanations for the main conflicts to occur, and the causal conditions are the events or variables that lead to the occurrence or development of the core category (or central phenomenon). Therefore, the causal conditions are the main conflicts, and they are the mediator variables between conflict origin and the core category.

Next, the model shows that causal conditions such as negative emotions, different needs, and split-up relationships were actually the real conflicts that were experienced by the participants and were mentioned by them in the data. Since the occurrences of these conflicts are the reasons why the core category, preparation for resolving conflict, has emerged: to make necessary and good preparations by the participants for resolving those conflicts. Hence, the these three categories – negative emotions, different needs, and split-up relationships – qualified as the causal conditions because they are followed by the core category: preparation for resolving conflict, which is the central phenomenon.

After that, the model shows that preparation for resolving conflicts is the main phenomenon which is the act of good and effective preparation by participants for the purpose of resolving the conflicts. More specifically, the core category refers to the initial steps that the participants usually undertake at the beginning or initiation phase of conflict resolutions by thinking and making necessary preparations ahead on how to work on resolving the conflict. It was found that there are actually four key preparation methods that were most often utilized by the participants for resolving their conflicts. They are: (1) examine the situation, (2) gather information, (3) prioritize the needs, and (4) search for alternatives.

Moreover, the model illustrates that contextual conditions include: (a) personal settings, (b) workplace settings, (c) school settings, (d) B2B settings, and (e) B2C settings. These different settings, in which the core category is developed, influence the strategies that are devised because people in different settings are driven by different considerations and interests.

Furthermore, in addition to contexts, there were also intervening conditions, which were broad, general conditions that influenced participants' choices of conflict resolution strategies by shaping, facilitating, or constraining them (Strauss and Corbin, 1990). Such Intervening conditions included (a) personality effect, (b) values, (c) communication effect, (d) low bargaining power, (e) lack of trust, (f) third-party intervention, and (g) other factors (such as risk factors, less confidence, institutional dynamics, unfamiliarity with negotiation process, and use threat). Next, the model shows that in the presence of the context and intervening conditions described above, the overarching central phenomenon of preparation for resolving conflict led to development of four core strategies for resolving conflicts: (a) collaborate, (b) compromise, (c) compete, and (d) avoid.



Fig. 7: Dimensional analysis model for conflict resolutions in everyday setting

Finally, the findings show that the types of consequences were broadly divided into positive and negative consequences. Positive consequences were solved outcome, positive feelings, relational outcome, substantive outcome, distributive outcome, integrative outcome, personal development, and unexpected positive effects. Negative consequences were unsolved outcome, negative feelings, and split-up relationship. The findings show that there is a relationship between the core category and consequences. In most cases, the participants mentioned that they failed in resolving the conflicts or realizing their needs because of lack of proper preparation in the initial phase of conflict resolutions. Hence, the core category preparation for resolving conflicts plays an important role. A good preparation can play in reaching favorable or unfavorable consequences.

# **Relationships among Main Categories**

**Relationships between Conflict Origins, Causal Conditions, and Central Phenomenon.** In the model in Fig.7, the conflict origins are the reasons or explanations for the main conflicts to occur, and the causal conditions are the events or variables that lead to the occurrence or development of the central phenomenon (or core category). Therefore, the causal conditions are the main conflicts, and they are the mediator variables between conflict origin and the core category. For example, XaX bought a pair of expensive shoes. However, he said:

"On my way back home, the shoes became too painful for my feet and the right pair even cut the back of my feet."

Hence, he took it back to the shoe store and asked the salesperson to take back the shoes because it was too painful for his feet and he could not wear them anymore. However, the salesperson refused to do so. As a result, the main conflict of different needs (causal conditions) occurred between XaX and the salesperson due to the factor of unmet expectation (conflict origin). This led XaX to make preparations for resolving conflicts. He prepared for it by examining the situation:

"I think it is very important to know the cultures and values of a place and the people who reside there. If the same situation has occurred in India or China, I would have been more aggressive in my negotiation style and showed some frustration which usually work quite well in those countries. However, this situation occurred in Taiwan. And based on my own personal observance, I got the impression that Taiwanese are actually very friendly and reasonable person who are usually nice to foreigners." Hence, the relationship between conflict origins, causal conditions, and central phenomenon, as shown in the model in Fig.7, are supported because the findings support that the conflict origins are the reasons or explanations for the main conflicts to occur, and the causal conditions are the events or variables that lead to the occurrence or development of the core category. Therefore, the causal conditions are the main conflicts, and they are the mediator variables between conflict origin and the core category.

**Relationship between Central Phenomenon and Strategies.** The model in Fig.7 shows that the core category, preparation for resolving conflicts, leads to the development of the strategies. The findings in our study support this relationship. For instance, when XdX did some preparation of examining the situation, he noticed that his opponent was: "an older woman who looked as though she could not afford to pay any compensation". As a result, he decided to use a collaborating strategy instead of competing with his opponent. On the contrary, XeX took a competing strategy with his opponent (the airline company) after examining the situation he was in and realizing that he has a higher bargaining power as a customer:

"I felt that I, as a customer, was in a stronger bargaining position since it was them who eventually made the mistake that led to the conflict." / "I thought that they would rather have a happy customer than "winning" the conflict.."

In summary, we can say that the relationship between the central phenomenon and strategies is supported because the findings shows that the core category, preparation for resolving conflicts, indeed leads to the development of strategies.

**Relationships between Contextual Conditions, Intervening Conditions, and Strategies.** The model in Fig.7 shows that in the presence of the context and intervening conditions, the overarching central phenomenon of preparation for resolving conflict leads to development of four core strategies: (a) collaborate, (b) compromise, (c) compete, and (d) avoid. In the following, we will verify how the contextual conditions and intervening conditions will lead to these four strategies by examples.

*Contextual Conditions.* Contextual conditions are the specific locations (values) of background variables. Fig.8 shows the relationships between the contextual conditions and the strategies. It demonstrates that contextual conditions are a set of conditions influencing the strategies that were devised through preparation for resolving conflicts because people in different settings are driven by different considerations and interests. Fig. 8 indicates, in personal setting, the entities involved often utilize compromising or avoiding strategy to resolve the conflict. The entities involved in a workplace setting also mostly use compromising strategy, while the entities involved in B2C or B2B settings mostly use either collaborating or competing strategy.



Fig. 8. The relationship between strategies and contextual conditions

*Intervening Conditions.* Intervening conditions shown in Fig. 5 are broad, general conditions that influence the participants' choices of strategies by shaping, facilitating, or constraining them. The findings support this. For instance, when XXy tried to take a collaborative approach in order to resolve the misunderstanding between him and his friend, he failed in resolving his conflict because his opponent would not reply his phone call or his text messages. Hence, although he made good preparations by examining the situation well

and came up with a good strategy, however, because of communication avoidance (a subcategory of communication effect), he failed in fulfilling his strategies and resolve his conflict:

"I tried to call him 3 times. XcX did not answer his phone. That is why I send a text message explaining that I did not mean to be rude for leaving him or to insult him. I did not receive anything in return" / "During night I left him alone and we did not talk." / "After this event we did not really communicate with each other anymore. I felt that I have put effort in restoring the relationship, so I gave up and accepted the fact."

Hence, the findings support that the core category, preparation for resolving conflicts, leads to the development of strategies; however, intervening conditions could influence the participants' choices of strategies by shaping, facilitating, or constraining them, as shown in the model in Fig.7.

**Relationship between Strategies and Consequences.** The findings displayed in Fig. 9 support that the consequences are resulting from the adopted strategies as the relationship shown in Fig. 7. Fig. 9 indicates that collaborative strategy mostly results in positive outcomes. Compared with compete strategy, compromise strategy still achieves more positive outcome.



Fig. 9: The relationship between strategies and outcomes

## Conclusions

This qualitative study explored conflict resolutions in everyday setting by applying grounded theory method to data on real-life conflict experiences. The grounded theory method has advantages which we could not achieve from lab experiments due to the gap that exists between experiments and real life situations. Through the implementation of Strauss and Corbin (1990)'s open, axial, and selective coding procedures, we found seven categories. By applying a dimensional analysis model, we not only identified that "preparation for resolving conflict" is the central phenomenon but also explored how conflict origins, casual condition, contextual condition, intervening condition, resolution strategies and consequences are related to the central phenomenon and the dynamics among themselves. This helped in developing a grounded formal theory that provide a detailed picture of the complex process of conflict resolution in everyday setting by covering its origins, dynamics, resolution strategies, consequences, and effects in different contexts.

This study made certain significant contributions to the conflict resolution literature in a number of ways. First of all, one of the important contributions of this research is the data. This study obtained data from the real life conflicts that were actually experienced by the participants in the past and the way they attempted to resolve them and the outcomes reached by such resolutions. Another significant contribution is the use of grounded theory method in understanding conflict resolution process. The beauty of this type of research is that grounded theory could provide a detailed picture of the entire process by incorporating the complexities of the conflict resolution process under investigation without discarding, ignoring, or assuming away relevant variables. Finally, we also modified the dimensional analysis model of Strauss and Corbin (1990) by adding a new construct called "conflict origins" before the causal conditions to show that it is the reason why the causal conditions have occurred.

Acknowledgments. The authors would like to acknowledge the research grant supported by the "Aim for the Top University Plan" of National Sun Yat-sen University and the Ministry of Education, Taiwan.

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# The Optimum Coalition under the Matching Mechanism in Climate Change Negotiations

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**Abstract**: This paper aims to apply a game theoretic matching mechanism to the international climate change negotiations. A numerical analysis has been carried out in order to examine whether the mechanism helps to overcome the free-riding problem without a central authority. The analysis demonstrates that the mechanism enables all the major emitting countries to choose more ambitious reduction targets by 2.4-13.5 times compared to the case without the mechanism. It also finds that the total reduction and payoff will increase along with the number of coalition members up to nine countries or regions.

Keywords: game theory, climate change, international negotiation, matching, free riding.

# Introduction

Recent studies show that aggregated emission reduction pledges by countries under the Conference of Parties of United Nations Framework Convention on Climate Change (UNFCCC) do not reach the level required for limiting a temperature increase by two degree Celsius compared to the pre-industrial level (UNEP, 2012). The fundamental problem of climate change negotiations lies in the free-riding issue. In addition, the international governance systems have no enforceable authority which can allocate an optimal reduction level to each country. The past experience on UNFCCC negotiation indicates that it is generally difficult to have an agreement to ambitious reduction targets.

Recently, a number of studies have proposed mechanisms for implementing efficient contributions by countries to international public goods. In particular, Guttman (1987) has proposed a mechanism which addresses the free riding problem without an authority. Based on Guttman's mechanism, this research aims to develop a matching mechanism and apply it to the international climate change negotiations in order to demonstrate that the mechanism can raise countries' pledges towards the required reduction. The previous paper evaluates and compares the results of only a six country case using different matching mechanisms with empirically relevant specifications and asymmetric players (Kawamata and Horita, 2012). This paper expands the analysis to all the combination from two country coalitions to a global coalition (total 4,083 cases) in order to find an optimum coalition and draw preliminary implications in consideration of the reality of the climate change negotiations.

# Model

Guttman shows that matching mechanism can realize Pareto-optimal outcome. His mechanism consists of two stages. In the first stage, players announce rates at which they will match the contributions of other players. In the second stage, given the announced matching rates, players choose their own contributions. Danziger and Schnytzer (1991) have further proved that the mechanism could be generalized to any number of players.

The matching mechanism necessitates the information on costs and benefits related to greenhouse gas reductions. Based on the STACO model developed by the Wageningen University team (Nagashima, 2010), the authors set the simplified functions for marginal abatement costs and marginal benefits from the abatement. The model's horizon is set at 100 years, ranging from 2011 to 2110, long enough to assess the benefits from abatement. The STACO model captures the net present value of the stream of payoffs generated between 2011 and 2110. It considers twelve world regions; USA, Japan (JPN), the European Union -15 (EU15), other OECD countries (OOE), Eastern European countries (EET), former Soviet Union (FSU), energy exporting countries (EEX), China (CHN), India (IND), dynamic Asian economies (DAE), Brazil (BRA) and rest of the world (ROW). This paper analyzes 4,083 cases which are all the combination for the matching from two country cases to twelve country cases. Numeric analysis has been conducted by using Guttman's equations with STACO model's assumptions and parameters.
# Preliminary results and conclusion

Results of the numeric analysis show that the matching mechanism enables the countries to choose more ambitious reduction targets and leads to Pareto superior outcomes. Different total reduction levels for each coalition member as well as the total additional payoffs are observed between different numbers of coalition cases (Table 1). The maximum total reduction and the players' total payoff will increase along with the number of coalition members up to nine countries. A nine country coalition records the maximum reduction among all 4,083 coalitions. All the maximum reduction case in each number of coalition cases includes larger emitting countries. As the number of countries increases, an amount of the total reduction also increases. For example, the coalition that produces the maximum reduction with eight countries consists of Japan and other seven countries. Whereas Japan's own reduction amounts only to 8.8 Giga tons (Gt) in this case of eight countries' coalition, the total reduction increase by 13.4 Gt compared to the case of the other seven's coalition. It means expanding coalition members derives more total reduction than the additional country would itself contribute. However, expanding the coalition does not increase total reduction amount in nine country coalition case or more. The ratio of achieving the solution in the calculation of the matching mechanism also decreased in cases with more than nine countries. In the actual negotiations, it is also more difficult to reach an agreement with an overly large number of countries involved. For instance, the two degree target was agreed in UNFCCC, which consisted of almost 200 countries, only after it was agreed among G8 countries. As Guttman shows that feasibility of matching behaviors decreases with group size, it is both theoretically and practically advantageous to limit the number of countries.

Number of coalition	Number of cases	Cases for plus	Ratio	Maximum additional reduction (Gt)	Maximum additional payoff (billion US\$)	Coalition of maximum case										
2	66	18	27%	18	666	USA	CHN									
3	220	67	30%	37	1270	USA	EU15	CHN								
4	495	117	24%	53	1782	USA	EU15	CHN	IND							
5	792	292	37%	71	2348	USA	EU15	FSU	EEX	CHN						
6	924	411	44%	88	2820	USA	EU15	FSU	CHN	IND	ROW					
7	792	288	36%	100	3154	USA	EU15	FSU	EEX	CHN	IND	ROW				
8	495	102	21%	113	3355	USA	JPN	EU15	FSU	EEX	CHN	IND	ROW			
9	220	29	13%	123	3555	USA	JPN	EU15	FSU	EEX	CHN	IND	DAE	ROW		
10	66	4	6%	86	2534	USA	JPN	EU15	00E	EET	EEX	CHN	IND	DAE	ROW	
11	12	1	8%	112	3176	USA	JPN	EU15	00E	EET	FSU	EEX	CHN	IND	DAE	ROW
12	1	0	0%	-	-											
Total	4083	1329	33%													

<b>TADIC 1.</b> Comparison of the realitions and payoffs by afferent number of tour	Table 1	Comparison of the reductions and	payoffs by different	number of coalition
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	USA	CHN	EU15	FSU	ROW	IND	EEX	JPN	DAE	OOE	EET	BRA
Emissions in 2010	1.76	1.13	0.94	0.77	0.64	0.34	0.47	0.34	0.32	0.36	0.23	0.12
2	24.5	25.4	-	-	-	-	-	-	-	-	-	-
3	28.5	30.0	16.7	-	-	-	-	-	-	-	-	-
4	30.9	32.9	18.2	-		12.4	-	-	-	-	-	-
5	33.1	40.7	19.5	14.3	-	-	7.4	-	-	-	-	-
6	35.4	38.4	20.9	15.2	14.6	14.3	-	-	-	-	-	-
7	36.5	39.4	21.5	15.6	15.0	14.8	8.3	-	-	-	-	-
8	37.7	41.1	22.2	16.1	15.5	15.3	8.6	8.8	-	-	-	-
9	38.5	41.6	22.8	16.5	15.9	15.6	8.8	9.1	7.3	-	-	-
10	34.9	25.7	20.6	-	5.0	14.0	7.9	8.2	6.5	7.8	5.6	-
11	37.2	22.2	22.4	16.1	15.4	15.1	8.6	8.9	7.1	8.5	6.0	-
Singleton	16.2	15.5	6.6	5.0	3.7	3.4	0.8	0.8	0.5	1.9	0.9	0.02
9 vs Singleton (times)	2.4	2.7	3.4	3.3	4.3	4.6	11.1	11.7	13.5	-	-	-

Table 2. Each country's reduction in maximum reduction case of different number of coalition (Gt)

Table 2 shows that each country's reduction in cases that produce a maximum total reduction with different numbers of coalition members. It is assumed that singletons play Nash equilibrium with regard to their abatement strategies. Non-signatories choose their abatement level by maximizing their own payoffs, taking the other regions' abatement levels as given. Compared to the singleton case, all the cases realize more reduction. The ratio of each country's reduction in the nine country's coalition (maximum reduction case of all the coalition) to that of singleton ranges from 2.4 times to 13.5 times. Countries with higher marginal cost such as Japan, DAE and EEX are found to reduce more compared to their singleton cases. Countries with higher marginal cost reduce more because their reduction is much subsidized by the matching contributions of countries with lower marginal cost through the matching mechanism.

Based on the Guttman's mechanism, Boadway (2007) has developed the quantity-contingent mechanism (QCM) under the condition that not all countries can commit to a matching contribution, which is more practical considering the reality of the climate change negotiations. Emission trading is quite effective for improving global and individual countries' payoffs. Based on the results of this paper, we will show the results of QCM as well as the emission trading applied to both Guttman's mechanism and QCM in the full paper.

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# A Model for Achieving Environmental Sustainability through Group Decision Making and Negotiation

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**Abstract**: This paper presents a model for how groups can negotiate to achieve environmental sustainability. The model is based on five "abilities": availability; dependability; capability; affordability; and marketability.

Keywords: Negotiating for environmental sustainability. Promoting sustainability.

Many factors have driven environmental sustainability initiatives. The current economic uncertainty in many countries is certainly one factor that has had an impact on such initiatives. However, the overall goal of a group of people in any organization (higher education, healthcare, the military, a product, or a service) as it progresses through its life cycle should be resilience, which can only be achieved through a comprehensive negotiation for sustainability.

In ecology, sustainability describes how biological species survive. For the environment, it is assessing whether or not project outputs can be produced without permanent and unacceptable changes in the natural equilibrium. For humans, it is our long-term physical and cultural well-being. For mechanical systems and structures, it is maximizing reliability while conserving required resources and reducing cost and waste.

Sustainability and sustainable development have become popular goals. They have also become wideranging terms that can be applied to any group or enterprise on a local or a global scale for long time periods. Historically, the term has been used more in the context of "green," which refers to having no negative impact on the environment, community, society, or economy (Bromley, 2008).

The traditional meaning of sustainability centers around the words "endure", "maintain", or "support", which is the focus of this paper. Here, sustainability means to aim to maintain the readiness and operational capability of a group through the adoption of a strategy that meets established performance requirements in the most effective, efficient manner over the group's life cycle. The scope varies among groups, but sustainability does include the key word "ability." The authors propose that, by focusing on five abilities, a group can successfully negotiate to achieve environmental sustainability. The five abilities are: (1) availability of resources, facilities, tools, and teams; (2) dependability of group services; (3) capability of the group to perform; (4) life cycle cost affordability; and (5) marketability of new concepts for endurance. Figure 1 illustrates these abilities. Availability focuses on team-building and collaboration. Dependability concentrates on the reliability of the services and people. Capability is about performance assessment. Affordability concentrates on the budget. Marketability deals with defining selected markets, understanding people's needs, and managing changes or improvements to benefit people, groups or organizations.



Fig. 2. A model for an environmental sustainability negotiation.

How can these sustainable abilities be negotiated and then communicated? The answer involves the Diffusion Process of Innovation (Assael 1987), which is "the process by which the adoption of an innovation is spread by communication to members of a target market over a period of time." The five groups in this process include: Innovators, Early Adopters, Early Majority, Late Majority and Laggards. This process relates to the strategy for change management. Often, people are resistant to change, like recycling or taking new prescriptions, even if they feel these changes may benefit them.

The most common questions asked by those to whom change is directed are: why change the way we do things? What does the change imply for me, specifically? Does change alter my work, lifestyle, or my function? What is the motivation for me to change? What is the motivation for me to be concerned about sustainability? Thus, every sustainability initiative should focus directly on change and the impacts of change. In a widely accepted view of change management, Kotter (1996) outlines eight stages of change. Research on best practices validates that organizational groups that follow this framework have the highest rate of success, and therefore sustainability. The eight change stages are:

- 1. Establish the Motivation for Change
- 2. Build a Guiding Coalition
- 3. Develop a Vision and Strategy for Change
- 4. Communicate the Vision
- 5. Empower Broad-Based Action

- 6. Generate Short-Term Wins
- 7. Sustain the Momentum
- 8. Anchor New Approaches in the Culture

Examples for each of the eight change stages that relate to groups and sustainability follow. For the first stage, employees may not understand change and fear job loss. To motivate employees to change, leaders need to explain thoroughly why change is needed. Second, in building a guiding coalition, current targeted customer groups could be ignored. So, they should be made part of the guiding group for change, perhaps in a focus group. Next, in developing a change vision, the rewards and strategies may not be linked or aligned. To correct this situation, employees need to know where they fit in the organization and what rewards and consequences occur if they embrace or impede change. Fourth, communication may be just coming from the top, or it may only be word-of-mouth. Here, two-way communication is needed from the bottom to the top of the chain among all groups. The fifth stage may be that employees do not have the training for empowerment. This can be corrected by making sure that the right people receive the right training just-in-time (e.g., an executive training course). Next, there may only be a few short term successes. So, any and all early successes need to be communicated and celebrated to all groups. Stage seven involves producing more change. If old performance measures have been used, then use new performance measures in the future to reinforce and sustain new strategy. Lastly, culture does not need to change to support sustainable approaches. Rather, cultural change should evolve from changes in norms and values during the transformation, just as it did for the penguin colonies in Our Iceberg Is Melting (Kotter and Rathgeber, 2006).

The authors' intent in the paper is to relate the five abilities to group decision making processes for environmental sustainability, such as the Diffusion Process of Innovation. Then, the focus will be on the implementation of the abilities using change management concepts.

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# Semi-Automated Group Decision Processes for Response Management to Environmental Threads

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**Abstract:** Response plans to environmental threads can require a group decision process where participants are separated by time or/and space. The challenges of such processes can be effectively addressed by a combined use of process modeling techniques and enhanced Group Decision Support Systems. The central technical aspects of this approach are described and exemplified by sample process models using the Business Process Model and Notation (BPMN) standard.

Keywords: Environmental Protection, Group Decision Process Modeling, GDSS, AHP

The response management to environmental threads such as oil and chemical spills or releases from hazardous waste sites involves the use of response management plans (EPA, 2011; Seager et al. 2007). Such plans describe actions to be followed by the response management organization which can include people from different disciplines such as fire, police, health and hazardous materials management.

It is a common pattern of many response management plans that in a first step several alternative courses of action together with evaluation criteria are to be specified. In the then following step a decision model is to be created in order to select the best alternative by the completion of a group decision process. Multicriteria decision models based on the Analytic Hierarchy Process (AHP) of Thomas Saaty (1980) are often considered in this context (Song and Hu, 2009).

One major advantage of group decisions over single person decisions is the fact that the decision will be based on a broader expertise and also a broader information base. Another advantage is that the risk of a bad decision due to the human factors (e.g. the responsible decider can be over-challenged by the decision problem) is reduced if the decision task is performed by several persons. There also exist drawbacks of group decisions such as the needed extra time, a relatively large coordination effort, and the demand for a trained moderator (Kolbe and Boos, 2009). Furthermore, group decisions can become biased by so-called Group Think Effects such as the illusion of invulnerability which can lead to excessive optimism and encourage risk taking (Janis, 1982).

Synchronous group decisions require face-to-face meetings to be organized. In environmental protection situations the participants can however be separated in time or/and space for a number of reasons and, henceforth, require an asynchronous group decision process. Some of the group members can be indispensable somewhere else due to other response management duties or other obligations. Also time or budget restrictions may not allow a personal meeting. Sometimes it is just not intended to obtain a decision through a synchronous group decision for example in order to prevent Group Think Effects. Furthermore, an asynchronous group decision can especially benefit from remote participants. For example, first-hand information and impressions of the situation status can be gained through dislocated decision participants that are situated close to the scene and that are equipped with mobile communication devices (Mendonca et al., 2000).

Several of the difficulties of asynchronous group decisions can be solved by the use of a Group Decision Support System (GDSS) (Gray, 2008). The GDSS can, for example, bridge the separation of the decision participants and perform information management as well as information sharing tasks. Furthermore, recent advancements of GDSS technologies lead to enhanced GDSS that can even automate group moderation management tasks (Thimm, 2011). The automation of these tasks can help to keep the extra coordination and moderation efforts on a manageable level without over-challenging a human moderator.

An automation of moderation management tasks can be obtained by the use of process models that capture group decision processes and that can be processed by an enhanced GDSS (Deokar et al., 2008). The execution of a given process model leads to moderation management tasks that are automatically performed by the GDSS. These tasks include time management tasks, information management tasks, and decision

method management tasks such as a decision result aggregation, consistency checks, and a sensitivity analysis. Our research builds on these capabilities of enhanced GDSS systems and targets to investigate the use of these capabilities for response management to environmental threads. The obvious focus of the investigation are group decision processes i) where members of the group are separated in time and location from other members and ii) where the criticality of the situation allows to determine the best alternative among different courses of action by a relatively time consuming group decision process.

In order to leverage the benefits of enhanced GDSS for environmental protection management we propose to prepare a repository of process templates that address the group decision processes as needed by response management teams. A repository of corresponding templates can be integrated in the Information and Communication Technology (ICT) infrastructure that is available for today's environmental protection organizations.



Fig. 1. Process model for response management to environmental threads.

In Figure 1 the approach to use process modeling techniques and enhanced GDSS systems for environmental protection management is presented in the form of a process model. The model is based on the well-known graphical modeling standard notation BPMN 2.0 (OMG, 2011). The big rectangle (called pool in BPMN) represents the Environmental Safety Management Organization which consists of two actors (called lanes in BPMN). There is first of all a human On Duty Incident Manager who performs monitoring tasks and acts as dispatcher for environmental threads (i.e. incidents). The second actor is an instance of the above described enhanced GDSS that operates in a standby mode and that offers a library of process templates for response management standard procedures.

Processes are described in BPMN mainly as flows (solid arrows) of activities (labeled rounded boxes) that can be controlled by so-called gateways (diamonds). Gateways that split the flow into only a single outgoing flow are called exclusive gateways (empty diamond), gateways that permit all possible combinations of outgoing flows are called inclusive gateways (indicated by "O"), gateways that force all outgoing flows to occur in parallel are called parallel gateways (indicated by "+"). Another major modeling primitive of BPMN are events (circles with optional labels). A start event (green circle) and an end event (red circle) are to be

modeled for every process. BPMN also supports a set of other event types such as an intermediate message event (indicated by the envelope symbol).

In the sample process the initial activities have the goal to determine appropriate templates for the intended group decision making process and the needed underlying decision model. When the incident is not known the best fitting process template and best fitting decision template are selected from a template database. If necessary the selected template can be adapted to specific conditions of the given situation. Following that the Incident Manager starts a partially automated execution of the asynchronous group decision process in which the GDSS plays an active role. The activities performed by the GDSS are: prepare process, execute decision making process, complete post processing, and notify incident manager. During the execution phase the decision process is supervised by the Incident Manager who also performs actions that are not automatically completed by the GDSS. When corresponding information is received from the GDSS the Incident Manager confirms the end of the decision process. The final activity of the model refers to the completion of the selected action alternative to respond to the environmental thread.



Fig. 2. Process model for repetitive adaptive group decision making.

The element labeled execute decision making process which is part of the above described process model is marked with a little plus sign to indicate that this element represents a sub-process. Sub-processes in BPMN can be refined in separate self-contained process models. The abstract sub-process execute decision making process is refined in the process model of Figure 2. The general pattern of this refined process model embodies a process that potentially is repeatedly adapted and therefore referred to as repetitive adaptive process pattern. A repetitive adaptive process pattern can be considered to be an advantageous option for group decisions in environmental protection situations especially when an immediate response is not necessary. The advantages of such a pattern are that the repetition of the decision process can lead to learning and training effects for the participants (Thimm and Katura, 2012). These effects can be reflected by corresponding adaptations applied to the decision process or/and the underlying decision model. The resulting more accurate decision making process can lead to better decision results.

The BPMN model of the sample repetitive adaptive group decision process is given in Figure 2. The pool consists of the three lanes referred to as Decision Moderator, GDSS, and Participants. Note that there is only a single lane does not mean that only a single participant exists. The Decision Moderator needs not necessarily to be the same person as the Incident Manager. The two activities of the Decision Moderator are make iteration decision and revise process and/or decision model. The GDSS distributes the relevant information and decision tasks to the participants. Furthermore, the GDSS collects the decision results and feedback, applies respective analysis such as consistency checks on the results, and prepares the group result through an aggregation of the individual decision results. Note that the two respective sub-processes of the model of Figure 2 are not included in this article. The participants check the decision tasks assigned to them by the GDSS and also the given decision relevant information. In turn they complete the decision tasks, prepare feedback that is useful for the problem situation, and return all results to the GDSS for further processing.

In a next step the presented system approach will be refined in several directions. We will in this context evaluate if BPMN offers enough expressive power to model the relevant details and aspects of group decision processes.

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# A Decision Quality Diagnostic Framework: A Decision Quality Perspective

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There is a tendency for decision makers to assume that there is a one size fits all approach to making decisions. Decision makers need to clearly locate their problem domain and ensure that their approach to the problem is one that fits the decision scenario. Many decision makers tend to deal with the situation based on their preferences and past experience. This limits their ability to deal with the dynamic environment their organizations currently face. The decision domains they have to accommodate include ordered, tame, linear decisions through to unordered, nonlinear, complex and wicked decisions This presentation proposes the adoption of a diagnostic framework to enable appropriate choices to be made with respect to the processes and tool(s) to be used for the decision scenario they face. The DQDF (Decision Quality Diagnostic Framework) was specifically designed to systematically allow decision makers to discover the appropriate tools and processes to use through a sequence of steps that utilizes as a starting point the CIDQ Decision Deck©.

The CIDQ decision deck is a set of cards representing 78 distinct factors that contribute towards the identification of key issues impacting on the decision. The issues are categorized under three dimensions that enable decision makers to systematically identify pertinent questions that need to be addressed to allow for the selection of appropriate support tools and techniques for "best bet" decisions.

The three dimensions inherent in the CIDQ deck include Sensemaking, Architecture and Team Capital. Sensemaking involves making sense of an ambiguous situation surrounding the decisions. The sensemaking dimension focuses on discovery and understanding of the decision situation and involves "a motivated, continuous effort to understand connections (which can be among people, places, and events) in order to anticipate their trajectories and act effectively". The spirit of sensemaking is "discovery"; the competency we look for in sensemaking is the "ability to identify relevant information and patterns" and the outcome we seek is "appropriate situation sensitising and framing".

Architecture is the art of design, creation and combination of frameworks, processes and tools to enhance decision quality. Architecture draws on Sensemaking and in taking a holistic perspective, attempts to determine the most appropriate decision theoretic tool(s) to adopt, choose the right processes and systems to accommodate these tools and finally to identify the parameters such as time frame, frequency of this type of decision and level of uncertainty. The spirit of architecture is "appropriateness"; the competency we look for here is the "ability to select relevant tools and techniques" and the outcome we seek is "correct application".

The final dimension, Team Capital encompasses those aspects which critically influence the ability of the decision making team to achieve its potential. The spirit of team capital is a "decision team with pertinent decision intelligences"; the competency we look for is the "ability to contribute positively towards a quality decision" and the outcome we seek is "human intellect".

The DQDF suggest several steps that need to be followed by the decision making team to enable "best bet" decisions to be made.. Earlier work on decision quality produced the theorizing of "best bet" decision making (Klass, Schmidenberg, and De Reuck, 2005, p.4). Best bet requires an environment that allows for authentic communication. This in turn is promoted by such factors as the encouragement and serious examination of diverse views, respect for the individual, acceptance of the possibility of fallibility, a democratic decision-making milieu, and agreement to accept the authority of the better argument as the final arbiter in debate (De Reuck, Schmidenberg, & Klass, 2001; De Reuck, Schmidenberg, & Klass, 2003). The procedural approach to the "best bet" decision determination is represented by the Decision Quality Diagnostic Framework. This presentation will demonstrate how the DQDF is augmented using the

Generalised Decision Assurance Methodology (GDAM) (Klass & DeReuck, 2007). Central to GDAM is the democratic ethos that informs its processes. It aims at the full emancipation of its participating members in order to both legitimize its modus operandi and release the combined intelligence and creativity of its participants. Given this methodology's pragmatic, recursive and democratised process, it minimises the role of power and authority while endorsing the notions of justification, sound argumentation, evidence, and validity. The theoretically informed process principles that include rationality assumptions, power assumptions and decision management assumptions govern the operationalisation of GDAM. Taken together, these process principles constitute a framework to optimise the cognitive quality of decision outcomes. The proposed DQDF adheres to this environment and the work presented here is aligned to the values expressed in "best bet" thinking.

The presenter's current research is focused on building on the DQDF through incorporating a change intervention that would increase the likelihood of decision makers within organisations adopting and integrating the DQDF and making it part of their built-in decision process to achieve better quality decisions. The change intervention is aimed at bringing about sustainable change where the application of the DQDF is not seen as a one-off application but a process that is inherent and forms part of the "decision making culture" of the organization. This action research study, which the presenter will share, resulted from the expressed need of decision makers to move forward from the way they made decisions to one having strong processes and frameworks that were organizational based and provided a basis for quality decisions to be made. There is a noticeable lack of awareness of problems of structured structures contrasted with structuring structures. Several theoretical perspectives were used to inform our change intervention research and these include autopoiesis, structuration theory and habitus, and theories of social change and dissipative structures. The traditional 'construct and reconstruct' process of decision making for change which is commonly practiced have been augmented using the insights gleaned from the above theoretical perspectives. The traditional approach has been augmented through the inclusion of a "deconstruct" phase in the change intervention.

**Keywords**: Decision quality; diagnostic framework; decision making; Sensemaking; Architecture; Team Capital; decision quality diagnostic framework; best bet; Generalised decision assurance methodology.

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# PART III

# AUTOMATED COLLABORATION, FACILITATION AND SUPPORT SYSTEMS

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# **Collaborative Decision Making Tools: A Comparative Study Based on Functionalities**

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**Abstract**: This paper is on collaborative decision making issues. The study is on collaborative decision making tools. To do that, a state of the art of these tools supporting collaborative work in general and especially the tools supporting collaborative decision making process GDSS (Group Decision Support System) has been realized. A comparative study of these systems is made in order to highlight their strengths and their weaknesses.

Keywords: Collaborative Decision Making, GDSS, Electronic Meeting Tools, Meeting Software, Brainstorming tools.

# Introduction

Decision making is a prolific research field for decades because of its relevancy not only in the research area, but also in all sizes organization (small, medium and large). Indeed, the success and even the durability of the actions of any organization depend on the decisions it make. If these decisions are good quality, then organization is going better.

Nowadays, the current economic context with the re-organization and merges Acquisition, and also the increasing complexity of problems to solve, decision making is no longer an activity involving just one or few people. Indeed, the decision making requires the participation of several stakeholders whose contributions are significant in final decision. This type of decision making is known as Collaborative Decision Making.

Many studies revealed that collaboration is more and more important in organizations. Thus, according to Parametric Technology Corporation, the 2/3 of the engineers working time is devoted to collaborate (PTC, 2005). Another survey made by Frost & Sullivan agency found that: "36% of a company's performance was due to its collaboration index. This is more than twice the impact of a company's strategic orientation (16%) and more than five times the impact of market and technological turbulence influences (7%). This is a key finding because it empirically demonstrates that increased high-quality collaboration can improve business performance" (Frost & Sullivan, 2006).

In addition, the introduction of technologies of information and communication (TIC) promotes the move of decision making toward the collective decision making in the organizations. That integrated several perceptions (ways to observe) of the solution of problem through the contributions of different participants. This common and shared vision is beyond the individual vision of each participant and that gives rise better description of the problem (Adla, 2010).

From above, the relevance of collaborative decision making and its impact in organizations is obvious. However, there are still some challenges including: the lack of effectiveness, the problems of decision makers' productivity despite of their willingness, the necessity of technologic supports to help mediated collaborative decision making, the decision monitoring, the knowledge capitalisation, and so on.

Some above identified problems have been addressed by Adla in his thesis titled "Aid to Facilitation for a Collective decision making: Proposition of a Model and a Tool" (Adla, 2010). This thesis proposes an approach in three phases, Pre-decision, Decision and Post-decision, for the collaborative decision making and an architecture for a cooperative system supporting this approach. Indeed, the needed phases for a collaborative decision making process execution require a system called GDSS (Group Decision Support System). That consists in collaborative systems with functionalities required to support the different steps.

In this context, this paper presents a study aiming to:

• identify collaborative systems for group decision making process,

- display comparative study of these tools,
- propose selection guide of collaborative tools for decision makers, especially facilitators.

The remain of this paper is organized as follow: the section 2 presents the decision making concept, the different types of tools used in decision making and an approach for collaborative decision making. The section 3 displays the state of the art on collaborative systems, and finally the section 4 presents the conclusion and further works.

# Background

This section briefly describes in the literature GDSS. In next subsection, the different types of existing GDSS and their characteristics are presented.

## **GDSS** types

The systems supporting decision making exist for several decades (years 1970) and they considerably evolved until now.

As an interactive system for decision making DSS (Decision Support System), the GDSS is designed to be a mean for the decision making in group context. There are two main categories of GDSS: some of them are called Face-to-Face systems and those are known as Interfaced Systems (Straub, Beauclair, 1988).

## A Collaborative decision Making Process Model

The figure 1 presents an overview of the decision making process divided into the three phases previously presented (Pre-decision, Decision, Post-decision). A detailed presentation of each phases is made below.

#### **Pre-decision phase**

Here, the participants have to share understanding of the problem and the targeted objectives to attain. Since all participants have not the same background, nether the save information, this phase helps to get a common representation of the problem following different viewpoints. Behond the shared understanding of the decision space, the creation of the common operattive referencial is a main important step in this pre-decisionnal phase (de Terssac, Chabaud, 1990).

In other words, that consistes to define the limits and boundaries of the problem and decision space through the specification of the all caracteristics of the decision to make. This can be done with expressing the group expectations, defining the all stakeholders and the roles assigned to them, identifying the conlogies to use and the accuracy about the required functionalities and their configuration, and finally creating an agenda.

This agenda presents an overview of the decision making process since the pre-decision phase. It contents the all required information for process conducting: brief description of each step, defining the objectives the steps, identifying participants and their role in each step and the duration of this step, etc.



Fig. 4. Process Model of collaborative decision making process. (Adla, 2010)

#### **Decision** phase

The decision phase is divided into four main steps that are ideas generation, organization, evaluation and then ideas selection. Each of these steps is presented below.

#### Generating alternative solutions

During this step, the group products ideas in two times: individual production in a private space, then the group generates collectively in a public space. Indeed, each participant has to generate ideas that have to be published and elaborated by other participants. The benefit of this approach in double steps is to incite participants to personal and collective thinking in successive and recurrent way by allowing them to compare their ideas.

#### Ideas organization

Once the ideas have been generated, they have to be organized in order to increase their visibility and understanding. So, ideas organization is required before to use them in one way or another.

In addition, since there are often redundant ideas, organization step allows merging similar contributions detected by the facilitator and participants. Tue use of a consolidated tool is required to facilitate the execution of this step.

#### Evaluation des alternatives

When the propositions are organized, it is necessary to compare the different viewpoints in the common referential of the decision. But, it is asked to each participant to make effort for individual evaluation before to share them. A negotiation can then start in order to bring group to a convergent point accepted by everyone.

There are three available methods for estimation: (1) the analytical method which is supported by constraints evaluation depending to decision environment. The estimation (Nasir, 2006), the voting (Schapire et al., 1998) and the multicriteria evaluation (Davies, 1994) are some examples; (2) comparative evaluation

approach which consists to put different alternatives facing each other in order to distinguish the similarities and differences. The ranking (Murphy, 1989) is an example of this type of methods; finally, (3) the analogical evaluation method (Privitera et al., 2003) which uses previously acquired knowledge in order to use them in a current situation and evaluate the solution.

The choice of these solutions depends on the situations and the decision makers involved according to their preferences. Thus, facilitator can suggests a method following the capabilities of used tool.

The evaluation results, i.e., the means, standard deviations, etc. are displayed for visualization. These results are interpreted and in case of contrast indicated by a high standard deviation, the facilitator intervenes to bring the group to a discussion phase for consensus. If necessary, this step can be re-executed until to get consensus. In this case, argumentations from group are constructed either by comparison (several alternatives), or by analogy (organizational memory), or even by authority (hierarchical reasons) (Adla, 2010).

#### Decision/ Choice of solution

This step consists to clearly identify and publish the agreements from participants. This requires a negotiation phase. It is important to keep in mind that decision is context related, i.e., it makes sense only if we consider the context and reality under which decision has been made. For example, following elements have to be taken into account: objectives, constraints, resources and the criteria. In addition, in order that this shared context remains to be mutually understood, the decision has to be known by concerned actors. Thus, these actors have to be notified about all modifications concerning the decision made even if they are involved indirectly in the process. The benefit is to conserve the validity of the common operative referential.

#### Post-decision phase

This phase is very important because it allows the decision monitoring. Monitoring a decision consists essentially to realize an action planning (in general on shape of projects) in order to implement the decision made. The action plan gives information on people involved in the projects by specifying their roles and the calendar according to which these projects have to progress. The decision monitoring also concerns the experience capitalization in the organization. To do that, a knowledge base is built and regularly updated. For the organization, the benefits of this practice are to facilitate the definition of decision making problem similar to previous problems, and the generation of possible solutions of new problems.

This organizational memory can be used in different contexts which are (Adla, 2010): (i) a decision making process management tool, i.e., a way for participants to get visions and consistent orientations in complex process; (ii) a tool to facilitate the reuse, i.e., allow decision makers to query the knowledge base in order to check if there are similar problems already solved (retrospection) or allow the elaboration of currently useful solutions and also those likely to be later (prospection).; finally (iii) a tool for new knowledge construction, i.e., a way to evolve the knowledge acquired by organization toward an increased added value know-how. So, it is not a accumulation of information in regular way, but it is a way to evolve knowledge consistently and harmoniously to give a new one which encompass the sum of previous ones.

As any decision making model, which is presented above is not a perfect model, but it is flexible and adaptable after the situations and the decision makers. The definition of current model takes into account the task and the process to which it belongs alternatively. The model also allows a distribution of decision makers into several decision groups, which can be preferable in the case of complex process requiring the participation of a large group. Thus, an environment offering the possibility to manage both the process and the task in order to attain the objectives is very desirable. That would facilitate the mutual regulation of decision for election of the task because both gives rise to final decision.

It is important to note that because of strong dependence of some steps, they are not sequential unlike their classical representation. For example, the problem evaluation and the elaboration of its solutions go hand in hand, that makes these steps implementation almost parallel. In addition, some steps can be implemented asynchronously and others require synchronous execution. Indeed, if we can admit that the ideas generation and organization are asynchronous, in reverse, it is preferable that the negotiation required in the evaluation and selection steps implements synchronously in order to facilitate these steps and to save time and finally to win effectiveness.

The construction of the organizational memory which has been previously apologized and its regular enrichment are one original point of the current model.

Moreover, the effectiveness of o decision making group does not depend only to the used process, but it also depends on an automated tool supporting the group activity. According to Denis et al., the use of a tool can reduce the working time to 50% and to cut the project time from 70% to 90% (Denis et al., 1990). On the basis of foregoing, we made a state of the art on systems supporting above process. These systems are presented in following section.

#### An architecture to the aid for collaborative and distributed decision making

The architecture presented here has been proposed by Adla et al. in which both cooperations are taken into account, i.e., Human-Machine cooperation and Human-Human cooperation. Below is a description of each cooperation type.

#### Types of cooperation

#### Human – System cooperation

The human, i.e. the decision maker in current case, is central to any decision process even if the use of a decision support system is sometimes necessary to increase performance of decision makers involved in the process. Thus, the system plays a cooperative role regarding the human who has master the system or at least to have useful knowledge tool using. Indeed, there are actions required by the system from the user so that the system reacts according to the user expectations. Coordinating actions between decision maker and the system is necessary in such a cooperative process. In other words, a set of rules that structure the cooperative action must be defined between the decision maker and the system. These rules take into account the used technology limitations.

Human – System cooperation is useful when the individual problems resolution phase made by each decision maker.

#### Mediated Human – Human cooperation

Since we are in the group decision-making situation and that it involves multiple decision makers simultaneously, a Human - Human dimension must be taken into account even if a system can be used. Indeed, the use of a system aims to facilitate and to make more effective the Human – Human cooperation instead to replace this one. Therefore, the system should allow the emergence of a new form of interaction between participants that brings added value compared to an execution without the system. Mediating the decision making process provides to decision makers realtime or differed communication features, advanced computing devices that are only possible by technology, anonymity, increased interactivity, distribution in different geographic locations, etc. It should nonetheless be noted that the system is not suitable to all situations. In some cases, decision makers make use of traditional way without technology (Boehm et al., 2001).

This type of cooperation is implemented at group level during the consolidation phase following the initial one (individual decision making). The facilitator defines the process and the types of cooperation to apply as appropriate. The facilitator has to lead participants through the different steps toward the final decision which requires the participation of all.

#### An architecture

Based on the descriptions of cooperation types involved in the collaborative decision-making process, an architectural model of a system supporting this process is presented here. It is a centralized architecture. Indeed, such a model has the advantage of implementing simplicity, which also generates a time savings. In addition, such architecture is well suited to a process that gives particular place to the session facilitator. In fact, according to the process model proposed, when each decision maker has finished individual resolving, the group is led by the facilitator to make a collective decision. Figure 2 shows an overview of the global architecture. Individual decisions are made using specific cooperative decision support systems called DM-DSS. The facilitator also has a system for facilitating named F-DSS. An F-DSS is particularly useful for inexperienced facilitators.



Fig. 2. Architecture of a system for distributed decision making. (Adla, 2010)

Figure 3 shows the modules required in GDSS to support previously collaborative decision making approach presented.



Fig. 3. Outils d'aide à la décision de groupe (Adla, 2010).

- 1. A collaborative decision making process is based on techniques and tools supporting ideas generation (brainstorming, brainswriting, etc.), organization (categorization, classification, etc.), evaluation (multicriteria vote, etc.) and the ideas selection (negotiation, consensus building, etc.).
- 2. An agenda builder allowing session facilitator to prepare in advance the decision making meeting by specifying the steps and their goals.
- 3. A feature for the construction of collective and organizational memory. This memory is primarily a database containing all data (users, agenda, dates, generated ideas, evaluations, decisions, etc.) related to the previous sessions conducted by a group for traceability issues. Secondly, the memory stores the set of solutions to various cases of solved problems; this facilitates the reuse of solutions.
- 4. A communication manager between the decision makers. Such component allows interactivity which is required in collaboration. Web applications well support this interaction between users. Thus, they are successful examples for that so that the GDSS are increasingly modeled on Web applications.

The next section presents a set of collaborative tools (free or charged) supporting all or part of the collaborative decision-making process presented in this section. A comparison of these tools based on features they offer and the number of steps they support is also proposed. These tools almost implement in different ways the architecture presented in this section.

# **Collaborative Decision Making Tools: GDSS**

There are several types of collaboration tools which support all or part of the decision making process from the problem formulation phase to solution choice phase.

According to Briggs, a tool supporting group work (decision making or other work) is a collection of tools for ideas generation which support several types of activities like voting (scales, multicriteria, etc.). Users can bring their contributions into a voting tool, evaluate them, and review instantly the results on line

(Boehm et al, 2001). Most of tools allow the data sharing. Any user can contribute to shared list, any time and any contribution from a participant is visible instantly on other screens. All participants can simultaneously and freely contribute to discussion when he is inspired without wait for other people.

We present in the next subsection a set of tools that we identified and we propose a comparative table based on functionalities offered by these tools. This comparison is made either after using these tools or after demonstration meetings made by editor, or after reading tools presentation documents provided by tools editors. Several methods of test have been used.

## Some GDSS tools presentation

All systems presented below do not require any set up technique because they are Web based applications. So, their use requires only internet connection and a Web browser. In this case, we consider the situation where the system is deployed on the editor server. But, if the user wishes to deploy the system on his own server for confidential reasons, it is necessary to make technical effort do satisfy this requirement.

- 1. **FacilitatePro**: this tool is a Web based application edited by Facilitate.com in USA (Facilitate, 1992). A simplified version of FacilitatePro is FacilitateExpress which supports the agenda creation, the generation, the categorization and the prioritization of ideas, and finally the reporting.
- 2. **Kindling**: this tool is also a Web based application developed by Arc90 organization (Arc90, 2004) in USA.
- 3. **ThinkTank**: this tool is one of the giants in the CSCW (Computer Supported Cooperative Work) field for several decades and edited by GroupSystem (GroupSystems, 1986) in USA.
- 4. **Grouputer**: this system is a Web based solution proposed by Grouputer (Grouputer, 1995) in Australia since 1995.
- 5. **Webcouncil**: this Web based solution proposed by CoVision (Covision, 1985) which is also one leader in the group technologies market for some decades in USA.
- 6. Brightidea: this system is a product of Brightidea organization (Brightidea, 1999) in USA.
- 7. Ideascale: developed by the society Ideascale (Ideascale, 2003), this tool is Web based solution dedicated to collaboration between product developers and their clients in order to better reply to their needs.
- 8. **Dialogr**: it is also a Web based solution developed by Dialogr.com (Dialogr, 2007) for collaborative decision making.
- 9. JamespotPro: this tool is another Web based application which is proposed by the organisation Jamespot.com (Jamespot, 2005).
- 10. **Campfire**: this tool is Web based application suitable to collaborative decision making. It is a solution from Campfire (Campfire, 1999) and it supports some steps of the process presented in previous section.
- 11. **BrainReactions**: this Web application provides basics for decision making process. It is a solution from BrainReactions (BrainReactions, 2005).
- 12. **CentralDesktop**: this system is a Web based application proposed by Central Desktop (Central Desktop, 2005).
- 13. **MeetingWorks**: this system is a Web based solution developed by IBM (Meetingworks, 1994) and which is actually less and less used.
- 14. ExpertChoice: this tool is a solution from ExpertChoice (Expertchoice, 1983) founded in 1983.

All these systems are described in deeper details in the Annex 1. These descriptions evaluate all of them through the group decision process described in section 2.2.

# Collaborative Tools Comparison based on functionalities

The table 1 displays an overview of tools previously presented according to some criteria based on functionalities and steps they support during each phase of decision making process. The table also allows a comparison of the different tools to help users to make choice according to their needs if criteria we defined make sense for them. Each of these tools can be used for decision making meeting either in synchronous or asynchronous way, and also either in same or different places.

It is important to note that this evaluation is not a judgment on tools. However, our evaluation proposes appreciation elements by using rating scale (very unsatisfactory, unsatisfactory, satisfactory, and very satisfactory) to measure the elaboration level of each functionality depending on tools. When a functionality

is very unsatisfactory (--), it does not exist or almost. When a functionality is unsatisfactory (-), that means it is not well elaborated. If a functionality is qualified as satisfactory (+), this functionality exists and it works well. Finally, when a functionality is very satisfactory (++) in a given tool, that means this tool supports functionality in effective way.

Table 2. Comparative table of collaborative tools decision for making process.

Legend

Symbols		-	+	++
Signification	Very unsatisfactory	Unsatisfactory	Satisfactory	Very satisfactory

It is interesting to notice that "Organizational Memory" functionality is developed in all studied systems. Two others functionalities "Brainstorming" and "Electronic Invitation" are also very well developed in almost all systems except Expert Choice that is developed for this kind of group tasks.

It is also interesting to notice that the "MeetingWorks" system is really adapted for Group Decision Process and supports in a very satisfactory way all described functionalities. We then can see that the two systems "ThinkTank" and "Webcouncil" even if they have some differences offers very good facilities for supporting Group decision Process, the time management item is not present in these two systems.

Functionalities												
Tools	Time Management	Organisational Memory	Anonymity	Agenda Builder	Electronic Invitation	Brainstorming	Organization	Prioritizing / Voting	Results Analysis	Actions Planning	Documenting	Decision Monitoring
Dialogr		+			+	+	-	+	-		-	-
FacilitatePro	-	++	++	++	++	++	++	++	++	++	++	++
Kindling	-	+	-	+	++	++	++	++	++	++	++	++
ThinkTank	-	++	++	++	++	++	++	++	++	++	++	++
Ideascale		+			+	+	+	+	-		+	+
Brightidea	-	++	-	-	++	++	++	++	++	+	++	+
JamespotPro		+	-		+	+	-	-	-	++	-	-
Campfire		+		-	++	+	-			-	-	-
Webcouncil	-	++	++	++	++	++	++	++	++	++	++	++
BrainReactions		+			+	++	-	-			-	-
CentralDeskto p		+		-	++	-	-			+	+	-
MeetingWorks	++	++	++	++	++	++	++	++	++	++	++	++
ExpertChoice		+						++	+		+	+
Groupputer	-	+	++	++	++	++	++	++	++	++	++	++

#### Discussion

It is important to note that there are tools on the market that address certain steps of collaborative decision making process. These tools sometimes called as GDSS and indeed they may be collaborative tools. Since these systems are not necessarily complete tools suite, and subsequent or prior steps of a decision-making process would require the integration of other features into process. So there would be no concept of an integrated flow of information from one step of the process to another or movement of people and their thinking from one step of the process to another (Collins, 2010).

Each of above tools has functionalities supporting all or important part of decision making process. They are proven tools that most of them are from market and used by great companies and universities.

The effective use of these tools requires facilitators who master them and who are able to bring decision making team their goals through a given process.

# Conclusion

This paper presents fourteen (14) tools supporting collaborative work. The main functionalities of these systems have been identified, in particular functionalities sustaining the steps of collaborative decision making process. A comparative study on these tools is made in order to highlight their strengths and weaknesses according to the steps of process. Thus, decision makers can use the comparative table as selection guide to choose their GDSS and to build their process. The paper also considers a decision making approach that has been proposed in previous research works. This methodology has three phases: predecision, decision and post-decision. One of the principle objectives of this approach is the knowledge capitalization. Even if some of the systems we identified allow backup and archiving data from previous decision making sessions, none of them really implement a specific functionality for consistence and dynamic organisational memory building. Indeed, the systems do not build new knowledge from existing ones. However, knowledge capitalization for organisational memory is a progressive construction of new knowledge from those already acquired and those being acquired in the coherence to be used for solving future problems. Thus, our works perspectives include: more studies on GDSS in order to increase their performance and efficiency in decision making by adding features such as real-time display of time that elapses during the meetings, the capitalization of knowledge based on Ontologies, etc. In addition, other studies can be conducted to develop approaches for collaborative decision-making by taking into account the limits of technology.

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# Annex 1: Tools description

Facilitate Pro supports the three phases (pre-decision, decision, post-decision) of the decision process as presented in the methodology proposed the section 2.3. FacilitePro proposes supports to send electronic invitations to participants and also for problem definition, i.e., the collection of data from inquiries or precedent studies, critical problems identification, discussion and problems classification. The agenda creating which is part of the pre-decision phase is supported FacilitatePro. In the agenda, there are defined the decision making essential points. So, the participants can access to virtual space where they interact in asynchronous way to develop a shared understanding of the agenda. Once the problem definition is established and the agenda has been built, FacilitatePro also allows to present information to participants in a step just before the decision phase. In decision phase, this GDSS allows ideas generation anonymously according to user desire. Ideas so generated can be visualized by all participants and those can add comments with tool. It also offers the capability de create categories and to drag and drop ideas into categories. This tool allows voting and to immediately access to results. The results (including means and standard deviations) can be displayed on graphical or tabular shape. FacilitatePro offers functionalities to support the post-decision phase : action planning elaboration with a calendar for decision monitoring, and assigned responsibilities to different participants; the documenting of meeting can be made by generating report in different formats (words, html) can this report can be sent by Email; free access to virtual work space in asynchronous way is still possible after meeting in order to that participants can monitor the progression of decision execution and to prepare next meetings.

**Kindling** : In the phase of pre-decision, it supports the preparation of meeting by creating agenda, making electronic invitation and to access to virtual space for decision. Concerning decision phase, Kindling allows ideas generation in a common and shared space. It offers spaces dedicated to ideas generation called rooms.

In these contextual spaces, we can classify ideas in specific themes. This is a way to early organize ideas since the generation phase. Kindling offers a functionality « Campaign » especially designed to support the group facilitator in particular when motivating participants to elaborate or comment ideas from other participants and to generate new ideas. The tool also supports the ideas rating according criteria in order to highlight the best ideas according to campaigns. It supports voting, ideas priorization and results analysis. The displaying of results can be made in graphical or tabular way. During the post-decision phase, there is the possibility to generate report with Kindling. Report can be exported into different formats like excel.

ThinkTank supports pre-decision, decision and post-decision phases of the collaborative decision making process. ThinkTank offers the functionalities for problem definition by collecting data from inquiries and preliminary discussion. It is also possible to create agenda with all information about meeting and to send electronic invitation to participants. This system offers to participants a forum for ideas generation. Ideas so generated are visible by participant who can elaborate or comment them. ThinkTank allows the creation of categories and ideas organization into categories. Voting (binary, decimal, multicriteria ...) and the ideas prioritizing are also supported and instantly results presentation. In order to support the post-decision phase, Thinktank offers functionalities to create for action planning by assigning roles to participants and by defining calendar. This allows decision execution and monitoring. The meeting documenting is also possible par generating the report containing all details of the meeting and it can be recorded into different formats of file (Word, Html, Excel). Participants can access to virtual space for others activities in decision monitoring context.

**Grouputer** supports the phases before, during and after decision. Specifically, it allows meeting agenda building, defining process to be executed. Grouputer offers a common space for ideas generation, categorization, voting and prioritization. The tool also allows surveys. About post-decision phase, Grouputer offers capability to generate reports, establish an action plan for decision monitoring and to access in free way to virtual shared space.

**Webcouncil** covers the upstream phase of decision making, the decision phase and the downstream phase of decision. It has several sophisticated functionalities to support a collaborative decision making process. Among these functionalities, there is agenda builder, a space for online information sharing between participants, electronic messaging invitation. The decision phase is supported by Webcouncil through features for brainstorming, commenting, organizing, voting (unique choice, rating, scaling, multicriteria) and prioritizing ideas. The results (including means and standard deviations) are viewable in different shapes (tables, graphics) in order to facilitate their interpretation.

Webcouncil is also adapted to support decision monitoring phase because it allows generating report, action planning with calendar and assigning tasks to responsible. The access to virtual space in order to share information and to consult them is also possible.

**BrightIdea** clearly makes distinction between phases of decision making process and it has appropriate functionalities to support each step. So, the pre-decision phase is supported by WebStorm which allows meeting preparation by creating a virtual space and to send electronic invitation. WebStorm also supports ideas generating, organizing and voting. Ideas evaluation and results analysis are made with SwitchBoard which another available features of Brighidea. Several evaluation methods are offered by this system, especially multicriteria voting. Results can be displayed in a graphic or a table. The post-decision phase is supported by another feature of Brightidea called Pipeline which offers functionalities for action planning and to monitor decision in the context of projects. Brightdea allows reporting in formats like word.

**IdeaScale** is a decision making support in that it allows users to make decisions for improvement of the quality of services provided by products developers and for customer satisfaction. It supports some steps of pre-decision, decision and post-decision phases. In pre-decision phase, the tool allows to send electronic invitation to participants by explaining the theme and the objective of the meeting, and the URL to access to virtual space for decision making. Thus, participants can access asynchronously to learn more about meeting. Ideas generation and their commenting are possible in the dedicated forum. Ideas so generated can be organized by categories, evaluated through voting and prioritizing. The results analysis is supported by Ideascale which also allows displaying in numerical our graphical shape. Ideascale supports the post-

decision phase by allowing access to virtual space to view activities and their results; it also allows reporting par mail. Even if Ideascale is freeware, some advanced functionalities are not free.

**Dialogr** allows to support some steps of the three phases of decision making process. In the phase of predecision, it is possible de send electronic invitations to participants with the URL of the virtual space and also comment about the objective of the meeting. Thus, participants can access to thus space to get information and to prepare the meeting. The decision phase is supported by Dialogr through its capability for ideas and comments generation, ideas evaluation by rating them with stars (five stars maximum) and the ideas prioritization. There is a minimalist analysis because it is not possible to make calculus of means, standard deviations and to display them in tables or graphics. So, Dialogr is more appropriate decision making tool for relatively simple problems and in which the consensus does not require many factors. A report can be sent to group members by Email when decision is made. The free access to virtual space is possible for decision monitoring and others information sharing.

**Jamespotpro** is also suited to collaborative decision making in organisations and it supports some steps of the three phases of the process presented in section 2. In the pre-decision phase, JamespotPro allows to define agenda and to invite participants through Email. About the decision phase, the ideas generation and their organisation are supported by this application. The post-decision phase is possible by generating reports from preceding phases and to build a calendar associated to actions people have to do and the execution dates. In addition, it is possible to access to access to decision space for monitoring.

**Campfire** supports the pre-decision phase by allowing meeting preparation and sending invitation to participants. It has not advanced functionalities for data analysis because it is essentially focused on data collection. Campfire allows report generation and access to forum for decision monitoring. Campfire is freeware for small size of group and its price increases according to group size.

**BrainReactions** supports following steps of the process presented in section 2: the meeting preparation phase through creating decision making virtual space and sending electronic invitations to participants. Ideas generation is supported by BrainReactions and it allows voting and organizing ideas. There are not appreciate functionalities for results analysis. The decision monitoring is possible by accessing to decision forum after decision phase.

**CentralDeskTop** mainly supports the pre-decision phase by allowing creating virtual space for meeting, agenda building and electronic invitations sending to participants. The decision phase is partly supported because CentralDesktop does not sustain ideas generation and their categorization according the topics. Concerning the post-decision phase, it is possible to send report by Email and to access to decision space for monitoring.

**MeetingWorks** is a tools suite supporting all steps of three phases of collaborative decision making process. It offers features for agenda building, electronic invitations and other steps of pre-decicionnal phase. One of its features allows following the progress of different steps defined in agenda by displaying the time during process execution. Ideas generation, organization and evaluation are also sustained by functionalities of MeetingWorks. Cross-analysis and multicriteria analysis of the results are supported by this tool and their displaying in shape of graphic and tabular. The analysis feature allows two levels in sense making: individual and collective levels. Generating and managing reports is possible in MeetingWorks as well as all steps in the post-decision phase, especially decision monitoring. This system has other interesting functionalities for decision making such as timer, document loader, etc.

**ExpertChoice** tool is powerfull in decision making especially in ideas evaluation step by using multiple criteria based on Analytic Hierarchy Process (AHP). However, this system is not effective for data collection, analysis, clarification and the reduction of a large number of ideas. The post-decision phase is possible through an access to data, report generation and decision monitoring.

# Engineering for Shared Understanding in Heterogeneous Work Groups - An Action Research study at a German Automotive Company

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Abstract: Heterogeneity in work groups creates challenges to build a shared understanding among diverse group members and to integrate knowledge of different actors successfully. In an action research study with experience diverse tool and dye-makers at a German car manufacturing company, we developed a collaboration process design to systematically support heterogeneous groups in building a shared understanding of the sequence of activities in complex work processes. Participants showed the intended team learning behaviors and an increase in shared understanding.

Keywords: Collaboration Engineering, Shared Understanding, Knowledge Integration, Heterogeneous Groups

# Introduction

## Motivation

Research on group work has shown that collaboration is critical for organizational productivity, as many tasks exceed the cognitive capabilities of any individual, due to their complexity (Fischer 2000; Langan-Fox, Anglim et al. 2004). It also shows that diverse groups can perform better on complex tasks than homogeneous groups (Bowers, Pharmer et al. 2000; Wegge, Roth et al. 2008). The existence of heterogeneous perspectives or "symmetry of ignorance" in groups has the potential to provide opportunities for creativity in solving ill-defined, wicked problems (Fischer 2000).

Heterogeneity in teams often leads to communication breakdowns and project failure. While group members usually do not have to be experts in all fields tackled by a complex project, "they have to be able to integrate their knowledge bases in a sensible manner" (Kleinsmann, Buijs et al. 2010). Otherwise, they might be unaware of unshared individual knowledge which could be crucial for completing the task successfully. Building a shared understanding "is important because people frequently use the same label for different concepts, and use different labels for the same concepts. People on a team also frequently use labels and concepts that are unfamiliar to others on the team" (de Vreede, Briggs et al. 2009). As no standard definition of shared understanding has evolved yet, we define shared understanding as an ability of multiple agents within a group to coordinate behaviors towards common goals or objectives based on mutual knowledge, beliefs and assumptions on the task, the group, the process or the tools and technologies used, which may change through the course of the group work process due to various influence factors and impacts group work processes and outcomes (Bittner and Leimeister 2013). The challenge is that diverse work groups may lack a shared understanding of the task, the characteristics of the group, the products to be developed or the collaboration process due to their different background and experience.

If techniques and processes can be applied that support the creation of shared understanding in diverse groups, those groups are expected to gain efficiency in their work and produce better results. This paper examines the challenge of knowledge integration in heterogeneous work groups in a real world setting at a German car manufacturing company. We chose and action research approach to develop a solution for the specific problem situation, while simultaneously investigating the phenomenon of shared understanding and knowledge integration in heterogeneous teams. The practical goal of this project is to design a reusable collaboration process by which experienced and inexperienced group members should increase their individual understanding by adopting knowledge from each other and agree on a shared understanding of a specific work process. The research goal is to exploratively generate new insights on the mechanisms leading to shared understanding in heterogeneous group work. While a basic version of the process logic itself was proposed earlier (Bittner and Leimeister 2013), we address the following questions here: How do the

designed collaborative work practices evoke group learning mechanisms? How are these mechanisms related to changes in shared understanding in the heterogeneous groups?

The paper is organized as follows: First we point out our underlying understanding of shared understanding. In section two, the research setting and our action research approach are outlined. Sections three to seven follow the action research logic and describe, how we (3) diagnose, (4) plan, (5) intervene, (6) evaluate and (7) specify the learning in the action research study. The paper closes with a consideration of implications, limitations and outlook on future research.

#### Shared Understanding

Two differing interpretations of "shared" can be found in literature, the division of a resource between multiple recipients versus the joint possession of some resource (Smart, Mott et al. 2009). While the former refers to the distribution of tasks or knowledge among different actors, the latter covers the phenomenon we see in shared understanding. Groups, who are engaged in collaborative work need to have a joint reference base of knowledge and understanding in common in order to work productively. Thus, we focus the definition of "shared" for our purpose as some resource being possessed jointly by several people, based on "the overlap of understanding and concepts among group members" (Mulder and Swaak 2002). "Understanding is an ability to exploit bodies of causal knowledge (i. e. knowledge about the antecedents and consequents of particular phenomena) for the purpose of accomplishing cognitive and behavioral goals" (Smart, Mott et al. 2009). This definition of understanding highlights the importance of both knowledge as facts, and the structure of this knowledge. Causal knowledge is necessary for directed action towards the group goal. Seeing understanding as an ability, or "meaning in use" strengthens the viewpoint that understanding is more than knowledge, but involves reasoned action (Cannon-Bowers and Salas 2001; Mohammed, Ferzandi et al. 2010). "Shared understanding refers to mutual knowledge, mutual beliefs, and mutual assumptions" (Mulder and Swaak 2002) in order to reflect subjective aspects of understanding and future oriented assumptions in addition to objective factual knowledge. We make this inclusion, as especially for complex tasks, there might not be one single right understanding. The construct of shared/team mental models is closely related to shared understanding (Hsieh 2006) and is thus included in our work wherever useful, especially for the assessment of documents generated throughout the process. Although it is differentiated from shared understanding by some authors due to its stronger focus on command and control teams with highly structured tasks (Mohammed and Dumville 2001) and its lack of consideration of evaluative beliefs (Mohammed and Dumville 2001; Langan-Fox, Anglim et al. 2004). . In the study at hand, we focus mainly on shared understanding concerning the group task, in particular the work process the group should document.

# Methodology

# **Research Setting**

The authors were asked to improve collaboration of experienced and inexperienced tool and dye makers and increase the mutual knowledge transfer to ensure the retention of tacit knowledge within the organization independent of individual people. The organization was a big German car manufacturer. The goal was to build training blocks that helps inexperienced worker to execute complex work tasks.

As many other organizations, this company faces an increasing challenge to enable its members to integrate diverse knowledge. Longtime employees with great experience and deep understanding of the company's processes are confronted with unfamiliar rapid technological change in their work environment. When approaching retirement age, the organization is endangered by losing the skills and tacit knowledge of those people, if no appropriate means are in place, which support the transfer of knowledge to new employees. New employees on the other hand bring recent technological education and an unbiased view on established work processes, but may lack the specific skills and expertise in highly complex fields. Young employees with recent educational knowledge and older, more experienced employees should be able to learn from each other to prevent critical knowledge from disappearing. Demographic change enforces this challenge, as a big proportion of experts are reaching retirement age and only a small number of young technicians are qualified to fill their positions. Both experienced and inexperienced group members need to understand each other's perspective and converge on a shared understanding in order to work together effectively.

Heterogeneity of group members becomes manifest in this setting in different dimensions, such as age, gender, formal education, work experience, duration of association with the company etc. In particular, we paid attention to the equal staffing of each group concerning members with much vs. little experience with the specific work task the group should document. 36 workers participated in the project, 5 females and 31 males. Experienced participants were on average 42.83 years old, inexperienced 23.06 years, with the youngest participant being 19 years old and the oldest 57. Total job experience of the participants reached from as low as 5 weeks up to 42 years.

	Non-Experienced	Experienced	Overall	
Gender				
Female	4	1	5	
Male	14	17	32	
Total	18	18	36	
Age				
Min	19	23	19	
Mean	23.06	42.83	32.94	
Max	30	57	57	
Job Experie	ence			
Min	0.1	1	0,1	
Mean	5.3	23.25	14.53	
Max	14	42	42	

Table 1. Demographics	• of	heterogeneous	participants
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As heterogeneity is given in the project and shared understanding can be expected to be critical for the solution to the practical problem situation, it is well qualified as an action research field to explore the general phenomenon described in the introduction.

#### Action Research Approach

Shared understanding is a complex phenomenon in real world settings and no sufficient body of theory is available to explain the mechanisms leading to shared understanding, which could be used to guide design efforts. Therefore we chose an exploratory research design. Exploratory research allows the researcher to gather unexpected observations, examine the phenomenon in a holistic way and react flexibly to new insights. To allow for a holistic view and compensate for the weakness of individual data collection methods, a combination of several data collection methods has been selected. Action research has been chosen as research framework for the study.

Action research is a research approach from social sciences, where the researcher gets actively involved in the intervention and interacts with the members of the focal organization. On the one hand it aims at changing the social system and solving a concrete real world problem. On the other hand, new insights on the system and the phenomenon of interest should be gathered. (Baskerville 1999)

In a systematic cyclical process, the state of specific field situations should be understood and changed. Five phases are passed in an iterative, cyclical way, namely diagnosis, action planning, action taking, evaluation and specifying learning. In this paper, we follow the extended action research model by McKay and Marshall (2001), who make a distinction between problem solving cycle and a research cycle. The two cycle approach has been chosen to address the dual goal of action research and counteract the critics of lacking research rigor of action research. The research cycle aims at exploring the real world phenomenon of interest to gain insights on the theoretical research framework. It leads to answering the research questions specified in section one and helps building a theory or elements of new theory. The problem solving cycle aims at

improving the specific real world problem situation by using a problem solving method to execute an intervention. In the study that underlies this paper, the problem situation exists in the challenge of supporting experience diverse work groups at a car manufacturing company to integrate and transfer their heterogeneous knowledge. The problem solving cycle results in a collaboration process design as the artifact that has been developed to change the real world situation. If the problem situation is related to the phenomenon of interest and is suitable to explore the phenomenon of interest, both cycles can benefit from each other. The dual approach is consistent with Briggs' (2006) claim to separate theory building research from the specific artifact/technological instantiation by defining separate research and engineering questions. The action research design and findings are described in sections three to seven. The piloting project with six teams allowed executing six iterative cycles.

# Diagnosis

In the diagnosis phase, the problem situation is identified and the phenomenon of interest is specified.

# **Real World Problem Situation**

From a problem solving perspective, the specific real world problem situation in the organization is diagnosed. In close interaction with the client organization the goals and general requirements for the piloting project are defined. From a practical point of view, this project aims at engineering a collaboration process design to improve knowledge integration and knowledge transfer concerning complex handcraft work processes within diverse work groups. In a series of three workshops, groups of six tool and dye makers should document a specific work process and develop learning material for new employees. The collaboration process needs to be standardized enough to be transferred to and executed by the organization at a later stage. In parallel to solving this specific problem situation, the project enables us to examine the more general problem of shared understanding in heterogeneous groups, as the groups are very diverse in their background, gender, age and work experience. While the practical solution includes further goals, e.g. producing the learning material as an artifact, shared understanding among the team members on the work process can be assumed as one central aim. Therefore, this pilot project seems suitable for exploring shared understanding from a research point of view.

#### Initial Research Framework

From a research perspective, we want to examine mechanisms leading to shared understanding in collaborative work. We are interested in analyzing how those mechanisms can be evoked by specifically designed collaborative practices. This research goal is based on the assumption that shared understanding is a dynamic state, which changes through the course of collaborative interaction due to certain mechanisms and that those mechanisms can be influenced to some extent by design choices (Bittner and Leimeister 2013). According to McKay and Marshall (2001) an initial research framework should guide the development of first design hypotheses. The collaborative practices we discuss in this paper are grounded on van den Bossches (2011) model of construction, co-construction and constructive conflict as mechanisms leading to shared understanding. Grounding on group cognition research from learning sciences and organizational sciences, van den Bossche et al. (2011) examined three kinds of team learning behaviors. They tested the effect of construction, co-construction and constructive conflict on the development of shared mental models. Furthermore, they measured how shared mental models mediate the effect of team learning behaviors on team performance.

Construction of meaning is referred to as "when one of the team members inserts meaning by describing the problem situation and how to deal with it, hereby tuning in to fellow team-members. These fellow teammembers are actively listening and trying to grasp the given explanation by using this understanding to give meaning to the situation at hand" (Webb and Palincsar 1996).

Collaborative construction (co-construction) is "a mutual process of building meaning by refining, building on, or modifying the original offer in some way" (Baker 1994). Construction and co-construction lead to mutual understanding. However, mutual understanding does not yet mean that group members share one perspective or are able to act in a coordinated manner. As our definition of shared understanding involves a "meaning in use" aspect, mutual agreement on one perspective is furthermore necessary to achieve shared understanding.

Mutual agreement is achieved through constructive conflict, "dealing with differences in interpretation between team members by arguments and clarifications" (Van den Bossche, Gijselaers et al. 2011). Following van den Bossche's model, collaborative groups should express, share and listen to their individual understanding (construction), discuss and clarify them to reach mutual understanding (co-construction) as well as controversly negotiate an agreement on a mutually shared perspective (constructive conflict).



Fig. 1. FPM of Collaboration Process Design for the Construction of Shared Understanding

# Collaboration Engineering as Problem Solving Method

In the diagnosis phase, Collaboration Engineering is chosen as the problem solving method, as it aims at developing reusable collaborative practices for high value recurring tasks that can be executed without the ongoing intervention of a professional facilitator (de Vreede, Briggs et al. 2009). This matches the demand of the organization for a solution which can be transferred from the researchers who engineered the pilot

process to the organization itself. The collaboration process design should be piloted, tested and documented for its future use by practitioners.

# **Action Planning**

#### Intervention Planning to Improve the Problem Situation

In the action planning phase, the intervention to improve the problem situation is developed. We use the Collaboration Process Design Approach (Kolfschoten and De Vreede 2009) to implement the goal (improve knowledge integration and transfer in the group while documenting work processes collaboratively) in a collaboration process design. We split the collaboration process into a series of three one day workshops with homework activities in between the workshops. Only the first workshop is discussed in this paper, as these activities are dedicated to creating shared understanding of the sequence of activities required in the work process and we focus on examining shared understanding here.

The workshop is characterized by three main phases, (1) an individual description (draft) of the craftsmen's work process, (2) integration of the individual drafts in pairs of two and finally (3) the integration of the pairwise drafts in one solution that all six group members commit to. This structure reflects the need for a shared representation of the sequence of activities in the work process at the end of the first workshop. The individual phase is based on the assumption, that an individual working space and individual reflection is critical, as members need to be aware of their own mental model. An individual representation should help by encouraging individual construction of knowledge, reflection and can serve as a boundary object and reminder of the aspects to discuss in the pairwise phase. A pairwise phase has been included between individual and group work to foster the exchange between experienced and inexperienced participants. While in a larger group experienced members could easily take over the discussion and less experienced or less extroverted people might resign from contributing to the group product, in pairs of one experienced and one inexperienced member, both perspectives are likely to be heard.

Both collaborative phases (pairwise and group) are further divided into three activities each according to the three learning mechanisms proposed by van den Bossche et al. (2011). First, the participants try to make sense of the documents for themselves by reading their partners or groups work process description. Second, clarification questions are collected and answered to foster the co-construction of meaning and the evolution of mutual understanding. However, mutual understanding is not sufficient for coordinated action, meaning the collaborative development of learning material based on a shared understanding of the work process. As the two (or three in the group) drafts may still differ or even contradict each other in certain aspects, a third activity aims at evoking constructive conflict. Participants are asked to identify and resolve differences as well as conflicts in a discussion, before integrating their drafts into one that all agree on. A detailed description, how the specific activities are grounded in the theoretical framework of the team learning behaviors can be found in (Bittner and Leimeister 2013). Figure 1 shows the collaboration process design in a facilitation process model (FPM) notation. In combination with a short introduction and a wrap-up, this process design is the basis for the first workshop day with six groups of six employees each from a car manufacturing company.

#### **Choice of Data Collection Methods**

For the research cycle, the data collection methods are selected in the action planning phase. In order to allow for a holistic exploration of the phenomenon of interest, a structured survey before and after the workshop is combined with field notes of the moderator and facilitator as well as a content analysis of the artifacts that evolve during the collaborative work. Those artifacts, the work process descriptions, are interpreted as individual, pairwise and group cognitive maps.

# **Action Taking**

In the action taking phase, the planned intervention is executed in the field. The researcher interacts directly with the participants and actively gets involved in the changes introduced to the problem situation. For the problem solving cycle, this means that the artifact – in our case the collaboration process design – is pilot tested. Six pilot workshops are executed with groups of six tool and dye makers each. Every workshop lasted for seven hours with a lunch break and several smaller breaks. They took place in a university

collaboration laboratory to release the participants from their daily routine and were moderated by one of the authors. Another collaboration engineering researcher facilitated and observed the workshop process. As the action research approach demands an iterative development of the solution, the full cycles where run through for every group and necessary adjustments were made to the process design after each cycle. Data for gaining new insights on the problem field as well as on shared understanding as the phenomenon of interest where collected throughout each cycle. We will present these results and insights in an aggregated manner in the following sections.

# Evaluation

In the fourth phase of the action research cycle, it is evaluated whether the intervention has had the intended effects and whether those effects were able to improve the problem situation. In particular we examine if the participants showed the three group learning mechanisms construction, co-construction and constructive conflict in the course of the collaborative process, that the collaborative practices were meant to evoke. Furthermore, we analyze whether shared understanding increases throughout the process and how the mental model of the work process of the participants changes towards a joint representation. For the problem solving cycle, the evaluation provides information in how far the intervention reached the goals that were set for the project, e.g. concerning knowledge transfer, group cohesion or satisfaction of the participants. The practical evaluation provides indication for the adjustments to the design that are necessary in the next problem solving cycle as well as when the action research project can be closed. For the purpose of this paper, we focus on the evaluation for the research focus of the project. In addition to new knowledge on the research frame, insights on the phenomenon of interest are gathered. Every instantiation serves the advancement of the collaborative practices for building shared understanding in heterogeneous groups.

From a theoretical point of view, two major issues have been assessed. First of all, it is of interest, if the applied collaboration techniques were able to evoke the three team learning mechanisms (construction, coconstruction and constructive conflict), as they have been identified as determinants for shared understanding. Table 1 shows the average values on all three learning behaviors on a 7 point Likert scale among all 36 participants that were measured using the items proposed by van den Bossche, Gijselaers et al. (2011) (1=do not agree at all, 7=fully agree). It can be noted, that all constructs got very high ratings, significantly above the neutral value 4 in a one-sample t-test (T), while no significant differences between experienced and inexperienced participants or between different teams could be detected.

	Average	Ν	SD	Т
Construction	6.3889	36	0.61075	23.468***
Co-construction	6.1481	36	0.66402	19.411***
Constructive Conflict	5.9375	36	0.70553	16.477***

Table 2. Team Learning Behaviors (7 point Likert response format, \*\*\*p<0.001)

As the team learning behaviors are only means to evoke shared understanding in the theoretical framework we use, the change in shared understanding has to be monitored as well to assess the effect of the techniques. We collected to self-assessment measures of shared understanding in a survey questionnaire in the beginning and in the end of the workshop. Shared knowledge has been assessed by the question "To what extent does your group have similar knowledge on [name of the work task that should be documented]?" (1=none; 5=very much). Differences in knowledge were assessed by the question "To what extent does your own knowledge on [name of the work task that should be documented] differ from the knowledge of your fellow team members?" (1=not at all; 5=very much).



Fig. 2. Changes of Shared Knowledge and Different Knowledge

Figure 2 shows that, however, the teams started with different levels of perceived shared knowledge and different knowledge, all teams experienced a substantial improvement of those measures. Table 3 displays, how the measures for shared knowledge and different knowledge among the members of each group change from pretest to posttest. Shared knowledge increased significantly from a mean of 3.0000 to 3.7500, while differences of knowledge decreased from 3.3056 to 2.5556. This self-assessment of the participants goes in line with our expectation, that construction, co-construction and constructive conflict in the collaboration process are related to an increase of shared understanding.

Table 3. Changes in Shared Knowledge and Different Knowledge (5 point Likert response format, \*\*\*p<0.001)

		Average	Ν	SD	Change	Т	
Shared	pre	3.0000	36	0.71714	-0.75000	5 147***	
Knowledge	post	3.7500	36	0.64918	0.75000	5.117	
Different	pre	3.3056	36	0.88864	0.75000	1 650***	
Knowledge	post	2.5556	36	0.84327	0.75000	4.032	

As self-assessed changes in shared understanding may be biased and only reflect a perceived development, we used the changes in the work process documentation the participants generated throughout the workshop as a complementary method to evaluate the evolution of shared understanding. Table 4 reports the number of unique activities mentioned in the work process documentation by each individual after activity A2 (Fig. 1), pairwise after A8, (Fig. 1) and group document resulting from A14, (Fig. 1), e.g. "retrieve data", "roughen component" etc. Furthermore, the increase (+) and loss (-) in number of constructs from individual to pairwise and from pairwise to groupwise documentation is displayed. This evaluation is based on data from five teams, as we changed the form of process documentation after the first team to improve clarity and process smoothness, which hindered comparability of the documents.

Table 4. Changes in Mental Models – Number of Constructs in Work Process Documentation

		individual	pair-individual	pair	group-pair	group
Group 2	non-exp. 1	15	+ 42	57	+ 28	
	exp. 2	24	+ 33			85
-	non-exp. 3	0	+ 70	70	+ 15	

	exp. 4	15	+ 55	_		
	non-exp. 5	12	+ 37	40	+ 36	_
	exp. 6	25	+ 24	_ 47	+ 50	
Group 3	non-exp. 7	52	+ 18	70	+ 9	
	exp. 8	65	+ 5	/0		
•	non-exp. 9	48	- 1	47	+ 32	- 79
-	exp. 10	15	+ 32			
-	non-exp. 11	44	+ 22	66	+ 13	-
	exp. 12	55	+ 11	_ 00	15	
Group 4	non-exp. 13	29	+ 36	65	+ 22	
	exp. 14	49	+ 16	05		
	non-exp. 15	17	+ 36	53	+ 34	- 87
-	exp. 16	26	+ 27		- 54	07
	non-exp. 17	16	+ 22	38	+ 49	_
	exp. 18	36	+ 2	_ 50	- <del>-</del> - <b>-</b>	
Group 5	non-exp. 19	57	+ 26	83	+ 23	
	exp. 20	80	+ 3	05	1 23	
	non-exp. 21	39	+ 27	66	+40	- 106
-	exp. 22	31	+ 35	0		100
	non-exp. 23	18	+ 46	64	+ 42	_
	exp. 24	54	+ 10	01	12	
Group 6	non-exp. 25	60	+ 10	70	+ 13	
	exp. 26	65	+ 5		15	
	non-exp. 27	54	+ 11	65	+ 18	- 83
	exp. 28	57	+ 8	_ 00	. 10	35
	non-exp. 29	27	+ 23	50	+ 33	_
	exp. 30	28	+ 22			

# Specifying Learning

Formally the last phase of action research, the documentation and interpretation of findings is in fact executed continually throughout the process. Knowledge that has been generated in the intervention and evaluation can be applied immediately in the diagnosis phase of the next cycle due to the open, exploratory research design. Thus, we made several adaptations to the collaboration process design after the first cycle. First, the initial participants documented their work process on flipchart sheets. As participants frequently wanted to change the order of their sequence or wanted to insert further activities, later teams worked with individual paper cards for each activity in the work process. This visualization aid also proved better, when pair wise and group wise documentations were created, as it was easier for team members to make sure to consider all activities and saved time, as descriptions did not have to be built from scratch.

The second process adaption concerned an evaluation activity, which was initially executed after A9, but was left out in the revised design. Participants had been asked to reflect on the differences of their own

pair's documentation in comparison to the other two. They should indicate on a Likert Scale, how much each other documentation conflicts with their own understanding of the work process. It turned out, that participants were not happy with this global level of evaluation and that we could not identify a recognizable impact on the further discussion. Therefore, it was omitted.

In further iterations, no major changes to the design had to be made. We observed that all teams acted relatively similar and followed the process design. Evaluation indicates that team learning behaviors could be evoked in every group and measures of shared knowledge and shared understanding developed positively. Several trends become apparent: First of all, in most cases the number of constructs increases substantially from individual to pairwise to group documentation. As participants showed commitment to their pair and group solutions, we come to the conclusion, that the understanding of the work process became more detailed and elaborate throughout the workshop. Even very experienced participants, who have been executing the work process for decades, were not able to explicate and write down all relevant process steps initially. New activities that had not been mentioned by any individual came up in the construction, co-construction and constructive conflict phases. This observation indicates that the team learning behaviors evoke mutual learning and that experienced participants can as well benefit from the collaborative effort due to questioning and reflection. Second, in most pairs, the experienced participants (exp.) contributed more constructs initially, while their less experienced co-workers (non-exp.) adopted more new constructs, when a pairwise description was developed. In two pairs of groups three and five, the non-expert contributed more than the expert. Both experienced participants noted in this situation, that they found it hard to explicate their knowledge and that they benefitted from the impulses and questions given by their colleagues. High values of pretest shared knowledge in both teams indicate that inexperienced members of those teams already had an idea of the work process, which could be verified in interaction with the experienced colleague, who was thus fostered to explicate his knowledge.

We conclude that getting involved in the collaboration process as it is described here led to construction, co-construction and constructive conflict as well as more shared understanding among the team members. Inexperienced participants in general started with less detailed mental models of the work process, which were refined and complemented within the collaborative phases. Experienced participants had more advanced individual documentation, but gained further insights from the different approaches of their colleagues. Especially, they reported that the critical questions by inexperienced colleagues made them think about how to explicate their tacit knowledge. Furthermore, some of them reported that the interaction made them aware of some activities they forgot to document as well as of the existence of different approaches within their work group. The formal evaluation goes hand in hand with oral reports by several participants, who had the impression that they learned a lot from each other and that the group work was advantageous for their understanding.

# Implications, Limitations and Future Research

To overcome the challenges in heterogeneous teams we used the action research approach to build a repeatable collaboration process to improve shared understanding.

The evaluation showed that the team learning behaviors construction, co-construction and constructive conflict occurred as intended. That leads to the conclusion that the applied collaboration techniques are a good means to evoke mechanisms leading to shared understanding. Furthermore, shared understanding could be increased, which became evident in the self-assessment of the participants as well as the changes in the working documents that reflect participants' mental models of the task. Both are indicators that the collaboration process design works and has the intended effects. Pairing of experienced and inexperienced co-workers seems advantageous for mutual learning.

This paper contributes to Collaboration Engineering practice by solving a specific problem in the organization and developing a pilot collaboration process design for shared understanding. The general process design can assist practitioners in building shared understanding in heterogeneous group work settings for complex tasks. Furthermore, we contribute to collaboration research by applying van den Bossche et al.'s (2011) model to guide design efforts. The application gives first insights on the mechanisms leading to shared understanding in groups of experienced and inexperienced workers.
However, the findings need to be interpreted in the light of exploratory action research design. The study was executed in one specific real world setting. Future applications in different settings could add to the understanding of mechanisms leading to shared understanding. For example, different combinations of experienced and inexperienced participants could be compared to identify an optimal degree of heterogeneity or different types of diversity could be explored. While the focus of this paper was on qualitative exploration of the phenomenon and design, data on shared understanding and team effectiveness, which has been collected after the workshop, should be used in future work to test the causal model. In this course, the assessment of the individual and team cognitive maps should be further extended. As work process documentation was mostly linear in the case at hand, we focused on the number of constructs, and excluded order and structure. They should be included in future research. In the real world situation, no control group was available to test for other influences than by the deliberate design choices. Therefore, no direct attribution of team learning behaviors to individual activities and design choices is possible at this stage. Also, alternative influences on the observed behaviors and shared understanding could not be controlled for, such as e.g. the influence of time spent together. Evaluation of the isolated collaboration techniques in an experimental setting could overcome those limitations in future work.

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# Toward Optimum Collaborative Group Dynamics for Decision Making for Sustainability: Key Competencies of Participants and Key Group Characteristics

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**Abstract**: Collaborative multi-disciplinary and multi-stakeholder groups are a necessary vehicle in a transition toward sustainability from the local to the global. What are the key individual attitudinal and behavioral competencies and what are the best collaborative dynamics for effective participation in negotiation and decision in these groups? We report here initial findings of research of individuals in the Arctic, Caribbean, and USA that participate in groups seeking to generate action for a sustainable future.

Keywords: Sustainability, Negotiation, Decision, Collaboration, Leadership, Community.

## Introduction

While mitigation and adaptation to the rapid global warming and extreme weather effects of climate change are at the forefront, there are many more challenges in a transition toward sustainability (Griggs et al., 2013). These include a reduction in poverty, managing human migration, improving access to healthcare and education worldwide, reduction in the consumption of limited natural resources, etc. To negotiate these challenges across the many cultures worldwide teams of researchers must work with a variety of experts both local and non-local to those cultures as well as a variety of others who have a stake in the outcome decisions (for policy, action, etc.) those negotiations reach. These teams must collaborate, negotiate, and make decisions on how to best coordinate their actions and those of their communities. The formation of these teams represents the first time when so many different experts have needed to work together toward such a complex and at the same time important cause - and do so with an acute awareness of urgency.

Commensurate with the multitudinous nature of sustainability, it appears an increasing diversity of people are taking-up the wide variety of tasks necessary for a transition toward a sustainable future across global societies. These individuals can be seen as being variously described in the literature as world benefit leaders, cultural creatives, evolutionary leaders, positive deviants, social entrepreneurs, international social workers, sustainability champions, adaptive network leaders, knowledge managers, transition managers, and boundary managers. Active in a variety of settings from small rural villages to multinational corporations, they can serve as key agents for change in public opinion, for example on global climate change (Gore, 2010; Krosnick et al., 2006) and key agents for public action, for example by building capacity through local participation rather than encouraging dependency (Bornstein, 2007). In general terms and for the purpose of discussion, these individuals can all be regarded as Community Leaders for Sustainability (CLS) because through their leadership and management they are all striving toward the achievement of the various criteria for global sustainable development. CLS are often engaged in action beyond their local communities and institutions, often linking local communities and institutions across cultures, boundaries, and across scale (c.f. Bradley et al., 2009) suggesting that the phenomenon is based in global similarities, that is, shared human attributes, rather than differences.

This presentation describes an ongoing research project funded by the US National Science Foundation that seeks to help develop CLS so that they can best work together within and across cultures, within and across challenges, and help support their network growth across the world. At the center of this research on leadership development for sustainability is the Sustainable Futures Protocol (SFP). The SFP is a social science research system by which the optimal competencies for collaboration and best practices for coordination of actions for sustainability can be understood, measured, and developed; those within specific contexts and those shared globally. Research and development of the SFP seeks to support the ongoing work toward optimum collaborative group dynamics for decision making for sustainability with regard to the key competencies of participants and key group characteristics. The SFP is currently being tested and developed with those seeking to achieve sustainability for communities in the Arctic, Caribbean, and USA. Results from this work will provide a testing, teaching, and development tool for individuals and groups with regard to community leadership and optimal community dynamics for sustainability. It will provide a guideline of skills we can all develop as we seek to move toward a sustainable global future. Some initial results from this ongoing research is shown in the Results section that follows.

# Results

Research and development of the SFP seeks to reveal some of the key individual competencies and key group dynamics in terms of attitudes and behavior that will best serve to forward the negotiation and decision making processes for sustainability. In this section one example of some of the initial results of ongoing research is illustrated.

An interpretive content analysis of the literature combined with analysis of interviews of community leaders for sustainability (CLS) in the Arctic, Caribbean, and USA has, to date, revealed that while the challenges in the transition toward sustainability faced by communities vary widely the leaders seeking to meet those challenges may possess and implement many similar personal and social characteristics in seeking to overcome them. In particular, results indicate the characteristics of leadership, connectedness, and resilience in relation to oneself and others seems to be prevalent in both the CLS described in the literature and in those participants' interviewed that are currently engaged in generating sustainable communities.

For instance, statements like, "[I have] a foundation of duty. It's something I have to do" and "I know there will be 7 billion [people] soon, but I'm an optimist. You have to put your mind to it. You have to help people. And if I am able to do it [which I am], I will" within the context of the interviews are highly suggestive of leadership in relation to self and others.

Interview data was analyzed utilizing Dedoose © software developed by Eli Lieber PhD at UCLA so that it could be organized, tabulated, and interpreted for results. An example of the results related to self/other leadership, connectedness, and resilience from some of the interview respondents (pseudonyms utilized) are shown here:

Concept	Leadership	Connectedness *	Resilience	Total
Kathy	3	3	14	20 (20%)
Pam	6	3	9	18 (18%)
Joe	4	4	5	13 (13%)
Ruth	8	4	4	16 (16%)
Frank	7	1	3	11 (11%)
Manny	6	1	2	9 (9%)
Roy	3	2	7	12 (12%)
Total Mentions	37 (37%)	18 (18%)	44 (44%)	

Table 1. Interview coding results based on Global Sustainability Inventory concepts

\*codes of indifference, separation, and disengagement were not found.

Thus, leadership, connectedness, and resilience in relation to oneself and others are likely key competencies that support a transition toward sustainability. These three dimensions were, therefore, utilized in this research to help construct the Sustainable Futures Protocol (SFP). The SFP utilizes both quantitative (survey methods) and qualitative (interviews, focus groups, etc.) research and integrates them in a mixed methods approach. In a recent review of the literature Wiek et al., (2012) collated the work of others to synthesize a list of five competencies for individuals seeking to forward a transition to sustainability they described as

systems-thinking, anticipatory, normative, strategic, and interpersonal competence. Comparative analysis of Wiek's work and the research presented herein is now in progress.

Furthermore, this study is beginning to reveal that not all CLS engage in exactly the same type of role in their communities. For instance, some are leaders, others take on a more managerial role, while still others act as social connectors. Given the broad spectrum of activities they are engaged in this may not be a surprising revelation. It is well established that leaders and managers can have different roles within organizational systems (Kotter, 2001; Zaleznik, 1992). Social connectors engaged in initiatives for sustainability (c.f. http://scwf12.wordpress.com/living-bridges/ ) can act as human or "living bridges" linking individuals in networks to optimize resources and action. The possibility of a typology of CLS is currently been investigated as part of this study.

#### Discussion

Collaborative groups involved in the decision and negotiating processes for sustainability might best be considered as a community in their own right, from the local to the global, because as suggested in this research and elsewhere (c.f. Leiserowitz, Kates, & Parris, 2006; Wiek, 2012), they may share a common outlook, common principles as well as other key competencies that make them effective across cultures and across situations. The term community can refer to either a physical locality or to any group that shares a "common interest or cause even if they do not share a common location" (Green et al., 2001, p. 20).

Psychologists have recognized for some time that certain people participate more than others in the betterment of their communities (Bronfenbrenner, 1960). A content analysis of the literature suggests this may hold true for communities transitioning toward sustainability as well. It may be prudent, therefore, to consider two types of communities based on the relative degree of participation individuals take for sustainability. The first community is comprised of those most actively involved as researchers and stakeholders that form collaborative groups to coordinate their efforts and action. For the sake of this discussion we can refer to these groups as Collaborative Communities for Sustainability (CCS). In this sense, CCS are a community within a community. The second community is the overall community and its citizens. They too can, and indeed must be (and many are) active in generating a transition toward sustainability but are, as a matter of this distinction less so than those of the CCS community. In this study, then, a distinction is made to explore three lines of inquiry: a) research of the optimum approaches to collaboration (for negotiation and decision making) and coordination of actions among CCS community members; b) the optimum indicators and models for sustainability of their communities as a whole (the overallcommunity/community-at-large); and, c) the best practices of interaction between the two communities that will yield the best outcomes in terms of reaching democratic consensus agreements and driving knowledge transfer and technology implementation from the local to global level.

A review of the literature reveals that CCS are best comprised of a diverse group of participants with local and non-local expertise and thereby optimally embedded in and linked to both the local and global community. These cross-scale linkages can support the various cross-cultural discourses necessary in a collaborative transition toward sustainability.

These are some of the exciting insights and results from ongoing research into the optimum collaborative group dynamics for decision making and negotiation for the human environment and for sustainability overall. Results from social science research with CLS/CCS seeking to transition communities in the Arctic, Caribbean and USA will be presented.

Acknowledgments. This research project funded funded through NSF funding OPP #1128004 (2011-2012) and pending.

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# Helping Facilitators Build on Experience When Preparing Meetings With Logical Information Systems

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**Abstract**: This paper reports work in progress about using Logical Information Systems to help facilitators build on experience when preparing meetings. Features of meetings similar to the one under construction are automatically suggested without having to ask for suggestions. Suggestions take into account the whole information about all the meetings already recorded in the system as well as facilitation knowledge, such as thinkLets. Usual techniques and processes that facilitators like to use are naturally suggested. An unusual technique is suggested for example if the facilitator enters a keyword that is a feature of that technique. Although a lot remains to be done, the proposed approach already shows contributions that make believe that it is worth investigating further. The main one is that it builds on the facilitator very practice. Other important features are flexibility and adaptability.

Keywords: Artificial Intelligence Methods in GDN, Logical information systems, Concept Analysis Application, Facilitator support, Agenda building, ThinkLets.

## Introduction

Group work represents a large amount of time in professional life while many people feel that much of that time is wasted. Briggs et al. argue that a meeting facilitator significantly improves the efficiency of meetings but that skilled facilitators are in general scarce and expensive (Briggs et al., 2010). It is therefore important to build tools to support inexperienced facilitators.

Facilitation Knowledge - In order that facilitators do not have to reinvent the wheel at each meeting, techniques have been collected. More than forty-three techniques are given in (Kaner, 2007). Thirty-nine thinkLets are described in a structured way in (Briggs & de Vreede, 2009). ThinkLets are defined as the smallest unit of intellectual capital required to create one predictable, repeatable pattern of group deliberation - a pattern of thinking among people working toward a goal. The two lists give different and complementary points of view but they do not yet give a complete picture. Indeed, more techniques and models can be found in the literature and thinkLets continue to emerge, for example "ExplainIt" in (Kolfschoten et al., 2010) or "LogicalMulticriteriaSort" in (Ducassé & Cellier, 2012). Furthermore, the knowledge about the techniques, tools and thinkLets is not unified. For example, (Kaner, 2007) classifies the techniques into 4 "zones" which happen in sequence: divergent, groan, convergent, and closure when (Kolfschoten et al., 2010) classifies them into 6 collaboration patterns: generate, reduce, clarify, organize, evaluate, consensus building. While divergent and generate match, groan includes a technique called "learning other's perspective", which corresponds to pattern clarify, and that pattern is claimed to help convergence in (Briggs & de Vreede, 2009). Even within a given community, the ontology is not yet stable, for example, the notion of modifier is introduced in (Kolfschoten & Santanen, 2007) to reduce the number of core thinkLets by introducing ways to parameterize them.

Techniques or thinkLets used to drive meetings are not the only important aspects of meetings. In (de Vreede et al., 2003), six items, which must be clearly specified for a meeting to be successful, have been identified: its goals, its outputs, who is responsible for the outputs, the meeting process, its inputs, the GDSS tools used. Concerning the meeting process, in (Kolfschoten et al., 2004) the transcripts of over 100 meetings supported by a given GDSS are analyzed. Half of the facilitators only had used formal thinkLets and all had changed the scripts to adapt to the needs of their groups. Furthermore, it was revealed that facilitators quickly tend to develop habits and use almost all the time the same schema of meetings independently of the meeting goals.

Facilitation knowledge is, thus, on the one hand still building and on the other hand not used as much as it could. Tools to help aggregate that knowledge and easily use it are needed.

**Personal Experience** - As Director of International Affairs of my university, I have to attend a significant number of meetings. Facilitation knowledge helps me understand situations, for example why a meeting fails when the group must reach a decision in a limited amount of time and the facilitator uses diverging techniques only.

I also have to organize many meetings that have several characteristics. For each meeting there are many topics to address, for example, reminders for actions still to be done, design of a stipend policy, information about new regulations, or open questions from the attendees. Topics are in general addressed at several, not necessarily consecutive, meetings: for example, a problem to be addressed is exposed at one meeting, propositions are discussed at another meeting, decisions may be made at another meeting and actions are followed up at yet other meetings. A major concern is therefore to avoid forgetting pending issues. There are also recurring topics that often come every year. Last but not least, the impact of each decision is in general limited.

I usually prepare slides, starting from the slides of two meetings: the previous one in order to address pending issues, and the meeting of the same kind a year ago to have the recurring topics. Each topic usually corresponds to a few slides with key information. If the topic is in an early diverging stage, they also contain open questions, and I plan to use brainstorming techniques or "birds of a feather" sessions. If a decision is needed, the slides contain one or several propositions, and I plan a discussion aiming at reaching a consensus, with a vote after a "time out". Using slides at meetings proves to be useful. It helps keep group attention focused, outputs are effective, and the slides, updated during the meeting, provide immediate minutes.

I am, thus, behaving as the average facilitator, I use almost all the time the same schema of meetings. Being convinced by the assets of facilitation techniques and thinkLets, why do I make such a limited usage of them? An important issue is that I have a very limited amount of time to organize meetings. Another issue is that, as the knowledge is constantly evolving, it is hard to master in depth all the existing techniques and thinkLets. With the current tools, using a new technique requires to go through the catalog, reading descriptions and comparing different techniques. Due to the limited impact of each decision and time constraints, it is rare that the addressed topics are worth spending that much effort.

The objective of the described research is to help facilitators prepare meetings following their preferred schema but with an easy access to alternative techniques. In so doing, we also aim at reducing the cognitive load of keeping track of pending and recurring issues, which currently requires a lot of energy, with no guarantee.

**Contribution** - This paper reports work in progress about using Logical Information Systems to help facilitators build on experience to prepare meetings. Meeting features are automatically suggested. Suggestions take into account the whole information about all the meetings already recorded in the system as well as basic knowledge about techniques and thinkLets. When building a meeting agenda, features of "similar" meetings are suggested without having to ask for suggestions. As soon as the facilitator starts preparing a meeting, all the features of all the meetings are suggested to him. Each time a feature is entered, the system adapts the suggestions, taking into account only the meetings similar to the one under construction. Usual techniques and processes that skilled facilitators like to use are naturally suggested. An unusual technique is suggested for example if the facilitator, either skilled or inexperienced, enters a keyword that is a feature of that technique. Facilitators, thus, do not have to investigate in depth the full catalog of techniques to enlarge their practice; they only have to consider a limited set of suggested techniques that are probably relevant. They also do not have to dig into meeting minutes to find pending and recurring issues.

Logical Information Systems (LIS) belong to a paradigm of information retrieval (Ferré & Ridoux, 2004) and update (Hermann et al., 2012) that combines querying, navigation and suggestion. The paradigm is formally founded. Logical formulas are used to represent queries, navigation links and suggestions. The user interface, through the navigation links and suggestions, allow users to easily select and re-use existing data.

Our current prototype, Serenelis, is built onto Sewelis, a LIS for the semantic web. The current knowledge base includes parts of the features given in (Briggs & de Vreede, 2009) to describe thinkLets and parts of the features identified by (de Vreede et al., 2003), as well as the description of some effective meetings. Preliminary experiments are encouraging, as illustrated by the example described in the following section. A discussion and comparison with existing agenda builders can be found in Section 3.



Fig. 1 Snapshot of Serenelis when Preparing a Meeting

# Example with a Preliminary Version of Serenelis

Figure 1 shows Serenelis at a moment where a facilitator is preparing a meeting to arbitrate the allocation of stipends for international student mobility. Serenelis interface is currently the generic interface of Sewelis. It is made of three parts: (1) the query, on the left-hand part, (2) the extent, on the right-hand part, and (3) the index, on the middle part.

(1) The query is a logical formula that typically combines attributes and Boolean connectors. The query of Figure 1 is equivalent to 2013-comm-bourse-jan and a Meeting and Structure : commission arbitrage RI and Institution : INSA Rennes and Date : 2013-01-31. It means that the facilitator is interested in objects describing the meeting called 2013-comm-bourse-jan, that concerns the International Relation Arbitrating Committee (structure) of the INSA Rennes (Institution), and that will take place on January 31st of 2013. The query is colored in red because there are currently no object satisfying the query. That is quite normal as we are creating a new object. The query has been produced by navigation. Namely, in the index part, the facilitator clicks on a Meeting, the query is then a Meeting. The facilitator then enters the identifier of the meeting, 2013-comm-bourse-jan. Then in the index part, which had shrunk to the actual features of existing meetings, he double-clicks on Structure, the query becomes 2013-comm-bourse-jan and a Meeting and Structure : ?. The focus, namely the place where the description can grow, is thus on the values of the structure. In the list of the suggested structures, namely the structures that have been used in other meetings, he finds the one he needs, namely commission arbitrage RI (International Relation Arbitrating Committee), he clicks on it. The query becomes 2013-comm-bourse-jan and a Meeting and Structure : commission arbitrage RI. In the same way he enters the institution just by clicking. He has to enter the date by hand, and the format of the dates of the previous meetings guides him to do it in a consistent way.

(2) The extent is the set of objects that are possible at the focus. As already mentioned, in Figure 1, there are no objects satisfying the query. The objects listed in the extent are actually suggestions of meetings similar to the meeting under preparation. They are obtained by relaxing properties or values in the current query that represents the description under construction of the new meeting. Here the similar meetings, obtained from the query by relaxing the date value and the meeting identifiers, are two other stipend-arbitrating committees (2012-comm-bourse-Jan and 2012-comm-bourse-mar) and another meeting of the same structure (HarmonisationJurys). A detailed description of the suggestion mechanism can be found in (Hermann et al., 2012).

(3) The upper part of the index, in the middle of the window, is a set of features, taken from a finite subset of the logic, and restricted to features associated to at least one object in the extent. The index plays the role of a summary or inventory of the extent, showing which kinds of objects there are, and how many of each

kind there are. With the information in Figure 1, the facilitator can see that the 3 other meetings of the same structure had all, an Agenda, a Date, an Institution and a Structure, one of the meetings had object and participants specified, another one had Technique specified. The bottom part of the index lists the techniques that have been specified in one of the 3 meetings, namely StrawPoll. The facilitator could decide to re-use the technique for the meeting under preparation.

Next steps for the preparation of the meeting could be, firstly, to double-click on Agenda and select agenda items from previous meetings that are relevant for the current one; then to add new items. Note that if the facilitator wants to add a new feature not yet in the knowledge base, he can simply enter its name and value in the dialog box of the query area and click on Create.

## Discussion

As already mentioned, this article reports about work in progress. The following three tracks will be explored as priorities. Firstly, the ontology of facilitation knowledge has to be refined. The suggestion mechanism does not need a pre-specified ontology to be effective (Hermann et al., 2012). The features (classes, objects, properties and values) can be entered when they are needed. The ontology is therefore built "bottom up". That is an advantage because one can start to populate the knowledge base even if the ontology is not complete. Building an ontology is a difficult task, and deciding than an ontology is complete is an issue per se. After preliminary experiments, it appears, however, that the suggestions would be more focused, thus more relevant, if the ontology had more structure and tags. Secondly, the user-interface has to be adapted to the specificity of meeting preparation. Indeed, as already mentioned, the user-interface of Serenelis is the generic one of Sewelis. Usability studies have shown that software engineers and computer scientists could adapt to it rather smoothly but it is not granted that it would be the case for casual facilitators. Thirdly, once the features of a new meeting are set up, a perspective is to automatically produce a set of slides.

Although a lot remains to be done, the approach of Serenelis already shows contributions that make believe that it is worth investigating further. The main one is that it builds on the facilitator very practice. Other important features are flexibility and adaptability. For example, AgendaPlanner of MeetingWorksTM (Lewis, 2010) provides an editor to enter agenda items. To our knowledge it does not provide support to choose agenda items among previously used items as in the Serenelis approach.

The GDSS Meeting Preparation Tool of (Antunes & Ho, 2001) is based on the classification and techniques of (Kaner, 2007). It helps facilitator design meetings and in particular choose techniques. The facilitator must first define the zone then the strategy among the proposed one then an activity. The order in which the choices must be made is rigid. Even if that order seems natural, there is always a moment where a facilitator knows exactly what he wants to do and in that case he should be able to go straight to the activity. With the Serenelis approach, the facilitator chooses which feature he wants to address first. Even if it turns not to be the best way to set up a meeting in the absolute, it is the way that fits best his current state of mind.

The "Choice tool" proposed in (Kolfschoten & Veen, 2005), is based on thinkLets and collaboration patterns (Kolfschoten et al., 2010). Meeting features are predefined. Part of them can be used as selection criteria, and part of them are only present as documentation. To design a meeting all selection criteria must be valued. With the Serenelis approach, any feature is an active criterion. The facilitator can choose to set values for any of them, or to ignore them. He can also add new features on the fly if necessary. The suggestion mechanism is able to adapt to every new state of the knowledge base.

Acknowledgments. The author thanks Sébastien Ferré and Benjamin Sigonneau for their kind and competent support to use Sewelis. She is also grateful to Peggy Cellier and the anonymous referees for their comments and suggestions.

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# Combining rank-dependent models and rule-based aggregation for experts' joint decision making

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Abstract: Nuclear power operators are currently performing maintenance programs of cooling towers basing the diagnosis and maintenance decisions on experts. Finally, the operator has to prioritize maintenance operations considering the fleet of nuclear power plants towers. The decision support described in this paper aims to sort towers with respect to their overall risk. It combines first a model rank-dependent utility model (RDU) in order to appraise risks locally and factor in experts 'attitude towards risks. Second, it employs a rule-based model in order to aggregate local risks into an overall risk. More precisely, it factors in majority and non-compensatory effects. Experts and decision-makers are brought together in a facilitation meeting so as to adjust the RDU constants and the parameters of the rule basis and reach a joint decision.

Keywords: group decision making multiple criteria sorting, rank-dependent utility, rule-based model

# Context

Cooling tower structural failures is an important concern for the nuclear industry. For that purpose, operators are currently performing maintenance programs basing the diagnosis and maintenance decisions on experts. Finally, the operator has to prioritize maintenance operations considering the fleet of nuclear power plants towers. The decision support described in this paper addresses this problem. According to Roy' multiple criteria taxonomy (Roy, 1996), it amounts to sort towers with respect to their overall risk. More precisely, each tower has to be assigned into ordered classes of priority. The approach described here aims to help a group of experts to make this joint decision. However, the risk assessed from mechanical data by experts raises cognitive issues. Besides, making the risk analysis auditable and understandable for corporate decision-makers is a second concern of this paper.

To this end, we developed and implemented a two-step decision support to tackle both issues. Both steps are of paramount importance to conduct a facilitation meeting with experts and decision-makers and to establish a sound and well-informed risk analysis of cooling towers.

## Information at hand for the decision-making problem

Here, risk managers' decisions rest on technical information provided by the structural engineering. Finite element analyses based on the structural engineering yield two-dimensional risk maps of cooling towers. A map consists of a large array, each mesh representing the aggregated result of mechanical loadings (i.e. local mechanical risk). Let us denote by X the attribute representing the result of the mechanical loadings computed on each mesh. X varies from 0 to 1 meaning respectively no mechanical risk to the state of extreme risk at the mesh level.

# **Decision-making support**

The decision support falls into two main steps.



Fig. 1 Overall framework of the decision support.

#### Step #1: accounting for experts' attitude towards mechanical risks

The first step aims to roll up risks computed for each mesh and factor in experts' judgments towards risks. The point is to aggregate dispersed consequences, here. Let us denote by the distribution of the above defined variable X. Let qi be the proportion of variable xi within the area Zk:

It is noteworthy that a distribution such as can be considered similar to a probability distribution. However, rolling up local risks to an overall risk score cannot be performed by a mere average, such as an expected value. Doing so would overlook the experts' attitude towards risk. Indeed, risks on scattered meshes are not deemed equivalent to risks of the same magnitude and concentrated on contiguous meshes. The Expected

Utility (EU) setting seems to be appropriate to handle dispersed consequences. However, individuals tend to overweight worse outcomes, when facing high-impact low-probability risks. Such an attitude does not comply with EU. In fact, individuals transform cumulative probabilities of lottery by a subjective weighting function w(.). The Rank-Dependent Utility model (RDU) (Allais, 1953), (Quiggin, 1982), (Tversky and Kahneman, 1992) is most appropriate to accommodate such a behavior and factor in the risk aversion. Within the RDU theory, individuals whose weighting function w(.) of cumulative probabilities is convex, exhibit risk aversion. Here, the experts' attitude (i.e. the function wi(q)) has been elicited by adapting protocols used in risky decision theory (Abdellaoui 2000). In our case, the elicitation of the function w(q) and the utility function u(X) yielded results in compliance with what is usually observed for probability distributions (convex and S-inverse shaped w(.) functions). Accordingly, our approach implemented the RDU model for processing the spatial distribution , as follows:

$$U(\widetilde{X}) = w(q_1) \cdot u(x_1) + \sum_{k=2}^{n} \left[ w\left(\sum_{i=1}^{i=k} q_i\right) - w\left(\sum_{i=1}^{i=k-1} q_i\right) \right] \cdot u(x_k)$$

$$With \quad u(x_1) \ge \dots \ge u(x_n), \quad w(0) = 0 \quad \text{and} \quad w(1) = 1$$

$$(1)$$

Where u(.) and w(.) are respectively the expert' utility and weighting function. Note that when w(q)=q, RDU reduces to EU.

The individual preferences w(.). were collected first, by an introspective and individual protocol. The collective preferences  $w_G$  (.) were then determined as the convex hull of the set of individual subjective transformations  $w_G$ (.), thus reflecting the highest risk aversion observed among the experts' panel.

However, this aggregation cannot be performed on the whole tower since risks X taken at the lowest, medium and highest parts of a tower have not the same impact to the overall tower risk. Thus, the tower map has been divided into 16 areas  $\{Z_1, ..., Z_{16}\}$ . Paralleling with the notion of certainty equivalent, an

(2)

equivalent of  $\widetilde{X}^k = (x_1, q_1, \dots, x_n, q_n)$  distribution is thus obtained for each area  $Z_k$  as follows:

$$\overline{\mathbf{X}}^{k} = \mathbf{U}^{-1} \Big( \widetilde{\mathbf{X}}^{k} \Big)$$

#### Step #2: aggregating areas so as to make risks analysis auditable

The set of scores  $\{\overline{X}_1,...,\overline{X}_{16}\}\$  is now the basis to assess the overall reliability of a tower. Considering the areas Zk as criteria whose values are given by  $\overline{X}^k$ , the second step aims to assign each tower in a class of overall risk (i.e. sorting problem). At this stage, when making an overall judgment based on risky areas, experts and decision-makers' rationale takes various forms such as veto, majority and partial compensation principles. Such principles cannot be accounted for neither by EU nor by RDEU models. Accordingly, the second step resorts to a rule-based model inspired by the European School of multiple criteria decision aiding.

Although not yet very widespread, rule-based models are well suited to represent the complexity of individual reasoning. They have been implemented in various cases (Beaudouin, 2009), (Chen and al. 2011), (Slowinski et al., 2002). Their intuitive 'if-then' syntax is easily understandable and close to experts' language. Here, the scores are transformed in ordinal values ranging from the 'Very Low' to the grade 'Very High, thereby providing an auditable map of risks, tractable by a rule-based model.

However, the use of classical rules is not convenient here, due the number of criteria  $Z_k$ . For that purpose, this paper advocates the use of predicates (Azibi, 2002) to model the conditional part of the rules. The syntax of predicates consists in considering no longer simple criteria but coalitions  $A_i$  of criteria  $Z_k$ , as follows:

$$Rule \ m: \ If \ and_{i=1}^{n} \left[ \Pr \ ed_{i}(\Delta_{i}, n_{i}, A_{i}, G_{i}) \right] \ then \ TowerRisk \mapsto Caterogy \ C$$
(3)

Where means 'at most'or 'at least' or 'exactly', Gi is a subset of grades ranging from the 'Very Low' to the grade 'Very High'. Ai is a subset included in . In equation (3), the predicate Predi of the conditional part is interpreted as follows: ({at most , at least, exactly} ni areas belonging in Ai take their values in Gi. Thereby, predicates allow to write rules in a compact form since criteria are of the same type, here.

The construction of predicates is based on an interactive process where experts and decision-makers express general principles of criteria interactions: veto principle for high-level risk areas, compensation for mediumlevel risks and majority mainly for low-level risks. However, a single rule cannot account for the complexity of experts'reasoning. A set of disjunctive rules (i.e. the rule base consists of rules linked by a 'or' operator) is thus necessary. Practically, a rule base is then presented and revised during several facilitation meetings.

Note that the consistency of a rule base is not guaranteed a priori and must consequently be checked formally (compliance with Pareto dominance, exclusivity and completeness). Observing that a rule base can be translated into an algebraic representation, it can be shown that rules can be rephrased into constraints of an optimization program. Then, checking the consistency of the base with regard to the three above-mentioned properties amounts to solve 0-1 an integer linear program (Azibi, 2002).

#### Conclusion

The major contributions of this communication combine a rank-dependent utility and a rule-based model using predicates, in a consistent way. These advanced models have a greater descriptive performance than the conventional ones.

The decision support presented here has been demonstrated on a full-scale case. It allows to rank significant maintenance operations involving a group of experts.

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# Analyzing expert and novice facilitated modelling in problem structuring workshops

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**Abstract**: This research provides an empirical comparison of expert and novice facilitators during facilitated modeling. Prior work is theoretical, thus we analyze the behavior of one expert and two novices during a Viable System Model workshop. The findings indicate common facilitation behaviors of experts and novices – contrasting the claim that experts and novices behave differently, and different facilitation behaviors – suggesting the new dimension 'internal versus external' facilitation.

Keywords: Problem Structuring Methods, facilitated modeling, expert, novice, Viable System Model

This paper focuses on Facilitated Modeling (FM), carried out in relation to participatory and interactive approaches known as Problem Structuring Methods (PSMs). PSMs are useful to tackle complex and uncertain problem situations by enhancing group negotiation, dialogue, decision making and agreement, and eventually make progress with the problem situation of concern. The aim of the paper is to analyze the differences in behavior between expert and novice PSM facilitators, in terms of how they carry out facilitation roles and use related skills.

PSMs are based on assumptions of stakeholders' different worldviews, decision making and negotiation within groups as the main organizational entity, and facilitated building of mostly qualitative models on visual displays. FM occurs during workshops involving a group of stakeholders in conversations and assisted by a facilitator with the aim at resolving complex and uncertain problem situations. The facilitator – Operational Research (OR) consultant or researcher – interacts with stakeholders using group modeling to address the problem situation of concern. During these model-supported interactions the facilitator enhances stakeholders' active and free contribution, so to extract knowledge about the problem situation useful to build models. (S)he aims at enabling stakeholders to work together much more effectively in tackling the problem situation, focusing on group tasks to move in a productive direction, and building models. At the same time the model reshapes group conversations and enables stakeholders to share different perspectives about the problem situation, to make sense of it, to consider options for action, and eventually to agree on actions for progress.

PSM scholars consider the successful PSM facilitator, one that is capable of fostering the achievement of workshop outcomes, to be an expert in PSM theory and practice, and external to the stakeholder group having an indirect interest in the workshop outcomes. However, any expert facilitator embarks on his/her facilitation journey as a novice who needs to gain theoretical knowledge and practical experience in order to become an expert. Keys (2006) defines experts as those who can see behind codified theories, modify and evaluate tools and techniques, engage in sophisticated exchanges, grasp subtle contributions, and draw on extensive experience and cognitive abilities. In contrast, novices have no deep theoretical and practical knowledge and experience concerning the modeling approaches, but are aware of their existence and can compare them with other approaches they have used. Moreover, novices see facilitation tools as rules to follow, accept theories at face value without reflecting on them and are limited in their language and abilities to interact with stakeholders. Novices also treat data more straightforwardly, focus less on identifying the meaning of the problem situation, and are less aware of the societal and organizational norms that influence their behavior. Importantly, Keys (2006) claims that experts and novices behave differently, dispose different knowledge, and use it differently. Despite this claim, research has not yet empirically analyzed the difference in behavior between PSM expert and novice facilitators in terms of how they carry out facilitation roles and use related skills. To further explore this claim we qualitatively analyze the transcript of a two-day PSM workshop facilitated by a PSM expert and two workshop participants, who we define as "PSM novices". The two-day workshop took place within a local food network in the UK and the PSM used was the Viable System Model (Beer, 1981). In our analysis we compare and contrast how the facilitators used and balanced the facilitation roles (P), (C), and (S) (Huxham and Cropper, 1994) to achieve workshop outcomes. Within (P) the facilitator manages the social process of group interaction, for instance by encouraging stakeholders' free and open contribution, actively listening to what they say, altering the relations of power and reaching closure. Within (C) the facilitator manages the complexity of the content of the problem by building, updating and using the model to facilitate further conversation. Within (S) the facilitator provides input of substantive expertise and knowledge (about e.g. specific management areas, environments and organizational issues) or opinion into decision making. Switching between and combining roles enables facilitators to manage the balance between the roles crucial to achieving workshop outcomes.

This analysis is important since useful insights can be gained in terms of: a) the difference in managing the process (P), content (C), and the injection of substantive expertise or opinion (S) by experts and novices, and b) the identification of effective learning environments for novices, as well as effective teaching and training strategies for facilitated modeling. To this end we provide empirical evidence to the claim that PSM experts and novices behave differently while facilitating workshops. In contrast to previous PSM research, our analysis also shows that the expert and the novice facilitators adopted similar behavioral patterns in terms of how they switched between and combined (P), (C), and (S). We illustrate those differences and similarities by presenting instances of FM carried out by the expert and the two novices during the two-day PSM workshop.

By showing behavioral differences between expert and novice facilitators our research contributes to PSM theory. In particular, we extend the definition of 'expert vs. novice' PSM facilitator to include the notion of 'external vs. internal' PSM facilitator, arguing that certain behavioral differences are due to whether the facilitator is external or internal to the stakeholder group. For instance, internal are compared to external facilitators more interested in workshop outcomes and know the problem situation of concern better, thus tend to inject more expertise and knowledge or opinion (S) in order to aid the process of decision making.

By showing behavioral similarities between expert and novice facilitators, on the other hand we provide empirical evidence to the claim that PSMs can be taught to stakeholders in order to enable them to selffacilitate and manage workshops without experts' support. Thus a contribution to PSM practice is provided by identifying effective learning environments for novices, as well as effective strategies for facilitated modeling in situations in which expert facilitation is not always possible. In particular, our research illustrates the potential of PSM introduction and training by experts during workshops in enhancing stakeholders' learning about PSM theory and practice. Introduction, training and learning support stakeholders in becoming PSM novices and self-facilitating workshops in the absence of expert facilitation.

Our research calls for further analysis and comparison of expert and novice facilitation during other PSM workshops. This comparison will contribute to further supporting the claim that PSMs can be taught to participants to enable self-facilitation, and indicating more teaching and training strategies for PSM experts and novices.

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# Utilization and Impacts of Collaborative Information Technologies: Global Comparisons

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**Abstract**: This detailed abstract describes a global study investigating the utilization and impacts of collaborative information technologies (CITs). Data collected from 607 organizations in Australia, Canada, Hong Kong, and US was analyzed to assess the extent to which CITs are used to support collaboration tasks and their perceived organizational level impacts. Our preliminary results reveal similarities and differences in the extent to which CITs support collaboration tasks and their perceived organizational level impacts. Our preliminary results reveal similarities and differences in the extent to which CITs support collaboration tasks and their perceived organizational level impacts in the study regions. Our presentation will provide more in-depth data analysis comparing the four regions and the implications of our findings for practice and research.

**Keywords**: collaboration information technologies, collaboration tasks, collaboration technology impacts, assimilation of collaboration information technologies, information technology use.

# Introduction

The importance of collaboration in organizational settings is considered critical for success by researchers and practitioners. Over the past few decades, information technology (IT) has been increasingly deployed to support collaborative activities of groups working together to accomplish a common task. Commonly known as collaborative information technologies (CITs), these technologies continue to emerge and gain popularity in all types of organizations across many global regions. Recent market research reports indicate that team collaboration applications market grew almost 15 percent during the first half of 2012 (http://www.techworld.com.au/article/441245/idc\_software\_market\_crm\_virtualisation\_collaboration\_s how\_strongest\_growth/). By some estimates, the global team collaboration and web conferencing market is expected to reach \$19.97 billion by the **year** 2015, a compound annual growth rate of 10.4%. (http://researchandmarkets.com/reports/1721862/global\_team\_collaboration\_software\_and\_audio).

Researchers have also been investigating CITs for decades. There have been hundreds of studies collectively, exploring traditional collaboration technologies such as GSS (for a review, see Arnott and Pervan, 2005; Fjermestad and Hiltz, 2000-2001), videoconferencing (Webster, 1998), and proprietary groupware (for a review, see Karsten, 1999). Research on virtual team collaboration (for a review, see Karoui et al. 2010) point to the large amount of existing attention CITs has received from academic researchers. Despite their widespread reach, there is little research aimed at systematically exploring utilization of emerging CITs from functionality standpoint. In other words, past research does not address the dimensions of collaboration or specific collaboration tasks supported by the full range of CITs at the organizational level. Furthermore, we also don't know much about the impacts of CITs at the organizational level. Finally, research on global comparisons of CIT utilization from functionality standpoint and their organizational impacts is practically non-existent. Our study attempts to address this gap in the existing literature. This detailed abstract briefly describes our research background, the study methodology, and preliminary results of our analyses.

# **Research Background**

At the organizational level, studies investigating CIT use and its impacts have been scarce and often limited in scope. While early studies of a single CIT use (Lotus Notes, a popular proprietary groupware) provide mixed evidence of any significant collaboration related organizational level impacts (Orlikowski, 1992; Vandenbosch and Ginzberg, 1996-1997), a more comprehensive review of 16 studies investigating Lotus Notes suggested that CIT use does result in organizational level impacts Karsten (1999). However these impacts from the use of CIT may not be consistent across organizations. Results from a study of another CIT (desk-top videoconferencing) parallel those from studies of Lotus Notes. Other studies have also been inconclusive. In one study, although all of the employees had access to desk-top video conferencing a few months after implementation, there was no notable increase in use after months (Webster, 1998). However, recent efforts exploring CITs suggest that there are significant organizational impacts from their deployment. Some of the impacts that have been observed include: an increase in the firm's ability to innovate (Merono-Cerdan et al., 2008; Chen et al., 2009; Antikainen et al., 2010; Troshani et al., 2011), greater productivity (Ding et al., 2010), and improved financial performance (Chen et al., 2009). Never-the-less, a key limitation of past studies is that majority of them have focused primarily on the use of a single CIT in the organizational context. Although a recent study has investigated the use of CITs across organizations in several global regions (Bajwa et. al. 2008), their impacts across organizations in global regions remains largely unexplored.

Similarly, practitioner insights also suggest that the utilization of certain ITs (for example, VoIP, text messaging, screen sharing, video conferencing, and presence awareness tools) enhanced performance in organizations that had deployed these IP-enabled tools compared to those that had not made any investments in them (Frost and Sullivan, 2009). Once again, these findings are limited to information and communication technologies (ICTs) and do not explore a myriad of collaboration tasks that can be supported by CITs and the organizational level impacts resulting from the use of CITs that have much wider range of functionality that ICTs.

# Study Methodology

The authors with combined experience of over seven decades collaborated on the research project. All of them have extensive experience in using CITs and one of them had developed a Group Support System (GSS) over three decades ago. The project was initiated by studying CIT use and their potential impacts in four organizations. We then followed the approach suggested by Sethi and King (1991) to develop a survey instrument. A review of many existing CITs was undertaken to identify key functionality that could support collaboration tasks. Organizational impacts of CITs were identified by reviewing CIT case studies, practitioner reports, and past empirical studies. The initial survey instrument was then pilot tested in three organizations. Feedback from the pilot test was used to slightly modify the survey instrument for clarity of the item measures.

Four key global regions were selected for the study. These included: Australia, Canada, Hong Kong, and US. Data was collected using multiple approaches. In Australia, data was collected by emailing the survey and mailing a hard copy of the survey to CIOs of 500 of the top 1000 organizations in Australia. The email included a copy of the cover letter and a link to the electronic version of the survey. The mail included the cover letter and a hardcopy of the survey. The cover letter explained the purpose of our study and included instructions for completing the survey and definitions of CITs and IT supported collaboration. The participants were also requested to forward the survey to the executive most knowledgeable about IT-supported collaboration in their organization, if other than themselves. In Hong Kong, the same questionnaire along with the same cover letter was mailed to senior MIS executives of the top 600 organizations. In Canada and US, data was collected using a web survey from the member organizations of Ziff Davis, Inc. Multiple mailings and reminders were sent in all the regions to boost responses. Six hundred and seven usable responses were received from the four study regions.

# **Preliminary Results**

Our review of the literature identified ten collaborative tasks that are commonly supported IT. These include: communications, information and knowledge sharing, decision-making, report writing/information pooling, planning, scheduling, monitoring progress, time management, issue resolution, and discussion and brain storming. A five point scale (1= never used, 2, 3= occasionally used, 4, 5 = always used) was deployed to measure the extent to which IT was used to support each of the ten collaboration tasks. The results across the four study regions are shown in figure 1.



Fig. 1. Comparison of Collaboration Tasks Supported by CITs

The utilization of CITs was found to be the highest for communication and information and knowledge sharing during collaboration. On the other extreme, CITs were used the least for discussion and brain storming. These findings appear to be consistent across all the four study regions.

We also identified fourteen organizational level impacts resulting from the use of CITs. These included: improvements in existing products/services, improved relationships with customers, suppliers, and business partners, improvements in existing business processes, structural changes, time savings, quick reaction to changes, speed of decision-making, increased productivity, appropriate responses to changes, facilitation of innovations, improved quality of decisions, and marketing the right products/services. A five point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) was deployed to measure the level of agreement with each of the impacts resulting from the use of CITs in the organization. The results across the four study regions are shown in figure 2.

Time savings to accomplish tasks, improvements in business processes, and getting more work done seem to have the highest level of agreement from organizational impact standpoint, while flatter organization structure has the least level of agreement as an organization impact resulting from the use of CITs. In our presentation, we will discuss more detailed data analyses comparing this association across the four study regions.



Fig. 2. Comparison of CIT Impacts

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# Dynamic Knowledge Support for Decision-making and Problem-solving

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**Abstract**: An effective knowledge approach requires that existing and created tacit and explicit knowledge are mobilised and integrated, and made available to support collaboration between team members. The paper presents a model validated during a longitudinal case study conducted at one of the world's leading software organisations that addresses the need to make dynamic tacit and explicit knowledge available and accessible for effective decision-making and problem-solving.

Keywords: Knowledge creation, integration, decision-making, problem-solving, collaboration, interaction, feedback

#### Introduction

Organisations function in rapidly changing and evolving environments characterised by high levels of uncertainty and ambiguity. Unpredictable and ill-structured operating conditions require dynamic resolution approaches supported by the sharing and application of tacit and explicit knowledge for creative problem solving. As organisations lay greater emphasis on people and interactions over processes and tools, knowledge increasingly underpins collaborative activities. Managing knowledge effectively allows organisations to develop a long-term and continuous perspective, and improve their decision-making and problem-solving processes.

Most work practices are increasingly being standardised to leverage existing knowledge for decision-making and problem-solving, but some situations require more flexibility than can be addressed by standardised processes. Rubinstein and Pfeiffer (1980) argue the problem-solving ability of an organisation can be hindered by repeatedly attempting to solve problems using approaches that have been performed successfully in the past. Previously tried methods of problem-solving may be effective sometimes, but certain fast changing and complex situations require new approaches. Simon (1977) distinguishes between structured and non-structured situations, where repetitive and routine structured situations are addressed by standardised processes and operating procedures, while unstructured situations require human judgement, insight and intuition for meaningful resolution. The complexities and unpredictability of unstructured situations require insights and tacit knowledge of individuals for effective decision-making and creative problem-solving. Standardised processes identify good practices and reduce mistakes and rework, but also reduce an organisation's ability and flexibility to adopt new approaches for problem-solving which may result in vital learning. Tacit knowledge must be available in a dynamic form to ensure that relevant shared contexts and interpretations create common knowledge and understanding in such situations. The interaction and flow of dynamic knowledge, including tacit knowledge, is required within an organisation's core work practices to provide feedback and facilitate collaboration for decision-making, problem-solving and innovation.

The flow of knowledge requires an effective knowledge management (KM) strategy and the mobilisation, integration, sharing, and application of tacit and explicit knowledge in a dynamic manner. However, most knowledge management (KM) frameworks lay an emphasis on managing explicit knowledge by focussing on the processes of capture, storage, retrieval, transfer and application (Argote and Ingram 2000, Sunassee and Sewry 2002, Dyba 2003, Arling and Chun 2011). Tacit knowledge, on the other hand, needs the key mechanisms of interaction and feedback for effective sharing and use (Polanyi 1967, Nonaka and Takeuchi 1995, Kreiner 2002. Xue et al 2011, and Margaryan et al 2011). Within a dynamic and holistic knowledge approach, the existing and created tacit and explicit knowledge are mobilised and integrated, and made available to collaborative team members. The need therefore exists for a knowledge management framework which addresses the requirements to facilitate the exchange and application of tacit knowledge, in addition to explicit knowledge. The paper presents a model which addresses this need to make dynamic, tacit and

explicit knowledge available and accessible for effective decision-making and problem-solving. The model was validated during a longitudinal case study conducted at one of the world's leading software and consultancy organisation which currently employs more than 245,000 individuals (Sandhawalia and Dalcher 2010).

The paper is organised as follows: the next section discusses the theoretical concepts of KM processes and knowledge flows, and how they influence the decision-making and problem-solving processes; Section 3 presents the research methodology and provides details of the case study and the methods of data collection and analysis; Section 4 presents the research findings and analyses how dynamic knowledge identified in the case study organisation supports the decision-making and problem-solving processes; Section 5 presents the conclusions and implications of the research; and Section 6 discusses the limitations of the work done, and also highlights possibilities for future work.

# **Theory Development**

Knowledge creation, and its integration, can be viewed as collective processes of constructing, articulating and redefining shared beliefs and mental models through social interaction that help manage complex tasks and activities during collaboration, (Grant 1996, Huang 2000, and Chang et al 2012). However, Huang et al (2001) argue that current conceptualisation of how knowledge is integrated and made available within the context of coordinating specialised expertise and tasks remains limited. It is therefore important to explore the dynamics of knowledge integration while performing collaborative activities such as decision-making and problem-solving which further generate ideas through collective input.

The ability to create, store, integrate, disseminate, and utilise knowledge and expertise has become a primary way to compete (Hayashi, 2004). Amassing and synthesising specialised knowledge from multiple sources is an integral factor during decision-making and problem-solving processes. The importation of new knowledge coupled with the recombination of existing knowledge provides information and knowledge that can be leveraged to improve decision-making and problem-solving, and lower performance risk. Decision-making is often compromised when team members fall victim to the fallacy where benefits are overestimated and costs are underestimated. Knowledge provides tacit insights and judgment, and forms the basis for better decision making. Moreover, the knowledge integration process involves social interactions among individuals using internal communication channels for knowledge transfer to arrive at a common perspective for problem-solving. Collaborative linkages are the primary means of transferring specialised knowledge (Tasi, 2001), which facilitates knowledge reuse, and the recombination of existing knowledge is an important antecedent of uncertainty resolution and innovation (Marjchrzak, Cooper, & Neece, 2004; Terwiesch & Loch, 1999).

Newell et al (2004) state that objective measures and collaboration strongly influence the creation of common knowledge. Measures provide tangible benefits to be gained by creating common knowledge and people working together need to be able to identify the value gained by creating common knowledge, and therefore learn and contribute to the effort. Also, collaborative activities form ties and are important for knowledge integration and researchers have long recognised the need for people to collaborate in order to sustain innovation (Davenport 1993 and Van De Van 1986). Dougherty and Hardy (1996) confirm that collaborative structures of cross-functional teams, and the collaborative processes of decision-making and problem-solving, are important for sustained innovation.

An effective collaborative mechanism for achieving knowledge integration is to facilitate the flow of knowledge and make it available to coordinate the planning of interdependent work process strategies (Styhre 2003). Prior research indicates knowledge integration can be achieved when people are involved early in the work process (Boynton, Zmud, & Jacobs, 1994). Mutual consideration of work process strengths and weaknesses allows individuals to identify requirements and capabilities for targeted work processes, predict what resources are needed to fulfil the requirements, and determine how best to deploy resources to optimise performance and minimise delays (Mitchell & Zmud, 1999). The act of coordination is a knowledge integration process that facilitates a common understanding of task objectives and the means to reach those objectives, (Reich & Benbasat, 1996).

Tasks that require knowledge integration are communal, and the flow of knowledge between individuals is essential to facilitate collaborative activities and foster complex knowledge transfer. The transfer process

can slow down where the complexity of knowledge is determined by the degree to which it is tacit, and whether an individual is dependent on another for the transfer and acquisition of knowledge, (Mckenzie & van Winkelen, 2004). Effective knowledge flows provide integrated, task relevant knowledge support from appropriate competence areas to balance multiple perspectives and stakeholder interests. Thus available knowledge and consequent collaboration help create a sense-making community who understand the interactions and synergy of workflows through a multi-perspective view of diverse knowledge competence areas.

Further, effective knowledge flows are critical for interaction and sustaining knowledge integration. Briggs, Vreede and Nunamaker (2003) report on the value of facilitating interaction and accomplishing organisational tasks, and how in the case of inter-organisational collaboration, knowledge flows support significantly complex tasks when goals are to be accomplished by teams whose members do not share culture, communication and coordination processes. Gladstein (1984), Hackman (1987), and McGrath (1984) argue that performance is a result of the interactions and dynamics among team members, and Argote and Ingram (2000) state that the utilisation of knowledge embedded within a team's interactions and tasks is the key to achieving better performance. Several researchers have investigated the importance of team work as members with diverse skills, knowledge, experiences, and expertise are required to work together to resolve the issues or problems encountered during project execution. However, a focus on how knowledge flows and supports collaboration and knowledge integration appears to be limited.

Knowledge flows influence the efficiency and scope of knowledge integration which Grant (1996) identified as critical for organisational competitiveness. Effective knowledge flows facilitate the generation of common knowledge and its seamless coordination between team members. The flow of knowledge within an organisation helps attain a level of integration efficiency relative to the scope of integration required, and facilitates the ability to continuously innovate and maintain competitive advantage. Knowledge flows enable the diverse pool of team members to access, share and discuss knowledge uniquely distinct to each member, thus creating knowledge integration is realised by synthesising different perspectives and expertise during decision-making and problem-solving processes, and enables different views to be incorporated. Team members bring different sets of assumptions about optimal ways to proceed, prioritising different values and perspectives, which are integrated in the problem-solving process to develop required solutions. With problem-solving being central to their work, team members recognise that failure is an opportunity for understanding and learning to avoid mistakes, and it is therefore imperative to make an effort to support collective problem-solving and reflection.

Distinct expertise needs to be shared between diverse team members with a sufficient level of congruence to enable individuals to understand each other and work together towards their common goals from different perspectives (Xue et al 2011). Combining previously unconnected aspects or recombining previously associated aspects creates common knowledge (Leonard-Barton, 1992), as team members realise that tasks are better achieved through dynamic interaction and feedback. In this way teams are likely to create new and common knowledge and engage in effective sharing and integration of knowledge to achieve their predefined goals. To study how this dynamic knowledge is created, integrated and shared while performing collaborative tasks, the research focused on identifying how knowledge flows during the decision-making and problem-solving processes.

# **Case Study**

An extended case study was conducted at a large software service organisation to examine how knowledge flow supports knowledge creation and integration and collaboration within the developmental processes. Exceptional access negotiated for this research provided an opportunity to study and analyse the well established and highly mature work methods practised in the organisation. The research propositions required the study, analysis and identification of the flow of knowledge between the functional areas of the development effort. The data was collected over a period of twenty-six months, through interviews, questionnaire and observation which were conducted in parallel to enable researchers to confirm key phrases, events, instances and insights and provide a degree of clarification, redundancy and triangulation.

#### Observation

The researchers observed the specific project management, knowledge and software process areas within the organisation, and the functioning of teams in their collaborative work environment. The observations were carried out by ensuring that each field visit was for a minimum of three weeks. This was done to ensure that after the initial observation session, individual team members were familiar and comfortable with the researchers being present during such meetings and sessions. Team members were made aware of the research being conducted, and this benefited the researchers by enabling them to conduct interactive group discussions, and also obtain confirmation and feedback about the observations at the end of each session. The interactive group discussions played a part in strengthening the value and perceived importance of the trends that were observed and enabled early clarification of issues. The researchers observed various meetings including weekly reviews, design, project start-up, closure, and conference calls with on-site developers and clients, in addition to software development activities and daily team interactions. Weekly review meetings lasted on average between an hour and a half to about two hours, while project start-up, closure and design meetings were considerably longer. Most design meetings lasted a minimum of a half day (four hours), with some meetings lasting for three-quarters of a day or even a complete day (eight hours). Certain design meetings required to be resumed the next working day. Focused project start up meetings that involved initial stakeholders would typically last for half a day, while the same was the case for project closure meetings.

The researchers were able to observe software processes and the functioning of project teams within their work environment. The researchers were present within the coded access areas of the team's workplace for a half day session at each instance, and were able to observe, examine and make notes of team interaction, and work methods and practices. The researchers were also invited to observe senior management interactions for extended sessions, for example 8am to 2pm, and make notes of work routines and problem solving methods. In total, the researchers observed 97 meetings, which were of 11 different types, yielding 340 hours of observation.

#### Interviews

Thirty-eight open-ended interviews were conducted with individuals within the organisation and included an Executive Vice President, the second most senior executive within the organisation, a Vice President, Consultants, Researchers, Project Managers, Project Leads, and members of the Software Engineering Process Group (SEPG). The depth in organisational hierarchy represented in the cross-section of individuals interviewed helped ensure that the interview data collected did not have an over-reliance on either easily accessible or elite respondents, as suggested by Miles and Huberman (1994). A total of 62 interviews were conducted involving 38 individuals with varying levels of seniority and experience lasting a total of 100 hours.

#### Questionnaires

A detailed survey questionnaire was administered primarily to obtain responses from a wider cross section of respondents within the distributed organisation. The researchers were able to get views and opinions of on-site team members, that is, those team members who were based on the client's site and were currently not available for interviews at the organisation's premises. The questionnaire provided access to employees working on the projects being examined and analysed and who were not available for a face-to-face interview. A total of 24 questionnaires were sent out of which 20 individuals responded; that is a response rate of 83 per cent. The researchers were subsequently able to communicate with the respondents via email to seek clarifications and further discuss relevant issues related to the research, thus extending the questionnaire instrument into a more dynamic information gathering tool from remote subjects.

The interview and survey questions were developed to determine and gain a clear understanding of the: organisation's knowledge strategy

- primary vision for the knowledge strategy
- issues and barriers faced while implementing the strategy
- flow of knowledge within the processes and functional areas of the organisation
- requirements to facilitate a smooth flow of knowledge

- modes and channels of communication and coordination within the organisation
- mode of facilitation of tacit knowledge within the organisation
- roles and responsibilities
- impact of use of KM tools and assets on work practices, project management processes and software development processes, and methods to measure the same if any exist
- organisation's knowledge strategy review process and ability to learn continuously, identify patterns, and formalise routines
- development of the organisation's knowledge culture
- influence of KM infrastructure and processes on organisational maturity
- role of KM infrastructure and processes on decision-making within the organisation and impact on problem-solving
- important and integral areas of decision-making
- decision-making tools, inputs and resources
- role of knowledge flows on quality and testing and
- use of knowledge and experience in subsequent projects, especially in the decision-making process

The collected data provided a rich empirical basis to analyse the flow of knowledge and its dynamic creation and integration during decision-making and problem-solving during project implementation within a software organisation. The large volume of data was examined, reviewed and checked to ensure accuracy. Data reduction and display techniques were applied in systematic ways as suggested by Miles and Huberman (1994) to categorise the data in groups based on their attributes that adhered to the theoretical propositions and orientation of the research. The groups and attributes were placed in multiple columns and rows matrix to enable analysis and identify similarities, interactions and relationships, and form impressions. An iterative process of ongoing analysis based on reformulation of ideas and emerging insights provided the basis for reliability in the qualitative approach suggested by Yin (2003).

## Findings

The case study provided evidence of the flow of knowledge during collaborative tasks in software development. The researchers established the mechanisms of feedback and interaction that facilitate the flow of knowledge by identifying the activities, tasks, and actors involved in the development processes. The effects of interaction and feedback, and the tacit and explicit dimensions of knowledge flows, were determined by analysing the knowledge input, executed tasks, and outcomes, of collaborative activities. The collective team performance, output, and experience was further analysed to identify the specific knowledge created and integrated during the development process and applied for decision-making and problem-solving.

The researchers analysed how knowledge was dynamically created and made available to team members within the functional areas of the development effort. The interactions between the knowledge flows and functional areas were identified and depicted the overall complexity of the development effort. The case study analysis is presented below, and the flow of knowledge between the functional areas is discussed and presented to model the relationships as dynamic systems of nodes and arrows. Nodes represent the functional areas, while arrows represent the relationships between these functional areas.

The case study analysis confirms the existing knowledge of team members is applied, and further knowledge created during problem-solving and engagement in development activities within the technical area. This process of knowledge creation and integration, creates process and product specific knowledge, and also enhances the individual and collective team experience. Thus the output flow from the technical area is the

creation of new product knowledge and an enhancement of individual and team experience. A diagrammatic representation of this relationship is provided below in Figure 1.



Fig. 1. Inflow and Outflows for Technical Area

The analysis further confirmed the product specific knowledge flows to the quality area where it is applied to identify mismatches and detect defects in the product. New learning emerges in this area when errors are corrected, and knowledge is also created while analysing the defects to ensure that the product conforms to the required specifications. The new knowledge created further integrates with the existing knowledge when updating checklists and performing causal analysis. Thus the quality area benefits from the product specific knowledge created in the technical area and provides further learning and reflection, (Dyba 2003). These flows are presented below in Figure 2.



Fig. 2. Inflow and Outflows for Quality Area

Analysis of the data establishes that the functional area where project management tasks are performed benefits from enhanced experience gained in the technical area, and from the further reflection provided by the quality area. The project management area integrates such experience and reflection by updating project management templates and modules to ensure more effective planning, control and monitoring of projects. Integrating experience and reflection creates further dynamic knowledge, which the project management area is able to transfer to the decision-making area. Figure 3 presents these relationships, highlighting the project management area's focus on the transfer of knowledge.



Fig. 3. Inflows and Outflow for Project Management Area

The functional area for decision making benefits from product specific learning from the quality area and the dynamic knowledge from the project management area. This enables more effective decision making that is applied within the technical area for current and subsequent projects. The literature confirms that knowledge is applied for effective decision making while making sense of uncertain and unstructured situations, (Simon 1977, Nutt 1989, Gruenfeld et al 1996, Politis 2003). The decision-making area is concerned with the application of decisions, and this is represented in Figure 4.



Fig. 4. Inflows and Outflow for Decision-Making Area

The above discussion analyses the flow of knowledge within the functional areas of the development process. The flow is iterative, and the continuous inflows and outflows of knowledge from the individual areas confirm the non-linear relationships and interactions between them. The relationships present in the form of closed and continuous loops of knowledge flows, and depict the interactions and feedback of the development process as established by Abdel-Hamid and Madnick (1991). The loops ensure that new knowledge integrates with existing knowledge in a dynamic manner, and allow experience gained while executing collaborative tasks to be effectively transferred and applied in the decision-making process. The continuous view provided by the feedback loops is modelled to represent the dynamic flow of tacit and explicit knowledge within the functional areas of the development effort and is termed the Knowledge-Dynamic Feedback Model (K-DFM).

The K-DFM presents the flow of knowledge between an organisation's functional areas of project management, technical development, quality assurance, and decision-making. The model balances the interactions and interdependencies between the different functional areas and provides a complete picture of how the problem-solving requirements of an organisation are addressed. The K-DFM addresses the knowledge needs of organisations and provides the framework that ensures both tacit and explicit knowledge are made available to the right person at the right time and place. In other words, the model depicts how knowledge is made available throughout the development processes of the organisation, and is not located in a single place. The K-DFM is presented in Figure 5.



Fig. 5. Knowledge-Dynamic Feedback Model (K-DFM)

# Assessing the K-DFM

Rubenstein-Montano et al (2000) recommend that a knowledge management framework should:

- be both prescriptive and descriptive, that is a combination of the two approaches
- be consistent with systems thinking
- link knowledge management to organisational goals and strategies
- be planned before the knowledge management activities take place
- acknowledge the organisational culture, and the knowledge management practices must be compatible with the culture
- direct knowledge management through learning and feedback loops

The K-DFM is a dynamic model that presents the flow of knowledge between the functional areas of project management, decision-making, technical development, and quality, through feedback loops. The model is descriptive in its depiction of the flow of knowledge between the four functional areas. However, rather than being prescriptive, the model highlights the flow of knowledge. The model uses a systems approach and depicts the relationships and interactions of project management, software development and knowledge management. In doing so, the K-DFM highlights the fact that consideration must be given to non-technical aspects of the software development effort. The function of the decision-making area is to integrate

different perspectives and considerations, and make sense of the knowledge that is created and emerges from the functional areas and flows through the feedback loops, thereby making the K-DFM consistent with systems thinking.

By presenting the flow of knowledge through the feedback loops, the K-DFM provides the organisation with the ability to provide knowledge management support to its software development and project management processes. The K-DFM provides the infrastructure that facilitates the flow of knowledge and hence supports knowledge sharing activities. Thus the model provides the framework that links knowledge management to a software project organisation's goal and strategy of continuously improving its processes in order to make them more efficient, effective and productive.

As mentioned, the K-DFM gives consideration to the non-technical aspects of the software development effort. The model acknowledges the important role of organisational culture in the effectiveness of the knowledge management initiative of a software project organisation. An organisation's culture is central to encourage interaction between individuals which is important to facilitate knowledge flow, and also provides individuals the ability to self-organise their own knowledge to facilitate knowledge sharing and therefore problem solving, O'Dell and Grayson (1998). The K-DFM provides the framework to facilitate such knowledge sharing with all functional areas, a further enables knowledge and new learning to flow through the feedback loops. Therefore, assessing against Rubenstein-Montano et al's (2000) criteria for knowledge management frameworks, the K-DFM:

- is a dynamic model
- is consistent with systems thinking
- links knowledge management to a software project organisation's goal and strategy of continuous process improvement
- provides knowledge management support to project management and software development processes
- acknowledges organisational culture and provides the framework to facilitate interaction and knowledge sharing
- enables the flow of knowledge and learning through feedback loops

Thus the K-DFM appears to match and satisfy Rubenstein-Montano et al's (2000) criteria for knowledge management frameworks. Table 1 presents how the K-DFM satisfies the knowledge management framework criteria.

Table 1 Assessing K-DFM against Knowledge Management Framework Criteria

No	Knowledge Management Framework Criteria	K-DFM Characteristics and Features
1	Combination of prescriptive and descriptive approaches	The model is dynamic, facilitative and descriptive
2	Consistent with systems thinking	Uses a systems thinking approach
3	Link knowledge management to organisational goals and strategies	Links knowledge management to a software project organisation's goal of continuously improving it processes
4	Be planned before the knowledge management activities take place	Provides knowledge management support to project management and software development processes
5	Acknowledge the organisational culture, and the knowledge management practices must be compatible with the culture	Considers non-technical aspects of software development; knowledge activities within and between the functional areas rely upon the organisation's culture
6	Direct knowledge management through learning and feedback loops	Enables the flow of knowledge through feedback loops

## **Conclusions and Implications**

The paper presents a long-term perspective for effective decision-making and problem-solving in organisations operating in environments of rapid and unprecedented change. The paper establishes that knowledge flows between functional areas can support tasks and activities of the development effort. The K-DFM presents a framework that emphasises dynamic knowledge support, especially tacit knowledge support in the form of human judgement, insight, intuition, and experience, for decision making in the non-structured situations identified by Simon (1977). The feedback loops presented in the model support collaboration, and integration of knowledge to create new common knowledge which is further applied for improved decision-making and problem-solving. The paper confirms the processual nature of knowledge as argued by Styhre (2003), which exists throughout an organisation and is not located at one single time or space.

The processual nature of knowledge and its flow has implications for a large part of management literature that focuses on how to make knowledge more manageable. Managing knowledge provides a connotation of control and ownership where the first step is to establish its ownership. However, it is difficult to assign ownership, and store and retrieve something that is abstract and elusive in nature. Knowledge is considered tacit by nature, that is, implied and understood implicitly in the situation, without being definable and visible. Capturing tacit knowledge is viewed as a challenge by organisations that need to spread knowledge for better decision-making and greater innovation. This research presents an approach where the flow of knowledge supports collaborative tasks and activities in areas where the knowledge is required and applied within a context. The approach considers knowledge as something that is made resourceful by being competently mobilised and utilised, and consequently new knowledge is created by improving the ability to facilitate, mobilise and utilise existing knowledge.

For organisations this paper's findings have implications regarding their ability to manage context, provide feedback and facilitate interaction, and therefore build upon their existing knowledge resources to improve problem-solving. The research provides organisations with a perspective that would help them achieve excellence not only through integrating various considerations for effective decision-making, but also through knowledge creation, sharing and learning. The K-DFM's focus on supporting the flow of knowledge, learning, experience and reflection within the functional areas provides organisations with the benefits of continuous process improvements and competitive advantage. Thus the research presents an approach to ensure that the right knowledge is available to the right person at the right time during the

decision-making process. This provides a starting point in the quest to address the requirements of effective problem-solving.

## Limitations and Future Work

The research has some limitations and several possibilities for future work emerge from the results of the current study. The case study is located within a single organisation. The study did not attempt to isolate specific conditions that may tend to moderate the findings within a specific organisation. A focused study within several organisations, combined with an objective evaluation of the flow of knowledge and capability support within the various knowledge management initiatives, would provide useful follow-up research. Also, the model presented in this research has been proposed and validated for collaborative tasks and activities associated with software development projects. Interesting research possibilities exist to extend and test the model within other developmental domains and industrial sectors. Therefore further studies need to be conducted to look at organisations in other areas and domains to determine if the same practices apply.

There was no attempt to categorise the findings based on the size of the organisation. Opportunities for similar research appear to exist in this area, to determine if the research factors differ based on organisation size or structure. While this study was focused on the flow of knowledge within collaborative activities, there is evidence in the literature that effective knowledge management strategies may tend to enhance the flow of knowledge. Therefore, a longer-term study examining changes in the flow of knowledge before and after performing collaborative activities would yield useful and interesting results.

Finally, further work is required to develop measures to determine the flow of knowledge while performing the above mentioned collaborative activities. Such research will help determine, establish and confirm the benefit and impact knowledge flows have on work practices and resources of an organisation. Assuming that such access can be negotiated, this will enable researchers to build on the findings of the extended longitudinal work offered through this research.

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# Group and Negotiation Support Systems Research from 1990 to 2010

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**Abstract**: This research project was principally motivated by a concern for the direction and relevance of research in systems that support group work and negotiation. The main areas of research focus are the publication frequency and outlets for G&NSS research, the research strategies used in published articles, and the professional relevance of the research. The project has analysed 383 GSS articles and 82 NSS articles published in 16 major journals from 1990 to 2010. The findings indicate dependence on the GD&N journal, a focus on experimental research and design science, weak theoretical foundations and research methodologies, and a focus on operational level problems. Of great concern is the finding that GSS and NSS research has relatively low professional relevance. Some strategies for dealing with these issues are presented.

Keywords: Group Support Systems, GSS, Negotiation Support Systems, NSS

# Introduction

This paper critically analyses the nature and state of research in group support systems (GSS) and negotiation support systems (NSS). These are the systems that are the main foci of both the Group Decision and Negotiation conference and journal. The paper presents trends in GSS/NSS research as individual disciplines and in comparison with each other. This investigation is based on the detailed analysis of 465 GSS/NSS articles published in 16 major journals from 1990 to 2010. The analysis is focused on a number of factors. These include (a) publication frequency, outlets, and recognition by funding bodies, (b) general research factors such as article type, epistemology, quality of theoretical foundations, research methodologies, and level of importance of the research, and (c) relevance to IS practitioners and managerial users. It must be noted that this research is focused on the systems that support group work and negotiation, so only those papers that mentioned a system (NSS or GSS) were included in the analysis.

This project was principally motivated by a concern for the direction and relevance of NSS and GSS research. We suspected that this research was the practice of IS professionals and managerial users. We also felt that the research was addressing an overly narrow range of concepts and issues and in particular we were concerned about the decision theoretic foundation and quality of the area. Further, it seemed that unlike the general trend in information systems research, GSS research was strongly dominated by a positivist, quantitative research orthodoxy. To explore these concerns we initiated the project described here. This paper presents the first comprehensive report on the comparative performance of GSS and NSS and is an extension of work presented at the 2005 and 2006 Group Decision and Negotiation conferences (Pervan and Arnott, 2006; Pervan et al., 2005). It presents descriptive results based on the analysis of 383 GSS papers and 82 NSS.

The paper is structured as follows: first, an introduction to the project is presented, followed by a brief history of GSS and NSS research. The research methodology and design is then described in some detail. The following sections discuss the results in terms of the factors listed as (a) to (c) above. Some recommended guidelines for GSS and NSS researchers which address the findings are then outlined. The final section addresses the limitations of the project and provides a summary of conclusions.

# Group and Negotiation Support Systems Research

A GSS "consists of a set of software, hardware, and language components and procedures that support a group of people engaged in a decision-related meeting" (Niederman and Bryson, 1998). GSS are typically implemented as group decision systems (GDS) (Pervan and Atkinson, 1995) or electronic meeting systems (EMS) (Dennis et al., 1988). Group Support Systems directly evolved from personal decision support systems by using theories of group behaviour and processes and behavioural decision theory with networked microcomputers (Arnott and Pervan, 2005).
Group environments that require the support of GSS can be classified by the time of the meetings, either synchronous (same time) or asynchronous (different times), or the location of the group (either face to face or dispersed) (DeSanctis and Gallupe, 1985). In the early 1980s, GSS research initially focused on "decision rooms" (synchronous and face to face) such as those facilities established at the University of Arizona and the University of Minnesota.

Negotiation support systems (NSS) also operate in a group context but as the name suggests they involve the application of computer technologies to facilitate negotiations (Rangaswamy and Shell, 1997). As GSS were developed, the need to provide electronic support for groups involved in negotiation problems and processes evolved as a focused sub-branch of GSS with different conceptual foundations to support those needs. It should be noted that this research is focused on a major subset, but not all, of the research that appears in the Group Decision and Negotiation journal and conference, namely papers that mention a system in investigation of issues in group decision and negotiation.

Two approaches to constructing systems that support negotiation arose, namely problem oriented and process oriented (Jelassi et al., 1990). Problem-oriented NSS products include Co-oP (Bui and Jarke, 1986), DECISION MAKER (Fraser and Hippel, 1984), GDSI and MEDIATOR (Kersten, 1987). These problem-oriented systems focus on providing support to support negotiation for specific problem types. On the other hand, process-oriented NSS focus on providing general support of the give-and-take process of negotiation (Chaudhury, 1995).

Negotiation support systems has its conceptual foundations in game theory (Von Neumann and Morgenstern, 1947), which supports many models of bargaining (Raiffa, 1982), and social choice theory (Arrow, 1951). While NSS may be considered a branch of GSS research, it has evolved using different theories, technologies and applications and now stands as a significant branch of decision support history.

#### Methodology and Design

In order to explore the concerns expressed in Section 2 above, the following general research questions were formulated in order to guide the project:

What publication and funding trends have occurred in GSS and NSS research?

What type and quality of research is being done?

How relevant is GSS and NSS research?

To answer these questions this project involved the bibliometric content analysis of relevant published research.

#### Time Frame

The time period of published research chosen for this project is 1990 to 2010. While GSS and NSS began to evolve in the late 1970s and early 1980s, it was not until the end of the 1980s that the field could be regarded as relatively stable and mature. Further, the period since 1990 also marks a period in information systems discipline which saw a significant growth in the use of non-positivist research methods. In industry, the analysis period saw the deployment of several new generations of collaboration technologies. To reflect these generations, the sample has been divided into three time periods: 1990 to 1996, 1997 to 2003, and 2004 to 2010.

#### The Article Sample

The sample of articles analysed is GSS and NSS research published between 1990 and 2010 in 16 journals. These included the field's two major Decision Science journals Decision Sciences (DS) and Management Science (MS). Then three specialist DSS journals were included: Decision Support Systems (DSS), Journal of Organisational Computing & Electronic Commerce (JOC&EC), and Group Decision & Negotiation (GD&N). The remaining nine journals were the major Information Systems journals Accounting, Management & Information Technologies/Information & Organization (I&O), Communications of the Association for Information Systems (CAIS), European Journal of Information Systems (EJIS), Information & Management (I&M), Information Systems Journal (ISJ), Information Systems Research (ISR), Journal of Information Technology (JIT), Journal of Management Information Systems (JMIS),

Journal of Strategic Information Systems (JSIS), Journal of the Association for Information Systems (JAIS), and MIS Quarterly (MISQ). Tables 1 and 2 show GSS and NSS publication where these journals have published any papers of that type.

Journal	199	90 - 1996	199	97 - 2003	20	004 - 2010		Total
	No.	% of Period	No.	% of Period	No.	% of Period	No.	% of Sample
I&O	2	1.3	3	2.1	1	1.2	6	1.6
DS	3	1.9	1	0.7	0	0.0	4	1.0
DSS	28	17.8	27	19.1	24	28.2	79	20.6
EJIS	2	1.3	4	2.8	0	0.0	6	1.6
I&M	14	8.9	16	11.3	4	4.7	34	8.9
ISJ	1	0.6	3	2.1	1	1.2	5	1.3
ISR	6	3.8	4	2.8	1	1.2	11	2.9
JAIS	0	0.0	0	0.0	4	4.7	4	1.0
ЈІТ	2	1.3	2	1.4	1	1.2	5	1.3
JMIS	21	13.4	23	16.3	7	8.2	51	13.3
JOC&EC	37	23.6	14	9.9	2	2.4	53	13.8
JSIS	0	0.0	0	0.0	0	0.0	0	0.0
GD&N	26	16.6	39	27.7	39	45.9	104	27.2
MS	6	3.8	1	0.7	0	0.0	7	1.8
MISQ	9	5.7	4	2.8	1	1.2	14	3.7
Total	157	100.0	141	100.0	85	100.0	383	100.0

Table 1: GSS Papers by Journal

The publication distribution of GSS articles is shown in Table 1. The Journal of Group Decision and Negotiation (GD&N), which is the primary specialist journal for the GSS discipline, is GSS's leading publisher with 27.2% of GSS articles overall and this share has increased from 16.6% to 27.7% to 45.9%. GD&N is clearly the leading outlet for GSS research and is becoming more so. Other major outlets for GSS research are DSS with 20.6%, JOC&EC with 13.8% and JMIS with 13.3%. JMIS and I&M are the only general IS journals that have published GSS papers in substantial numbers, but this has (alarmingly) seen a significant fall over time. Most general IS journals publish little GSS research (CAIS published none). Even more alarming is the fall in GSS share of JOC&EC over time. The European journals publish little GSS research perhaps indicating that GSS research is mostly a North American university phenomenon which is now fading, or perhaps GSS researchers are concentrating more effort on distributed collaboration technologies and their impact on virtual teams, for example.

Four issues stand out in Table 2. First, there much fewer NSS papers published (82) than GSS papers (383), so NSS is a substantially smaller field. Second, very few journals publish NSS research (only 6 of the 16 journals) so there are a limited number of outlets for NSS researchers. (Note that the other 10 journals in this study are not listed in Table 2 as they published no NSS research.) Third, the GD&N journal completely dominates NSS research (84.1% of total publications) reinforcing the limited publication outlets issue. Finally, and more promisingly, NSS publication is growing (from 16 to 24 to 42 papers in the three eras) indicating a growing interest among researchers.

Journal	19	90 - 1996	199	97 - 2003	20	004 - 2010		Total
	No.	% of Period	No.	% of Period	No.	% of Period	No.	% of Sample
DSS	0	0.0	2	8.3	3	7.1	5	6.1
I&M	0	0.0	1	4.2	1	2.4	2	2.4
JMIS	1	6.3	1	4.2	1	2.4	3	3.7
JOC&EC	0	0.0	0	0.0	2	4.8	2	2.4
GD&N	15	93.8	20	83.3	34	81.0	69	84.1
MISQ	0	0.0	0	0.0	1	2.4	1	1.2
Total	16	100.0	24	100.0	42	100.0	82	100.0

Table 2: NSS	Papers	by Journal	1
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#### Procedure

The protocol used to code each paper addressed each of the factors described in this paper. This protocol has been previously published in detail (Arnott and Pervan, 2005; Pervan et al., 2005; Pervan and Arnott, 2006) and is not provided here to save space.

#### Findings

The discussion above on publication rates and outlets addressed the first research question. An additional issue associated with publication was the declared support (if any) in terms of funding from competitive grants, industry, or the university itself.

	1990 - 1996		1997 - 2003		2004 - 2010		Total	
	No.	%	No.	%	No.	%	No.	%
GSS Support	51	32.5	24	17.0	29	34.1	104	27.2
NSS Support	4	25.0	7	29.2	19	45.2	30	36.6

Table 3a: GSS and NSS Financial Support

Table 3a reports the number and percentage of projects/papers supported financially and reveals that NSS research is more often supported in the most recent era in particular, and overall.

Table 3b below breaks down research funding by type (major competitive, industry, university) for both GSS and NSS. Where funded, both GSS and NSS researchers seem to be quite successful in winning major competitive grants, particularly more recently. However, neither is attracting funds from industry which is disappointing for applied disciplines such as GSS and NSS, and may reflect a low relevance in the eyes of potential industry research partners.

	1990 -	1996	1997 -	2003	2004	- 2010	۰ ۲	Fotal
GSS	No.	%	No.	%	No.	%	No.	%
Major competitive	30	58.9	19	79.2	26	89.5	75	72.1
Industry	22	43.1	2	8.4	2	6.8	26	25.0
University	14	27.4	8	33.4	9	30.9	31	29.8
	51		24		29		104	
NSS								
Major competitive	3	75.0	6	85.7	17	89.4	26	86.7
Industry	0	0.0	0	0.0	1	5.3	1	3.3
University	2	50.0	1	14.3	3	15.8	6	20.0
	4		7		19		30	

Table 3b: GSS and NSS Financial Support by Type

In answering the second research question "What type and quality of research has been done?" we investigated the research epistemology, article type, strength of theoretical foundations and research methodology, and problem importance.

	1990 -	1996	1997 -	1997 - 2003		- 2010	Total	
GSS	No.	%	No.	%	No.	%	No.	%
Positivist	101	64.3	91	64.5	55	64.7	247	64.5
Interpretivist	7	4.5	17	12.1	6	7.1	30	7.8
N/A	49	31.2	33	23.4	24	28.2	106	27.7
	157		141		85		383	
NSS								
Positivist	5	31.3	11	45.8	20	47.6	36	43.9
Interpretivist	0	0.0	1	4.2	0	0.0	1	1.2
N/A	11	68.8	12	50.0	22	52.4	45	54.9
	16		24		42		82	

Table 4: GSS and NSS Research Epistemology

Data on research epistemology appears in Table 4. In relation to GSS it appears that positivist research is dominant over all three eras (64.5% of papers) with only 7.8% of papers identified as interpretivist. In NSS research interpretivist research is virtually non-existent (1 paper out of 82!). Note that 27.7% of GSS papers and 54.9% of NSS papers had no identifiable epistemology. Chen and Hirschheim's (2004) study of Information Systems research in general from 1991 to 2001 reported that 81% of papers had a positivist orientation with 19% using an interpretivist approach. These results confirm that, even more strongly than IS research in general, positivist research dominates both GSS and NSS.

There are a number of different approaches to classifying the type of research in addition to paradigm. The approach used in this project is a simplification of that used by Arnott and Pervan (2005). The different types are as listed in Tables 5a and 5b below.

	1990 -	1996	1997 -	2003	2004	- 2010	,	Fotal
	No.	%	No.	%	No.	%	No.	%
Conceptual Study	33	21.0	24	17.0	9	10.6	66	17.2
Descriptive Research	16	10.2	9	6.4	1	1.2	26	6.8
Experimental	45	28.7	55	39.0	27	31.8	127	33.2
Field Study	3	1.9	11	7.8	0	0.0	14	3.7
Case Study	19	12.1	17	12.1	12	14.1	48	12.5
Survey	7	4.5	1	0.7	5	5.9	13	3.4
Literature Review	2	1.3	5	3.5	1	1.2	8	2.1
Secondary Data	2	1.3	3	2.1	1	1.2	6	1.6
Action Research	0	0.0	2	1.4	3	3.5	5	1.3
Design Science	30	19.1	14	9.9	26	30.6	70	18.3
Total	157		141		85		383	

Table 5a: GSS Article Type

Table 5a reveals that experimental research dominates GSS (33.2% of GSS papers) where universitydeveloped GSS (GroupSystems, SAMM, Meetingworks) are studied in decision rooms on artificial problems with students as subjects. It is promising that design science studies are common, particularly more recently, suggesting that there may be new technologies and processes developed to support group work.

	1990 -	1996	1997 -	2003	2004	- 2010	•	Гotal
	No.	%	No.	%	No.	%	No.	%
Conceptual Study	8	50.0	8	33.3	3	7.1	19	23.2
Descriptive Research	2	12.5	5	20.8	0	0.0	7	8.5
Experimental	2	12.5	6	25.0	11	26.2	19	23.2
Field Study	0	0.0	0	0.0	0	0.0	0	0.0
Case Study	1	6.3	0	0.0	0	0.0	1	1.2
Survey	0	0.0	0	0.0	3	7.1	3	3.7
Literature Review	0	0.0	0	0.0	1	2.4	1	1.2
Secondary Data	0	0.0	0	0.0	2	4.8	2	2.4
Action Research	0	0.0	0	0.0	0	0.0	0	0.0
Design Science	3	18.8	5	20.8	22	52.4	30	36.6
Total	16		24		42		82	

Table 5b: NSS Article Type

The major NSS article type is design science research (Hevner et al., 2004) reflecting an interest in developing new NSS technologies, processes, and methods. This was followed by conceptual studies and experiments

(both 23.2%). It should be noted that there are few field and case studies in NSS or GSS research. Clearly, despite the maturity of these research areas, there is still a need for more research involving real stakeholders tackling real problems using different types of system.

The quality of each paper was addressed by assessing the strength of its theoretical foundations and research methodology (strong, adequate, weak), as well as the importance of the problem (strategic, tactical, operational). Tables 6-8 contain these assessments for both GSS and NSS research.

	1990 -	1996	1997 -	2003	2004	- 2010		Fotal
	No.	%	No.	%	No.	%	No.	%
GSS								
Strong	47	29.9	62	44.0	42	49.4	151	39.4
Adequate	60	38.2	56	39.7	35	41.2	151	39.4
Weak	50	31.8	23	16.3	8	9.4	81	21.1
Total	157		141		85		383	
NSS								
Strong	5	31.3	1	4.2	23	54.8	29	35.4
Adequate	7	43.8	14	58.3	15	35.7	36	43.9
Weak	4	25.0	9	37.5	4	9.5	17	20.7
Total	16		24		42		82	

Table 6: Strength of Theoretical Foundations

Overall both NSS and GSS papers could claim adequate theoretical foundations with around 20% weak for both GSS and NSS. However, an examination of the trend over time reveals that there has been some improvement in the 2004-2010 period with less than 10% in the weak category in both cases.

Another, deeper, assessment of the nature and quality of the theoretical foundations of GSS and NSS research was to carefully review the number of papers actually used in providing a theoretical foundation to the research. This was not a raw citation analysis, but was based on cited references actually being used to develop a theoretical model, form some hypotheses, or explain some results. Some 30.3% of GSS papers and 35.4% of NSS papers cited no 'real' references, 19.3% GSS and 23.2% NSS cited one, 15.1% GSS and 14.6% NSS cited two, and only 30.2% GSS and 26.8% NSS cited three or more. An examination of citations over time showed there was no significant improving trend. This demonstrates that much GSS and NSS research has limited theoretical foundation.

In GSS research the research methodologies are fairly weak and not improving over time, which occurs for a variety of reasons. These include poor choice of method, lack or reliability and validity of instruments, poor data collection choices, and so on. There is much room for improvement. Alarmingly, it is even worse in NSS research with only 8.5% strong and 63.4% weak. There has been a little improvement over time but with half of the papers in 2004-2010 weak on methodology there is cause for concern.

	1990 -	1996	1997 -	2003	2004	- 2010	•	Fotal
	No.	%	No.	%	No.	%	No.	%
GSS								
Strong	36	22.9	49	34.8	27	31.8	112	29.2
Adequate	31	19.7	47	33.3	28	32.9	106	27.7
Weak	90	57.3	45	31.9	30	35.3	165	43.1
Total	157		141		85		383	
NSS								
Strong	0	0.0	1	4.2	6	14.3	7	8.5
Adequate	2	12.5	6	25.0	15	35.7	23	28.0
Weak	14	87.5	17	70.8	21	50.0	52	63.4
Total	16		24		42		82	

Table 7: Strength of Research Methodologies

	1990 -	1990 - 1996		2003	2004	- 2010	,	Total
	No.	%	No.	%	No.	%	No.	%
GSS								
Strategic	11	7.0	17	12.1	14	16.5	42	11.0
Tactical	28	17.8	31	22.0	17	20.0	76	19.8
Operational	118	75.2	93	66.0	54	63.5	265	69.2
Total	157		141		85		383	
NSS								
Strategic	1	6.3	2	8.3	7	16.7	10	12.2
Tactical	4	25.0	3	12.5	9	21.4	16	19.5
Operational	11	68.8	19	79.2	26	61.9	56	68.3
Total	16		24		42		82	

Table 8: Importance of the Problem

Table 8 shows that most GSS research addresses operational problems with 69.2% at that level and that focus is fairly consistent over time. A similar finding is apparent for NSS research with 68.3% focused at operational level problems. This may relate to the emphasis on experimental research on artificial problems and a lack of interaction with managers concerned with more strategic issues.

In answering research question (c), "How relevant is GSS and NSS research?", the practical relevance of the research in each article was analysed, both from an IS practitioner and a managerial user point of view. Any professionally focused academic areas (like GSS and NSS) need a reasonable balance between theory development and application since research and practice inform each other (Galliers 1994). The assessment of practical relevance is a subjective judgement that was informed by the aims and objectives of the paper, the nature of the discussion, and in particular the content of the concluding comments of each paper. The

scale used for both types of relevance was high-medium-low and assessments erred on the generous side where possible.

	1990 -	1996	1997 -	2003	2004	- 2010	,	Fotal
	No.	%	No.	%	No.	%	No.	%
GSS								
High	3	1.9	6	4.3	1	1.2	10	2.6
Medium	34	21.7	25	17.7	18	21.2	77	20.1
Low	120	76.4	110	78.0	66	77.6	296	77.3
Total	157		141		85		383	
NSS								
High	0	0.0	1	4.2	0	0.0	1	1.2
Medium	3	18.8	4	16.7	3	7.1	10	12.2
Low	13	81.3	19	79.2	39	92.9	71	86.6
Total	16		24		42		82	

Table 9: Relevance to IS Practitioners

Very few GSS papers were assessed as highly relevant to IS practitioners (only 2.6% overall) and most were assessed to be of low relevance. This is particularly in the light of the interest in design science (see Table 5a). The findings are even worse for NSS research with 1.2% of papers assessed as highly relevant to IS practitioners.

	1990 - 1996		1997 - 2003		2004 - 2010		Total	
	No.	%	No.	%	No.	%	No.	%
GSS								
High	10	6.4	12	8.5	12	14.1	34	8.9
Medium	44	28.0	37	26.2	33	38.8	114	29.9
Low	103	65.6	92	65.2	40	47.1	235	61.4
Total	157		141		85		383	
NSS								
High	0	0.0	3	12.5	2	4.8	5	6.1
Medium	3	18.8	3	12.5	13	31.0	19	23.2
Low	13	81.3	18	75.0	27	64.3	58	70.7
Total	16		24		42		82	

Table 10: Relevance to Managerial Users

The results for managerial relevance are slightly better than those for IS practitioner relevance for both NSS and GSS. However, the high relevance assessment occurred in only 8.9% of GSS papers and 6.1% of NSS papers and the vast majority of both GSS and NSS papers are in the low managerial relevance category.

While the project was initiated with a concern for the relevance of GSS and NSS research, we were surprised by the strength of this adverse finding. The relative lack of exposure of academics to contemporary professional practice is a particular problem.

#### **Issues and Strategies**

The structured review of 383 GSS papers and 82 NSS papers in 16 major journals that may be expected to publish some GSS or NSS research has revealed a number of significant issues. These issues may be summarised as follows:

- 1. GSS research publication is strongly dominated by its specialist journal, the Journal of Group Decision and Negotiation, though other significant avenues of publication are DSS, JMIS and JOC&EC.
- 2. NSS research publication is completely dominated by its specialist journal, the Journal of Group Decision and Negotiation.
- 3. Both GSS and NSS researchers have had competitive grant success but not with industry.
- 4. GSS research is strongly dominated by empirical studies that adopt a positivist ontology and epistemology, while interpretivism is slowly gaining popularity. GSS research is more dominated by positivism than general IS research.
- 5. The most popular research methods used for GSS research are experimental, design science, conceptual, and case study.
- 6. The most popular research methods used for NSS research are design science, experimental, and conceptual, but there is little work in the field.
- 7. Both NSS and GSS have limited theoretical foundations.
- 8. GSS research methodologies are weak and not improving, while NSS are even worse.
- 9. GSS and NSS have mostly focused on operational level problems.
- 10. The assessment of the practical relevance to IS practitioners and managerial users of GSS and NSS research shows a discipline that is significantly distanced from professional practice.

This research has been valuable in revealing these issues and they suggest a number of guidelines or strategies that GSS researchers may follow in order to address them. First, GSS researchers should follow industry trends and focus more of their research on collaboration technologies and virtual teams. Second, there should be more field research of all types (case studies, action research, field experiments, surveys) so that NSS and GSS researchers can learn more about support of real stakeholder groups facing or negotiating real problems. Third, researchers with appropriate skills should undertake more interpretive studies so that they can discover new perspectives about group support. Fourth, the research quality can be improved by greater real use of existing theory in forming hypotheses, developing frameworks and models, and explaining findings. Fifth, there should be greater attention paid to research methodology issues to improve research quality. Finally, GSS and NSS researchers should devote significant effort to engage with industry too improve the relevance of their research.

#### **Conclusions and Limitations**

This paper has reported results of a project that aims to critically examine the nature and theoretical foundations of GSS and NSS research. Although the reported analysis is only descriptive, it does throw some light on the issues and concerns that motivated the study. Ten such issues have been revealed by the study. The biggest concern among these issues is the low practical relevance, and this is contributed to by several of the other issues, including the lack of focus on wider collaboration and negotiation technologies. Most of these problems are relatively easy to address and the eight suggested strategies have been proposed that GSS and NSS researchers might consider in tackling these issues. By selectively applying these strategies where appropriate, both the rigour and relevance of their research may be improved.

Any such study must have its limitations. First, by its very nature a literature analysis is very subjective, but the researchers are both very experienced as both researchers and practitioners in the field. Second, the sample is finite, but 465 papers represent a sizeable chunk of GSS/NSS research and enough to substantiate the findings. Third, the journal set is finite but they represent a comprehensive and representative sample of the key G&NSS, DSS and IS journals in the field.

These findings provide researchers with a call for reflection and reassessment of their discipline. Without this reflection and redirection we believe that GSS and NSS will be increasingly distanced from professional practice, contemporary reference research, and other sub-specializations of IS.

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## PART IV

## MODELING NEGOTIATION CONTEXTS

180

## Linguistic variables and TOPSIS-based negotiation support

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**Abstract**: In this paper we discuss a possible extension of the TOPSIS-based approach that allows to handle the imprecise information that may occur when the negotiator's preferences are elicited. We use the notion of the linguistic variables as the potential way of defining the consequences of the negotiation offers. We apply it to the formal negotiation model and the fuzzy TOPSIS algorithm, previously modified and adapted to the requirements of the negotiation context.

Keywords: negotiation, multiple criteria decision making, fuzzy number, Fuzzy TOPSIS, linguistic variable

#### Introduction

The decision support in negotiation is a major focus of the negotiation analysis. The scoring system of the negotiation offers helps negotiators to evaluate any feasible negotiation offer and make decision on accepting or rejecting any proposal at the negotiation table. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) (Hwang and Yoon 1981) is a straightforward method for solving the multiple criteria decision making problems that has already proven its applicability to support the decisions in negotiation (Wachowicz and Blaszczyk 2012). In this work, being a part of the larger ongoing research on building a TOPSIS-based negotiation support mechanism, we try to apply the notion of the linguistic variables to the previously prepared and modified fuzzy TOPSIS negotiation model (see Roszkowska and Wachowicz, 2012).

For many reasons it may be useful (and sometimes even necessary) to operate with the linguistic assessments instead of the numerical ones in defining the negotiation template. Such an approach is more flexible and allows negotiators to describe their preferences in a natural and intuitive way, especially when the qualitative negotiation issues need to be taken into consideration. It may be also of better use when the negotiators are faced with the problem of vague information or imprecise knowledge. Despite the linguistic fuzzy TOPISIS approach has already been considered in the literature (Chen 2000, Cables at el 2012; Kahraman at el 2007; García-Cascales at el 2012) there is no research on applying it to the support of the ill-structured negotiation problems. In this paper we will consider the problem of using the fuzzy data in the negotiation template description. The linguistic variables will be used to assess the weights of the issues and the consequences of each alternative with respect to each issue. We introduced some basic concepts of the linguistic variables and the associated fuzzy sets theory and next formalize negotiation problem with a linguistically defined negotiation template.

#### Linguistic variables in negotiation

#### Basic notions of linguistic variables

A linguistic variable is a variable, which applies words or sentences in a natural or artificial language to describe its degree of value (Zadeh, 1975). The linguistic variable is represented by the linguistic term set with its semantic in order to express the linguistic performance values according to all the criteria.

Definition. A linguistic variable is characterized by a quintuple: {X; T (X); U; G; M}, where

- i) X is the name of the variable,
- ii) T (X) is the term set of X, that is, the collection of its linguistic values
- iii) U is a universe of discourse,
- iv) G is a syntactic rule for generating the elements of T (X) and

v) M is a semantic rule for associating meaning with the linguistic values of X.

The linguistic term set is used to analytically express the linguistic value and describe the evaluation of the alternatives in terms of various criteria. In our approach the uncertain linguistic evaluation is transformed to the triangular fuzzy numbers (TFN).

#### Using linguistic variables for evaluation of options

In negotiations there are various issues that can be evaluated by means of the linguistic variables. The example of such a variable may be the returns policy, terms of warranty or quality. For example, the options of the returns policy issue (X = "returns policy") may be defined by means of the separate contract for returns (a document of a few pages). In their evaluation the linguistic terms like "good", "fair", "poor" can be used that constitute the term set  $T(X) = \{Poor, Fair, Good\}$ . According to the semantic rule M we assign the meanings to the linguistic values, here defined by TFN: M(Poor) (0,1,3), M(Fair) (3,5,7), M(Good) (7,9,10) respectively (Chen 2000).

The numerical values may also be evaluated by means of linguistic variables represented by TFN, if the granularity of such an evaluation is sufficient for the supported negotiator. This granularity, i.e. the cardinality of the linguistic term set used, should be small enough so as not to provide negotiator with too many information (a useless precision). On the other hand it should be rich enough to allow the discrimination of the assessments in a limited number of degrees (Herrera and Herrera-Viedma 2000).

#### Negotiation model for linguistic definition of negotiation problem

We formalize the negotiation problem for linguistically defined template. We assume that negotiator wants to evaluate (to rank) *m* feasible negotiation offers (packages):  $P_1, P_2, ..., P_m$  taking into consideration the set of issues:  $Z = \{Z_1, Z_2, ..., Z_n\}$  (where Z can be divided into two subsets: I - a subset of the benefit issues, and J - a subset of the cost ones). Let  $w = [w_1, w_2, ..., w_n]$  be a vector of issue weights defined subjectively by the negotiator (in a linguistic or quantitative way). We assume that every package  $P_i$  is represented by a vector  $P_i = [\hat{x}_{i1}, \hat{x}_{i2}, ..., \hat{x}_{in}]$ , where  $\hat{x}_{ij}$  is a TFN representation of the resolution level of jth issue's in ith package. If for some issues the crisp evaluation is of better use, we encode them into TFN form (Chen, 2000). Negotiator also defines the ideal ( $P_i$ ) and anti-ideal ( $P_{AI}$ ) package that reflect the lowest acceptable offer as well as the ideal one.

The modified fuzzy TOPSIS method (Roszkowska and Wachowicz, 2012) is used to aggregate the linguistic performance values and rank the negotiation packages. The fuzzy decision matrix is built, in which the TFN represent both the linguistic and crisp variables that define the set of packages P

$$\hat{X}_{P \cup \{P_I, P_{AI}\}} = [\hat{x}_{ij}], \text{ for } i = 1, \dots, m+2, j=1, \dots, n.$$
(1)

According to the fuzzy TOPSIS algorithm the set  $C = \{CC(P_i), P_i \in P \cup \{P_I, P_{AI}\}\}$  of closeness coefficients  $CC(P_i)$  for each package is determined. The negotiator problem of defining and evaluating the negotiation template in the linguistic form can be thus formally described as the following nine-tuple:

$$(Z, P, I, J, w, P_I, P_{AI}, \hat{X}_{P \cup \{P_I, P_{AI}\}}, C).$$
 (2)

The full scoring system of negotiation offers obtained by the fuzzy TOPISIS procedure with the linguistic variables can be a useful tool in supporting the actual negotiation phase. The negotiator can evaluate any package at any time in terms of its overall performance. The important advantage of the proposed method is that this scoring system is resistant to the introduction of new packages and does not lead to the ranking reversal, which may appear in traditional TOPSIS approach. It is because we developed three different approaches for handling the problem of scoring the under-bad (worse than  $P_{AI}$ ) and over-good (better than  $P_{I}$ ) alternatives. Therefore the scoring system is stable and does not change during the negotiation process due to the changes of negotiation problem (Roszkowska and Wachowicz 2012).

#### Supportive tools for linguistic definition of the template

One of the biggest challenges in our approach is to develop the tools (like the software ones) that would help negotiators to design the negotiation template using the linguistic descriptors. Both the protocol for the negotiation problem definition and preference elicitation need to be developed and the software graphical solutions need to be selected that would allow negotiators to define the template in the most convenient and easy way. There are many negotiation issues, especially the qualitative ones, that cannot be intuitively described by negotiators by means of TFNs. Similarly, they probably will not be willing to operate with TFNs while defining the issue weights. In such situations the negotiators may feel rather more comfortable to use the traditional and intuitive web-specific tools like sliders, volume bars etc., the examples of which are shown in Figure 1.



Fig. 1. The possible definitions of the importance of negotiation issues

Currently we are conducting the questionnaire-based research that would allow to answer the question, which of such software solutions is perceived as an easiest but simultaneously most (or sufficiently) informative by the potential users of negotiation support system that will have implemented the modified fuzzy TOPSIS algorithm for linguistic definition and evaluation of negotiation template.

Our future work will focus on implementing the approach proposed into the TOBANS negotiation support system (Wachowicz and Brzostowski 2012) and conduct the use and usefulness tests in comparison to the negotiation support systems that operate with standard decision making tools based on the simple additive weighting, such as Inspire (Kersten and Noronha 1999) or Negoisst (Schoop et al. 2003).

Acknowledgments. This research was supported by the grant from the Polish National Science Center (DEC-2011/03/B/HS4/03857).

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### Reference points in negotiation support

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**Abstract**: The reference points such as BATNA or aspiration levels are the elements of negotiation problem definition. In this paper we investigate the applicability of various multiple criteria decision making models that are based on the notion of reference points to negotiation support both for design and evaluation of negotiation template and the post negotiation improvements of negotiation agreement.

Keywords: evaluation of negotiation template, reference points, TOPSIS, VIKOR, BIPOLAR, Bireference procedure.

#### Introduction

Designing the negotiation template and building the scoring system of the negotiation offers is a starting point for negotiation analysis. It is usually done by means of classic additive scoring model and the simple additive weighting (SAW) method (Keeney and Raiffa, 1976). Despite SAW is a straightforward method of preference elicitation some results of negotiation experiments show, the SAW-based ranking is sometimes misinterpreted or misused by the negotiators (Wachowicz and Kersten 2009, Wachowicz and Wu 2010). Latest research confirms however that other multiple criteria decision making (MCDM) methods may be effectively used in template evaluation and are good alternatives for SAW-based models. One of such approaches is based on TOPSIS algorithm (Hwang and Yoon, 1981). After the adaptation to negotiation context TOPSIS may significantly ease the processes of template definition and negotiator's preference elicitation (Roszkowska and Wachowicz, 2012; Wachowicz and Blaszczyk, 2012). What is more it operates with the parameters, that are negotiation-context specific, such as the reference points: a positive ideal solution (the equivalent of aspiration level in negotiation template) and a negative-ideal solution (the equivalent of reference points, especially while defining their strategies and goals and evaluating their final performance (see GRIN results: Paradis et al., 2010; Wachowicz and Wu, 2010).

In this work, which is a part of bigger ongoing research on using TOPSIS and fuzzy TOPSIS for negotiation support, we analyze how next three selected MCDM methods that are based on the reference points may be hybridized with TOPSIS to build a tool that helps the negotiators in preference elicitation, evaluation of negotiation offers and improving the mutually negotiated agreement. Here we focus on VIKOR (Opricovic and Tzeng, 2004) as well a BIPOLAR (Konarzewska-Gubala, 1991) and Bi-reference procedure (Michalowski and Szapiro, 1992). We try to show how the key notions of VIKOR and BIPOLAR may increase the flexibility and functionality of TOPSIS-based scoring system of the negotiation offers and how the Bi-reference procedure may be applied for searching the improvements of negotiated agreement.

#### Formalizing the negotiation problem

To support negotiators in building the negotiation template and its evaluation the negotiation problem should be first adequately structured and formalized. To do so, the key important elements of negotiations need to be identified such as: negotiation issues; options (issue resolution levels); and packages (feasible negotiation offers). Each negotiator needs also to define the importance of negotiation issues and declare their reference points, that are going to be used to determine the scoring system for the negotiation offer.

Formally, the problem of negotiation template design and evaluation may be described as the following eight-tuple:

$$(Z, I, J, P, P_{I}, P_{AI}, w, S) (Z, I, J, I, P_{I}, P_{AI}, w, S),$$
(1)

where Z is a set of negotiation issues (I is a subset of benefit ones, while J is a subset of cost ones), P is a set of alternatives (the feasible negotiation offers),  $P_I(P_{AI})$  is the ideal (anti-ideal) reference alternative, w is a vector of issue weights and is a vector of alternatives' ratings.

The first four elements of the eight-tuple (1) comprise the negotiation template, while the latter four are the elements of the negotiator's scoring system of negotiation offers.

#### Negotiation template evaluation

For determining the scoring system  $(P_I, P_{AI}, w, S)$  we apply the modified TOPSIS algorithm, as it was suggested in our previous papers (see Roszkowska and Wachowicz 2012, Wachowicz and Błaszczyk 2012). For some problems with definition of preferences may occur we consider now the following changes and improvements for the process of building the negotiator's individual scoring systems:

#### BIPOLAR in definition of the reference points of the scoring system

In some negotiation problems it may be easier for negotiators to define the sets of reference points instead of the single  $P_I$  and  $P_{AI}$ . In such a situation we may use the notions of BIPOLAR (Konarzewska-Gubala, 1991), which does not operate with the single reference alternatives (the ideal and anti-ideal ones) but uses the sets of reference alternatives: the set of good solutions ( $G = \{G_1, G_2, ..., G_n\}$ ) and the set of bad ones ( $B = \{B_1, B_2, ..., B_m\}$ ).

The idea of reference sets cannot be implemented directly into the modified TOPSIS algorithm, for it measures the distances for each alternative  $P_i$  to single alternatives  $P_I$  and  $P_{AI}$ . However, we may change the distance formulas by applying the methods for determining the intra-class distances (see Everitt et al., 2001), such as: single-link method, complete-link method and the group average link method, the basic idea of which are presented in Figure 1.



Fig. 1. The Examples of intra-class distances

#### VIKOR scoring formulas for alternative global rating definition

VIKOR differs from TOPSIS since it does not measure the distances to  $P_I$  and  $P_{AI}$  (Opricovic and Tzeng, 2004). Instead, it determines two ranking measures  $S_i$ , which reflects the average weighted distance between  $P_i$  and  $P_I$ , and  $R_i$ , which reflects the maximum, single-criterion distance between  $P_i$  and  $P_I$ . These two measures are used then to calculate a global ranking  $Q_i$ , that takes into consideration the negotiator's evaluation strategy defined by means of

$$Q_i = qS_i + (1-q)R_i \tag{2}$$

Alternatively the similar idea of Chen et al. (2011) for TOPSIS global score may be used. These scoring formulas are more useful than the traditional TOPSIS one, for they linearly aggregate the single criteria scores, which allows conducting easily the symmetric analysis of the negotiation offers and compromise in the joint scoring space of both the negotiators.

#### Improving negotiation agreement by applying Bi-reference procedure

Usually the post-negotiation improvements for the negotiated agreement are suggested by searching for the dominant alternatives in the extreme-efficient frontier or applying the various notions of bargaining solutions (Kalai and Smorodinsky, 1975; Raiffa et al. 2002). Here we use the idea of Bi-reference procedure (Michalowski and Szapiro, 1992), which originally is an interactive MCDM method. We use this method iteratively for generating a set of alternative improvements that are extreme-efficient. The solution obtained in the first iteration can be considered as the fair improvement of the negotiated agreement and is generated on the basis of the negotiated agreement and  $P_I$  (see A(1) in Figure 2). The solutions from further iterations are determined on the basis of the new reference levels ref(t), that reflect the worst acceptable rating for each negotiator defined by A(1), and the ideal reference  $P_I$ . All of them may be suggested as the alternative contract improvements and renegotiated in the post-negotiation phase.



Fig. 2. Bi-reference procedure in generating the improvements of negotiated agreement in the negotiators' rating space  $(S_1, S_2)$ .

#### Final remarks

In our future work we will try build a new software tool that will hybridize the solutions proposed in Section 3 and incorporate them in the previously proposed TOPSIS-based approach and could be applied in the electronic negotiation process as a decision support mechanism.

Acknowledgments. This research is supported by the grant of Polish National Science Centre (DEC-2011/03/B/HS4/03857).

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## Multi-value negotiation – context and conditions of agreement and equilibrium: The Perspective of Sociological Game Theory

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**Abstract**: In this paper we propose formalization negotiation as a multi-value decision making problem taking advantages of several techniques introduces by Sociological Game Theory (SGT). This model can incorporated two main negotiation approaches: the game-theoretic and behavioral. Such conceptualization allows us discuss some value context negotiations factors taking into account both cooperative as well competitive elements of negotiation process.

Keywords: negotiation, agreement, equilibrium, fair division, game theory

#### Introduction to the Approach

The negotiation is often a relatively open interaction process. Drawing on Generalized Game Theory (GGT), we apply several of its key concepts (Burns and Gomolińska, 2000; Gomolińska, 2004) and analyze selected types of negotiation interactions. Negotiation situations are represented in GGT by a rule complex which specifies participants, their roles, role relationships, goals, negotiation procedures, communication forms, tactics, etc (Roszkowska and Burns, 2010). Rules in negotiation games can be incomplete and imprecise; also both sides can modify them during the process of negotiation. In the SGT framework, negotiation is based critically on judgment process on two correlated levels: player interests and the social relationship(s) among the parties to a negotiation. The SGT concepts include:

- 1. negotiators' value complexes which contain evaluative rules about ideal points or expectation levels, on the one hand, and limits of acceptance, on the other;
- 2. their models or belief complexes which frame and define the negotiators' "situational view" and what they each would expect or would accept;
- 3. the action repertoires of the negotiations, which in our models here are assumed to be open and flexible. They typically contain activities of exchanging information, making offers and bids, and trying to reach or rejecting agreement on a particular accord or compact and including attempts to persuade, deceive or bluff, among other actions;
- 4. judgment modality entailing negotiators' methods of judgment and decision in the situation, for instance, about strategic actions in the situation; modality may be routine -- simply the application of an algorithm -- or may involve non-routine judgments and decisions, e.g., determination of actions realizing particular norms or instrumentally achieving a particular state of the world.

A social negotiation space based on the beliefs, values, and options of the negotiating agents is defined in the SGT.

#### Applications

Negotiators' perceptions and evaluations regarding a suitable accord or agreement is influenced by the social context in which negotiation takes place, for instance the established social relationships and institutional roles of the actors. The outcome(s) - whether agreements or continued negotiation or withdrawal – are shown to be a function of the social or institutional context and the negotiators' value complexes, models of the situation, and judgment modalities.

The models developed in this article enable us to determine the likely outcomes of negotiations, whether or not these are equilibria, in particular, whether "normative equilibria" are accomplished (Burns at al .2005; Burns and Roszkowska, 2007).

The approach will be applied to selected multi-criteria negotiation situations:

- I. Market actors are negotiating an agreement with different possible gains and losses. Three distinct social or institutional contexts are considered: one characterized by conditions of solidarity (or social attachment), another characterized by solidarity but with status differentiation between negotiators, and the third characterized by conditions of competition or enmity. Negotiation patterns and outcomes and possible equilibria are a function of negotiation contexts, negotiators actor properties, and the interaction process.
- II. The three situations of (I) obtain, but they are modified by the relevance or application of an influential norm of fairness or distributive justice (e.g., concerning the distribution of benefits and/or costs among negotiators). Deals reached are evaluated by the participants not only terms of benefits and losses but in terms of fairness or distributive justice. Our models show that "acceptable" agreements may be judged unfair by one or both negotiators and make the agreements unstable. Instances of agreements that are "normative equilibria" are shown to be relatively easy to achieve under some conditions and difficult or impossible to achieve under other conditions.
- III. Finally, we analyze negotiation about an accord or a complex "package deal" in the situations of (I) under conditions where the negotiators utilize persuasion, fabrication, deception, bluff and related strategies to realize their values or goals in situation. The analyses indicate ways in which the negotiation patterns and outcomes in (I) and (II) are shifted or transformed. Potential agreements may be distorted or blocked, but under some conditions difficult agreements may be accomplished.

Acknowledgments. This research was partially supported by a grant from the Polish National Science Center (DEC-2011/03/B/HS4/03857).

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#### On the Inverse Problem for Binomial Semivalues.

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**Abstract**. In a recent work of the author (Dragan,2004), the Inverse Problem has been solved for Semivalues: given a payoff vector, find out the set of games for which the Semivalue corresponding to some set of weight vectors is exactly the a priori given payoff. The Semivalues, axiomatically defined (Dubey et al., 1981), are game values which contain as particular cases the Shapley Value, the Banzhaf Value, and many other values. The Binomial Semivalues (Puente,2000) are extensions of the Banzhaf Value, and depend on only one parameter. In the present work, we shall solve the Inverse Problem for Binomial Semivalues, by using previous results of the author (Dragan,1991,1996).

Keywords: Semivalues, Binomial Semivalues, the Inverse Problem, Null space and range of a Linear Operator.

#### Introduction

In an earlier work, (Dragan,1991), we introduced the Inverse Problem for the Shapley Value of a cooperative transferable utilities game (N, v), (briefly, a TU game), as follows: for a fixed finite set N, let  $L \in \mathbb{R}^n$ , where n is the cardinality of N; find out all cooperative games with the set of players N, such that the Shapley Value equals L. In the mentioned work, the problem has been solved for the Shapley Value and the Weighted Shapley Value. In the case of a TU game, the Semivalues, axiomatically defined for cooperative games (Dubey et al.,(1981)), were proved to be given by a formula valid for an arbitrary Semivalue, which can be taken as a definition for this value. Here we use this approach. Let  $G^N$  be the vector space of TU games with the set of players N, and a sequence of weight vectors  $p^1, p^2, ..., p^n$  with  $p^t \in \mathbb{R}^t$ , satisfying the following normalization conditions

$$\sum_{j=1}^{t} {\binom{t-1}{j-1}} p_j^t = 1, \quad t = 1, 2, ..., n,$$
(1)

and also, what we called the inverse Pascal triangle conditions

$$p_j^{t-1} = p_j^t + p_{j+1}^t, \quad j = 1, 2, ..., t-1, \quad t = 1, 2, ..., n.$$
 (2)

For any subset T of N, the weight vector  $p^t = (p_j^t)$  gives all  $p_j^t$ , the common weight of all subsets of T with size j, for j = 1, 2, ..., t. Obviously, if  $p^n$  is given, and satisfying (1), then all weight vectors are uniquely determined by (2) and they are also satisfying (1). For example, if vectors  $p^1 = (p_1^1)$  and  $p^2 = (p_1^2, p_2^2)$  are computed by means of (2) from  $p^3$ , that satisfies our normalization condition (1) with t = 3, that is we have  $p_1^3 + 2p_2^3 + p_3^3 = 1$ , then we get  $p_1^2 = p_1^3 + p_2^3$ , and also  $p_2^2 = p_2^3 + p_3^3$ , which gives  $p_1^2 + p_2^2 = 1$  and  $p_1^1 = p_1^2 + p_2^2$ , i.e.  $p_1^1 = 1$ . Now, by definition, the Semivalue associated with the weight vector  $p^n$  is given by formula

$$SE_i(N, \nu) = \sum_{S:i\in S} p_s^n[\nu(S) - \nu(S - \{i\})], \forall i \in N,$$
(3)

where S is any nonempty subset of N, and s is its size. Particular Semivalues are the Shapley Value and the Banzhaf Value obtained for

$$p_s^n = \frac{(s-1)!(n-s)!}{n!}, s = 1, 2, ..., n,$$
 and  $p_s^n = 2^{1-n}, s = 1, 2, ..., n,$  (4)

respectively, and many other values. The Inverse Problem for Semivalues has been recently solved by the author, (Dragan,2004), so that the present work is a continuation of the mentioned one.

The Binomial Semivalues have been introduced as follows (Puente,2000): the Semivalue associated with the sequence of weight vectors  $p^1, p^2, ..., p^n$  is a Binomial Semivalue, if, beside (1) and (2) above, the weight vector  $p^n$  will satisfy

$$\frac{p_2^n}{p_1^n} = \frac{p_3^n}{p_2^n} = \dots = \frac{p_n^n}{p_{n-1}^n} = r,$$
(5)

where no weight can be zero. If (5) under the form  $p_i^n = r^{i-1}p_1^n$ , is used in (1) for all i = 1, 2, ..., n, all terms have the common factor  $p_1^n$ , and noticing that the other factor is the power  $(1+r)^{i-1}$ , we get the weights in terms of the ratio r, as

$$p_s^n = \frac{r^{s-1}}{(1+r)^{n-1}}, \ s = 1, 2, ..., n,$$
(6)

(see also Freixas and Puente, 2002). From (2) we obtain that for all weight vectors  $p^t$ , t = 1, 2, ..., n, we have relationships similar to (5), with the same ratio r, and formulas of the form (6) hold, if we replace n by t. Note that among the Binomial Semivalues we have the Banzhaf Value, obtained for r = 1, hence it makes sense to introduce this class of values, as generalizations for the Banzhaf Value, and get suggestions about their properties from the properties of the Banzhaf Value, (Dragan, 1996).

#### Properties of the Binomial Semivalues, the Null space

For a fixed N, the set of TU games with the set of players N, denoted  $G^N$ , is a vector space in which the operations are

$$(v_1 + v_2)(S) = v_1(S) + v_2(S),$$
  $(av(S)) = av(S),$  (7)

for all subsets S of N, all games  $(N,v_1), (N,v_2), (N,v)$  and any number a. It is well known that  $\dim G^N = 2^n - 1$ , because the number of no empty subsets of N is  $2^n - 1$ . From Linear Algebra it is known that a basis of  $G^N$  is a set of  $2^n - 1$  linearly independent games. The following result is obvious:

**Theorem 1:** If  $SE: G^N \to R^n$  is any Binomial Semivalue, defined by the weight vector  $p^n$ , given by the parameter r and formula (6), then the Semivalue is a linear operator on this vector space.

In our previous work, we introduced for Semivalues an interesting basis of the space  $G^N$ , which was called the potential basis. The basis

$$W = \{ w_T \in \mathbb{R}^t : T \subseteq N, T \neq \emptyset \},\tag{8}$$

is given by

$$w_{T}(T) = \frac{1}{p_{t}^{t}}, \qquad \qquad w_{T}(S) = \sum_{l=0}^{s-t} \frac{(-1)^{l} \binom{s-t}{l}}{p_{t+l}^{t+l}}, \quad \forall S \supset T, \qquad (9)$$

and  $w_T(S) = 0$  otherwise. Notice that the basic vectors for all coalitions of the game depend on the coalition S via s = |S|. This can be seen in the next example, where we consider the case n = 3.

**Example 1:** Consider TU games with three players; then the basic vectors given by formulas (9) can be expressed in terms of the ratio r as follows:

Obviously, they are linearly independent, because their determinant is different of zero, therefore they form a basis for  $G^N$ . Notice that there is no need to use (6) in formulas (9) to express each weight in terms of r, the parameter of the Binomial Semivalue, as it was done here above: we can use (6) in (9), to get directly the basic vectors in terms of the ratio. If we do this in general, we have to prove:

**Theorem 2:** Consider the Binomial Semivalues defined by means of ratio r, and the basis of  $G^N$  given by formulas (9), then the basic vectors are expressed as

$$w_T(T) = \frac{(1+r)^{t-1}}{r^{t-1}}, \forall T \subseteq N, \qquad w_T(S) = \frac{(-1)^{s-t}(1+r)^{t-1}}{r^{s-1}}, \forall S \supset T,$$
(10)

and  $W_T(S) = 0$ , otherwise.

*Proof:* While we have the first formula from (6) and (9), we should compute the sums shown in (9), based upon (6). Replace in (9) the weights given by (6), to get

$$w_T(S) = \sum_{l=0}^{s-t} (-1)^l {\binom{s-t}{l}} \frac{(1+r)^{t+l-1}}{r^{t+l-1}}, \forall S \supseteq T.$$
(11)

Factor out the ratio  $r^{1-s}(1+r)^{t-1}$  to obtain

$$w_T(S) = r^{1-s} (1+r)^{t-1} \sum_{l=0}^{s-t} {s-t \choose l} r^{s-t-l} (1+r)^l, \forall S \supseteq T.$$
(12)

Now, develop the sum and notice that this is the power of a binomial which makes  $(-1)^{s-t}$ , so that (10) is proved.

To justify the expressions found in the right hand sides in the Example 1, we can consider the case n=3, and use the formulas (10). Further, our Theorem 2 helps us to get immediately the Semmivalues of the basic vectors; the formulas (10) will be used in the following three cases:

a) 
$$S = N$$
; b)  $S = N - \{i\}, \forall i \in N$ ; c)  $|S| \le n - 2$ .

**Theorem 3:** Consider a Binomial Semivalue, defined on the space of games  $G^N$  by only one parameter r. Let  $W = \{w_r : T \subseteq N, T \neq \emptyset\}$  denote a basis for the space. Then the Binomial Semivalues of the basic vectors are

$$\begin{split} SE(N, w_T) &= 0, \forall T \subset N, T \neq \emptyset, |T| \leq n-2, \\ SE_j(N, w_{N-\{i\}}) &= 0, j \neq i, \forall i \in N, \end{split}$$

$$\begin{aligned} SE_i(N, w_{N-\{i\}}) &= 0, j \neq i, \forall i \in N, \\ SE_i(N, w_N) &= 1, \forall i \in N. \end{aligned}$$

$$\begin{aligned} SE_i(N, w_N) &= 1, \forall i \in N. \end{aligned}$$

$$\begin{aligned} SE_i(N, w_N) &= 1, \forall i \in N. \end{aligned}$$

$$\begin{aligned} SE_i(N, w_N) &= 1, \forall i \in N. \end{aligned}$$

*Proof:* Consider successively the cases a), b), c), mentioned above.

a) If S = N, then the game  $(N, w_N)$  has only one component, namely  $w_N(N) = \frac{(1+r)^{n-1}}{r^{n-1}}$ ,

different of zero, while  $p_n^n = \frac{r^{n-1}}{(1+r)^{n-1}}$ ; therefore, via (10), the last formula (13) is proved.

b) If  $S = N - \{i\}$ , for some fixed  $i \in N$ , then by formulas (10), the game  $(N, w_{N-\{i\}})$  has two components different of zero, namely

$$w_{N-\{i\}}(N-\{i\}) = \frac{(1+r)^{n-2}}{r^{n-2}}, \qquad w_{N-\{i\}}(N) = -\frac{(1+r)^{n-2}}{r^{n-1}}, \tag{14}$$

while we need in (3), from (6), the weights

$$p_{n-1}^{n} = \frac{r^{n-2}}{(1+r)^{n-1}}, \quad p_{n}^{n} = \frac{r^{n-1}}{(1+r)^{n-1}}.$$
(15)

Now, either j = i, and we are computing

$$SE_{i}(N, w_{N-\{i\}}) = p_{n}^{n}[w_{N-\{i\}}(N) - w_{N-\{i\}}(N-\{i\})] = -1,$$
(16)

where we have used in (3) the above weights and the non zero components, or we have  $j \neq i$ , and we are computing

$$SE_{j}(N, w_{N-\{i\}}) = p_{n-1}^{n} \sum_{S: j \in S \subseteq N-\{i\}} w_{N-\{i\}}(S) + p_{n}^{n} w_{N-\{i\}}(N),$$
(17)

in which we have shown all the non zero terms. As among these coalitions included in  $N - \{i\}$  and containing j there is only one with a nonzero worth, namely  $N - \{i\}$  itself, and we take the weights from above, we get

$$SE_{j}(N, w_{N-\{i\}}) = p_{n-1}^{n} w_{N-\{i\}}(N-\{i\}) + p_{n}^{n} w_{N-\{i\}}(N) = 0,$$
(18)  
that is the middle formulas (10) have been proved.

c) When we compute any  $SE_j(N, w_T), |T| \le n-2$ , we compute the sum found in formula (3), by computing the group of terms corresponding to all coalitions of the same size, taking into account that in formulas (10), the right hand sides depend on S, only via s = |S|. To do this,

notice that (10) gives nonzero values only for coalitions of the form  $S = T \cup L, L \subseteq N - T$ . then we can rewrite (10) as

$$w_{T}(T \cup L) = \frac{(-1)^{l}(1+r)^{t-1}}{r^{t+l-1}}, \forall L \subseteq N - T,$$
(19)  
where  $l = |L|.$ 

Now, we are ready to continue the proof of Theorem 3. Two mutually exclusive cases may occur: (c')  $j \in T$ ; and (c")  $j \in L$ .

(c') If  $j \in T$ , then the difference occurring in the sum (3), precisely

$$p_{t+l}^{n}[w_{T}(T \cup L) - w_{T}((T - \{j\}) \cup L)],$$
(20)

has a null second term, because the coalition  $(T - \{j\}) \cup L$  does not contain the coalition S. All terms for coalitions of size t+l are equal, given by (6); there are  $\binom{n-t}{l}$  such terms, all of them multiplied by

the weight  $p_{t+1}^n = \frac{r^{t+1-1}}{(1+r)^{n-1}}$ . Hence, from (19) we get these terms as a unique term in the sum

$$SE_{j}(N, w_{T}) = \sum_{l=0}^{n-t} p_{t+l}^{n} [w_{T}(T \cup L) - w_{T}((T - \{j\}) \cup L)] =$$
$$= \sum_{l=0}^{n-t} (-1)^{l} \binom{n-t}{l} \frac{1}{(1+r)^{n-t}} = \frac{1}{(1+r)^{n-t}} \sum_{l=0}^{n-t} (-1)^{l} \binom{n-t}{l} = 0,$$
(21)

where the sum is at last shown to be the power  $[1+(-1)]^{n-t}$ .

(c") If  $j \in L$ , then the difference in the bracket above has two nonzero terms, and can be expressed via formula (10) as

$$w_T(T \cup L) - w_T(T \cup (L - \{j\})) = (-1)^l \frac{(1+r)^t}{r^{t+l-1}}.$$
(22)

This happens for one term associated with a coalition of size t+l and there are  $\binom{n-t-1}{l-1}$  such coalitions, those obtained by adding n-t-1 players to j. It follows that in the sum giving  $SE_{j}(N, w_{T})$ , we have  $\binom{n-t-1}{l-1}$  multiplying the weight  $p_{t+l}^{n} = \frac{r^{t+l-1}}{(1+r)^{n-1}}$ . We get

$$SE_{j}(N, w_{T}) = \sum_{l=0}^{n-t} p_{t+l}^{n} {\binom{n-t-1}{l-1}} (-1)^{l} \frac{(1+r)^{t}}{r^{t+l-1}} = -\frac{1}{(1+r)^{n-t-1}} \sum_{l=1}^{n-t} (-1)^{l} {\binom{n-t-1}{l-1}} = 0,$$
(23)

where we have used again the expression of the sum as the power of a binomial.  $\blacksquare$ 

As a combination of results (a) and (b), an obvious fact is given by

**Corollary 4:** Let W be the basis of  $G^N$  given by formula (10); then we have  $SE(w_N + \sum_{i \in N} w_{N-\{i\}}) = 0.$ (24)

Another result obtained from Theorem 3 and a fundamental theorem of Linear Algebra is: *Theorem 5: The set of games* 

$$W^* = \{ w_S \in \mathbb{R}^n : S \subset \mathbb{N}, S \neq \emptyset, |S| \le n - 2 \} \cup \{ w_N + \sum_{i \in \mathbb{N}} w_{N - \{i\}} \},$$
(25)

defined by means of formulas (10) and Corollary 4, is a basis of the Null space of the Binomial Semivalues.

*Proof:* In Linear Algebra it is proved that any vector space is the direct sum of the Null space and the Range of the linear operator. A consequence of this fact is that the dimension of the space, in our case  $2^n - 1$ , is the sum of the nullity, the dimension of the Null space, and the rank, which is the dimension of the Range, in our case n. Hence, the nullity equals  $2^n - n - 1$  and this is exactly the number of linearly independent elements in  $W^*$ , as shown by (13), so that this is a basis for the Null space.

Note that Theorem 5 will help us in solving the Inverse Problem for Binomial Semivalues, in the next section.

#### The Inverse Problem for Binomial Semivalue

Now, we have available all tools needed to solve the Inverse Problem for any Binomial Semivalue. A TU game  $(N, v) \in G^N$  can be written in basis W as

$$\nu = \sum_{S:|S| \le n-2} a_S w_S + \sum_{i \in N} a_{N-\{i\}} w_{N-\{i\}} + a_N w_N,$$
(26)

so that by Theorem 5, we can exhibit the basis of the Null space, by writing (26) as

$$v = \sum_{S:|S| \le n-2} a_S w_S + a_N (w_N + \sum_{i \in N} w_{N-\{i\}}) + \sum_{i \in N} (a_{N-\{i\}} - a_N) w_{N-\{i\}}.$$
(27)

By Theorem 5 and the linearity of the value, from (27), we obtain componentwise

$$SE_{j}(N, v) = \sum_{i \in N} (a_{N-\{i\}} - a_{N}).SE_{j}(N, w_{N-\{i\}}), \forall j \in N.$$
(28)

In the last sum, as shown in (13) of Theorem 3, there is only one nonzero term and we obtain

$$SE_i(N,\nu) = a_N - a_{N-\{i\}}, \forall i \in N.$$
<sup>(29)</sup>

If the Semivalue is known, given apriori by a vector  $L \in \mathbb{R}^n$  then the left hand side in (29) is known to be  $L_i$  and the difference from the right hand side may be substituted in (27) to get

$$v = \sum_{S:|S| \le n-2} a_S w_S + a_N (w_N + \sum_{i \in N} w_{N-\{i\}}) - \sum_{i \in N} L_i w_{N-\{i\}}.$$
(30)

This last formula shows the solution of the Inverse Problem for a Binomial Semivalue, a result which is proved and should only be stated:

**Theorem 6:** For a Binomial Semivalue SE defined on the set of games  $G^N$  by a constant r, and for a given payoff vector  $L \in \mathbb{R}^n$ , the set of games (N, v) such that SE(N, v) = L, is given by formula (30), where  $w_T, \forall T \subseteq N$ , are expressed by formulas (10) and the  $2^n - n - 1$  parameters  $a_S, \forall S \subset N, S \neq \emptyset, |S| \le n - 2$ , and  $a_N$  are arbitrary constants.

Note that the solution of the Inverse Problem for any Semivalue looks similar, but here the basic vectors depend explicitly on the parameter, while in general we have an implicit dependence on the weight vectors, (Dragan,2004). The use of the solution is illustrated for a general three person game presented below.

**Example 2:** Return to the Example 1, above, where the basic vectors for three person games were given in terms of r. Formula (30) may be written as

$$v = a_1 w_1 + a_2 w_2 + a_3 w_3 + a_{123} (w_{123} + w_{12} + w_{13} + w_{23}) - \sum_{i \in N} L_i w_{N-\{i\}},$$
(31)

with  $w_T, T \subseteq N$ , shown in Example 1. If we use those basic vectors in the last formula and rewrite it componentswise, we obtain the explicit form of the expressions of the characteristic function for the inverse solution:

$$v(1) = a_1, v(2) = a_2, v(3) = a_3,$$

$$v(1,2) = -\frac{1}{r}(a_1 + a_2) + \frac{1+r}{r}(a_{123} - L_3),$$
  

$$v(1,3) = -\frac{1}{r}(a_1 + a_3) + \frac{1+r}{r}(a_{123} - L_2),$$
  
(32)

$$v(2,3) = -\frac{1}{r}(a_2 + a_3) + \frac{1+r}{r}(a_{123} - L_1),$$
  

$$v(1,2,3) = \frac{1}{r^2}(a_1 + a_2 + a_3) + \frac{(1+r)(r-2)}{r^2}a_{123} + \frac{1+r}{r^2}(L_1 + L_2 + L_3).$$

In words, the solution of the Inverse Problem for a three person game and a Binomial Semivalue defined by a constant r, depends on the parameters  $a_1, a_2, a_3, a_{123}$ . A numerical example may be easily given. We take also the opportunity to show how the parameters can be computed in terms of the characteristic function of the game. Beside  $a_1 = v(1), a_2 = v(2), a_3 = v(3)$ , we find easily

$$a_{123} = -\frac{1}{r^2 - r - 2} \{ v(1) + v(2) + v(3) - r^2 v(1, 2, 3) + (1 + r)(L_1 + L_2 + L_3) \}.$$
 (33)

In this way, for a game

$$v(1) = v(2) = v(3) = 0, v(1,2) = 10, v(1,3) = v(2,3) = 8, v(1,2,3) = 18,$$
(34)

with the Banzhaf Value B = (7, 7, 6), corresponding to r = 1, we have  $a_1 = a_2 = a_3 = 0$  and  $a_{123} = 11$ . Of course, the other three person games with the same Banzhaf Value are given by  $v(1) = a_1, v(2) = a_2, v(3) = a_3$ ,

$$v(1,2) = -(a_1 + a_2) + 2a_{123} - 12, v(1,2) = -(a_1 + a_3) + 2a_{123} - 14,$$

$$v(2,3) = -(a_2 + a_3) + 2a_{123} - 14, v(1,2,3) = a_1 + a_2 + a_3 - 2a_{123} + 40.$$
(35)

Obviously, we may consider other Binomial Semivalues than the Banzhaf Value and give the solution for the Inverse Problem. The coefficients of the expansion may be computed by using the potentials of those values, as it was shown earlier for the Shapley Value (Dragan,1991).

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# A combination of a distance measure and an additive model to support group decision making

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**Abstract**: This model is based on a combination of three elements: a vector representation of all decision makers' values for each alternative; the setting of agreement and disagreement zones; and the distance from each alternative to the ideal alternative. The model proposed seems to minimize the inherent compensatory effects of additive models by aggregating DMs' opinions in a different manner. The simplicity of the model may be an advantage for its use.

Keywords: group decision making, additive model, distance measure, vector model.

#### Introduction

Over the last decades, several Multi-Criteria Decision Making (MCDM) methods have been proposed to help in selecting the best compromise alternatives or in ranking or sorting a set of alternatives. Aggregating different opinions in order to achieve a social final recommendation continues to motivate the development of studies in this research field (Daher and Almeida, 2010).

One of the major problems in traditional aggregation models is the compensatory effect. With a view to minimizing this problem, Daher and Almeida (2012) proposed a group decision making model which introduced a veto threshold concept for additive models and the use of a value reduction factor (VRF) to penalize conflicting alternatives in a ranking problem. In that study, each decision maker (DM) must inform a veto threshold which is the minimum acceptable value that an alternative may have in order to be considered as an acceptable (or desirable) solution. The combination of all veto thresholds defines a virtual alternative  $\alpha$  representing the last alternative (if it exists) acceptable to all DMs and its global value  $v_{\alpha}$  is obtained using the additive function.

In a vector representation, the combination of all veto thresholds set also establishes the identification of at least four zones: two agreement zones and two disagreement zones. The agreement zones are positive and negative areas. A positive agreement zone means that all alternatives located in this area are considered acceptable by all DMs. On the other hand, a negative agreement zone means that all DMs consider that alternatives located in this area are unacceptable. A disagreement zone means that at least one DM does not accept an alternative allocated in that area. In a choice problematic, DMs can minimize conflicts by focusing their effort on trying to achieve a more consensual group recommendation by considering alternatives from the positive agreement zone. The use of veto is typically found in multicriteria outranking models and usually represents the intensity of preference of the minority (Roy and Slowinski 2008). Its use in additive models is not common, but it is feasible.

Although this earlier study indicated a way to minimize conflicts among DMs, the model presented in Daher and Almeida (2012) uses the traditional additive function to aggregate DMs' preferences. Moreover, the fact of representing alternatives in a vector space results in there being several possibilities of aggregation of preferences that can be investigated.

#### Group decision model proposed

The proposed model extends the study by Daher and Almeida (2012) by modifying the second step of that model. Now the major idea is that the closer an alternative is to the ideal alternative, the better it is. Alternatives not accepted by any DM should be discarded. An analyst is responsible for conducting the whole decision process and presents the final results to the group. All DMs must be thoroughly familiar with the model and the methodology adopted. DMs may review the preferences that they have already given at any time in order to increase their confidence in the decision making process. Group meetings may not be necessary or could be held back until the last step of the model.

The new steps in the model are:

- *First step: calculate the individual value functions.* Multi-attribute value functions are elicited separately from each DM, as per the 5 step-procedure given by Keeney and Raiffa (1976).
- Second step: identify the individual veto threshold. DMs are invited to set a veto threshold. To obtain this, the analyst may inform DMs' individual ranking of alternatives and also conduct a sensitivity analysis to give the DM more confidence. The combination of all veto thresholds set generates the four zones and also results in the virtual alternative  $\alpha$  being selected.
- Third step: calculate the distance between any given alternative and the ideal alternative and generate the final ranking. A combination of the distance measure adopted and also some additional information is incorporated to the model. If an alternative is in the disagreement zone and also its distance to the ideal alternative is smaller than the virtual alternative, a value reduction factor should be incorporated. In this case, it is considered that any alternative in such situation is going to have its value reduced to the same as the virtual alternative distance.
- *Fourth step: sensitivity analysis and presentation of the result.* At this time, the analyst must conduct a sensitivity analysis to check the robustness of the final result and then presents the outcomes from the model.

#### Final remarks

Initial studies suggest that the model proposed minimizes the compensatory effect of the traditional additive model for group decision making. The fact of considering a vector model to represent the combination of DMs' preferences over alternatives and also a scalar measure to represent how close an alternative is to the ideal alternative give extra insights to the group decision process. Furthermore, by using this kind of representation, no degree of importance is assigned to any of the DMs, namely they all have the same weight. The introduction of a veto threshold concept into the additive model and penalizing conflicting alternatives could give extra support to increase DMs' confidence in the final recommendation. One of the model's drawbacks is the fact that DMs may modify their veto threshold in order to boost the alternatives they most prefer.

Acknowledgments. This study is part of a research project funded by the Brazilian Research Council (CNPq).

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## Group Decision Support System based on PROMETHEE integrated with Problem Structuring Approach

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**Abstract**: Group decision making is characterized by deep complexity, being necessary to promote a group discussion to find a sustainable solution for the problem, in order to taking into account all arguments from the involved members. However, although there are several methods of problem structuring to support the group discussion and also methods to evaluate the problem, there are still few works dealing with the integration of these two approaches. This paper proposes a group decision support system integrating tools of problem structuring and PROMETHEE multicriteria evaluation.

Keywords: Group Decision; PROMETHEE; GAIA; Problem Structuring Methods.

#### Introduction

There are various studies about group decision making that analyze the aggregation of opinions of group members in order to achieve a final recommendation (Munda, 2008; Morais and Almeida, 2007; Antunes and Ho, 2001). In this context, Group Decision Support Systems (GDSS) can be defined as a class of electronic meeting systems, a collaboration technology designed to support meetings and group work (Dennis et al., 1988). Nevertheless, one of the most important parts of a group decision support is how the members can share common concepts or give their arguments in favor or against a specific situation. However, there are still few studies analyzing how incorporate properly the members' perceptions and what to do when they do not agree about the objectives for the development of the problem solution in a GDSS.

Besides, in many situations related to social problems, there is a tendency that government tries to incorporate the public opinion to obtain the social decision, which can be called participative decision. Munda (2008) defined by Social Multi-Criteria Evaluation (SMCE) when decision problem puts the society in the domain of public choice. If the public interested is adequately represented, the solutions explored will be better, in the sense of both fairly and efficiently working toward the best interests of the society, than the solutions implemented without the involvement of the public. In this context, problems are multidimensional and the evaluation of public plans or projects has to be based on procedures that explicitly require the integration of a broad set of various and conflicting points of view (Munda, 2004).

In that perspective, Problem Structuring Methods (PSMs) have been used to help the groups of several compositions to analyze problems situations. The characteristic of those methods is the use of a model to represent alternative versions of the complex situation of common interest, helping the group members to make constructive mutual fittings (Franco et al., 2004).

In fact, there are various PSMs that can be used to support the group decision process in structuring the problem, but there are few studies that integrate this approach in GDSS. Therefore, to contribute in this field, this study proposes a model of group decision support system based on the integration of PSM with a multicriteria method for evaluating the problem, focusing on the PROMETHEE-GDSS method which belongs to the outranking multicriteria methods. PROMETHEE-GDSS method, developed by Macharis, Brans and Mareschal (1998) extends the use of PROMETHEE method to be applied in the group decision context. It was shown that the PROMETHEE net flow can be used to represent the arguments of the different actors involved in the decision making process and has the advantage of a conflict visualization tool, displayed in the GAIA plane (Brans and Vincke, 1985; Brans et al., 1986; Brans and Mareschal, 1994). Then, the purpose of this model is to design a Group Decision Support System (GDSS) to generate a richer and more effective way of handling the problem situation.

#### **Model Formulation**

This section describes the proposed model of multicriteria group decision support system, integrating the problem structuring approach and PROMETHEE-GDSS multicriteria method.

The problem structuring approach is incorporated as a way to generate ideas and improve the learning process among all decision makers involved. According Mingers and Rosenhead (2004), what each PSM offers is a way of representing the situation enabling participants to clarify their understanding of the problem and agreeing commitments that will at least partially resolve it.

There are some PSMs meeting those characteristics, such as: Strategic Options Development and Analysis (SODA), which uses cognitive mapping as a modelling device for eliciting individuals views; Soft Systems Methodology (SSM), which builds ideal-type conceptual model and compares it with real model in order to generate debate about what changes are culturally feasible and systemically desirable; Strategic Choice Approach (SCA), which manages uncertainty in strategic situations by modelling the interconnectedness of decision areas; Value Focused Thinking (VFT), which focus on the objectives of the decision makers instead of known alternatives.

In the proposed model, tools of PSM should be incorporated to facilitate in sharing information and to formalize the integration among the members of the group based on the participative development, with the intention of providing a learning cycle on the problem, improving all the involved participants' understanding, and then, to generate alternative ideas of solution (Eden, 1985; Franco et al, 2004). Besides, this approach can be applied not only to allow appearing innovative alternatives to be incorporate to the problem, but also to create a favorable atmosphere for debate and discussions about the plans that were already applied, being treated positive and negative aspects and the factors that influenced in success or failure.

The PROMETHEE method is used with the problem already structured, through the multicriteria evaluation in an individual way with all group members. Each decision-maker needs to define the criteria weights (wj), representing the relative importance among criteria, and the information within the criteria which will be given by preference functions (Pj(a,b)), that represents for each pair of alternatives a, b, the intensity of preference of a over b for a given criterion. A multicriteria preference index is defined as

$$\pi(a,b) = \sum_{j=1}^{n} w_j P_j(a,b)$$

Where  $\pi(a,b)$  expresses the degree a is preferred to b over all criteria, varying from 0 to 1. The following preference flows are then defined:

The leaving flow:  $\boldsymbol{\Phi}^{+}(a) = \sum_{b \in A} \frac{\pi(a,b)}{n-1}$ 

The entering flow:  $\Phi(a) = \sum_{b \in A} \frac{\pi(b, a)}{n-1}$ 

The net flow:  $\Phi(a) = \Phi^+(a) - \Phi^-(a)$ 

Meanwhile, after the use of PROMETHEE the members can visualize the GAIA (Geometrical Analysis for Interactive Aid) plane, which is a visual representation of the alternatives and their contribution to the criteria. In addition, further investigation about sensitivity analyses can be done through a decision axis as a function of weight changes (Brans and Mareschal, 1994).

Besides, it is important to emphasize that the GAIA plane is not an isolated tool in the GDSS, instead, it is integrated with the tools of problem structuring approach. Then, anytime the decision makers can incorporate new ideas and arguments and also change criteria weights.

After these two analyses, everybody has a good individual view of the decision problem and the values of the net flows obtained by the method summarize the point of view of each decision-maker. With these data, a new decision problem is then considered including n alternatives and r decision-makers (n x r), being the individual net flows the assessment suggested by the alternatives with regard to decision-makers (the new set of criteria). In this phase of analyses, the GAIA plane can also be performed, but the axes now represent

the points of view of the decision makers and show the amount of consensus or conflict within the group. Figure 1 represents a GAIA plane, where it is possible to visualize the decision makers (D1, D2, D3 and D4), the alternatives (A to H) and the decision axis (pi). In this graph it is easily noticed that D4 has a divergent opinion from other DMs.



Figure 1 – Example of GAIA Plane global visualization (Morais and Almeida, 2006)

In that perspective, the model aims to treat the group decision in four stages. In Stage 1 the identification of the problem is accomplished. In Stage 2 the discussions happen, when is incorporated the problem structuring approach for the specialists' meeting and other actors involved in the process, in order to generate ideas that appear from the comparisons with other perceptions, forming a rich panorama of the situation, helping the decision-makers to know better the problem. In that stage, not only possible alternative solutions are formulated, but also the criteria are discussed. In the Stage 3 occurs the clarification of the problem, when an individual multicriteria evaluation with all group members is realized, in other words, all decision-makers face the same matrix alternatives x criteria, but they can evaluate according to their own values systems, considering their specific interests. In this stage, the GAIA plane is integrated with tools of PSM. Finally, in Stage 4 a final decision is obtained through a new multicriteria analysis, where the decision-makers are the new criteria and the results of the net flows are the evaluations of the alternatives. Also, the GAIA analysis and tools of PSM are also performed. The Figure 2 shows an outline detailed by stages.



Figure 2 – Outline detailed by stages of the proposed model

Accompanying all stages, there is a process of recommendations, what makes dynamic the evolution of the model in terms of learning about the perceptions of the problem among the decision-makers. During each stage are generated recommendations that can be used during the next stage and, consequently, for all the remaining process. The decision-makers interests and preferences are evaluated, modeled and explored to generate ideas and to allow revisions of judgments of other decision-makers, until any more new ideas

appear on the problem. That interactive process facilitates the fast learning cycle and understanding and even possible changes in the subjective point of view of the decision-makers.

The recommendations suggest that there are discussions at every moment, enriching the decision process. That procedure is in accordance to the adopted by the constructive decision aid (Roy, 1996), where the final result of the decision process is not a decision just imposed by the model, but, a recommendation of a solution to be adopted. Thus, one of the main objectives of the model is to provide a better understanding of the problem among all group members.

#### **Final Remarks**

This work in progress about group decision support model combines two approaches of different paradigms with the purpose to generate a fairer and more transparent way of handling problems, when several actors are involved in the decision process and their opinions and perceptions should be taking into account, adapting a participative development. The proposed model is capable to support the group decision process during all stages: definition and structuring of the problem, identification of possible alternative solutions, and analysis of the individual priorities reaching the final decision of the group. Besides, the model has a constructive conception, then, accompanying all stages there is a recommendation process, what makes dynamic the evolution of the model in terms of learning about the perceptions of the problem among decision-makers.

Next steps of this research will contribute to the practical use of the integrated model, showing software with the implementation of the model and case studies applications.

Acknowledgement. This work was partly funded by the Brazilian Research Council (CNPq).

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## On Using Prisoner Dilemma Model to Explain Bidding Decision for Compute Resources on the Cloud

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**Abstract**: In this paper we have used a game-theoretic approach to model the bidding strategies of bidders in a cloud spot market who are attempting to procure the computing resources. We discuss the decision making dilemma faced by these bidders and identify the conditions under which the situation can be modeled as a Prisoner Dilemma game. We then analyze simulation results based on real time data to validate this model. In a single shot prisoner dilemma game mutual defection is the Nash equilibrium. However, we find that a majority of bidders choose to Cooperate. We attribute this irrationality in the bidders decision making to behavioral biases.

Keywords: Bid Decision, Prisoner Dilemma, Irrational Bidders, Behavioral Bias, Spot market, Cloud computing

## Introduction

Cloud computing is one of the emerging paradigms in distributed, service-oriented computing that has enabled on-demand access to computing resources which can be rapidly provisioned and released. As per the National Institute of Standards and Technology (NIST) definition, Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2009). Though cloud computing faces drawbacks like security, trust and privacy; cloud adoption is on the rise. From the recent industry reports (Gartner Predicts) one can clearly deduce that the upcoming network of cloud players is bound to grow (Weinman, 2011). This is primarily because of the elasticity that cloud offers to organizations to meet their variable workloads without any fixed investment in computing capacity. Online businesses typically experience variations in the number of users of their platforms. It is thus critical for e-businesses to support any sudden surge in demand without incurring high upfront investments in computing resources. The growing demand for cloud has resulted in adoption of different types of pricing models by the cloud vendors. Newer schemes of pricing such as the on-demand pricing (pay-per use model and the price is fixed upfront and listed) and dynamic pricing (where users bid for compute resources on the cloud), have been introduced by cloud vendors. Such schemes demand the users to think strategically, particularly in the case of dynamic pricing, they need to decide on their bids.

The purpose of this paper is to specifically examine the behavior of bidders in a dynamic cloud resource pricing environment and propose strategies that can serve as a reference for decision making by bidders intending to procure compute resources on the cloud. We have noticed that the spot market which is considered to be much cheaper than other forms of pricing is spiky in nature. Also a significant number of bidders often bid above the on-demand price. Clearly these indicate the presence of irrational bidders in the spot market. The motivation section provides more details on this. A game theoretic approach has been taken to model the strategies available to bidders. We have proposed a Prisoner Dilemma game to model the strategies of bidders. We then identify the conditions under which this game can be modeled as a Prisoner Dilemma game. We evaluate our model using real-time spot price data. Next we examine the strategies of the bidders from this data to understand the decision making behavior of bidders in real-time.

Section 2, provides the motivation and the background for the problem. Section 3, details the dilemma situation faced by the bidders in a spot market for computing resources. We model the bidding strategies as a normal form game and compare it with the classical prisoner dilemma game. In section 4, we provide the conditions under which the game follows a prisoner dilemma and how bid decisions can be based on the spot history data. In section 5, we conduct analysis for real time spot market data to complement our findings in section 4. Section 6 gives the implications and results of our study.

### Background

#### Motivation

Currently, a lot of research is taking place in the technical aspects of cloud and there is an urgent need for understanding the business-related issues surrounding cloud computing (Marston et al, 2011). A search with 22 different keywords on 9 journal databases returned 2891 unique papers pertaining to various aspects of cloud computing. Of these papers, only 144 (approximately 5%) involved decision models in business aspects of Cloud computing and out of this, a mere 32 comprised of pricing and none of these considered behavioral biases.



Fig. 1. Snapshot from Amazon EC2: Spot Bid distribution as a percentage of On-Demand price



Fig. 2. A plot of spot price history for the month of Dec 2012 for a First generation standard Linux Instance

On the other hand, research on behavioral biases in the context of pricing decision for the cloud cannot be waived of as irrelevant. A snapshot (see Fig. 1) from Amazon's Spot price video serves as an evidence of irrational bidding. On careful observation of the chart, it can be noted that approximately 15% of the bidders quote a price much higher than the on-demand price and almost 0% quote a price less than 30%. Fig. 2 provides further evidence of irrational bidding. Spot price is determined based on the lowest clearing bid and is expected to be less than the on-demand price since it deals with unused or left over capacity from

the on-demand market. However from Fig. 2, we can observe that the price of a spot instance spikes much higher than the on-demand price, indicating the presence of irrational bidders who are bidding so high.

## Spot Markets for Computing Resources

Virtual markets for computational resources have been proposed by many researchers even much before the advent of Cloud Computing. Few of the earliest works include the Popcorn market project and Network of workstations (Anderson et al, 1995), (Regev & Nisan, 2000). Since then many economic models for sharing computing resources have been formulated. In the case of Cloud service providers, every provider has its own pricing scheme. Currently, the most widely used method of pricing in cloud is pay per use (also known as the on- demand model), which is based on units with constant price. For example, Rackspace uses "pay per use" scheme (Rackspace, 2012). Elastic Compute Cloud (Amazon EC2) by Amazon uses "pay-per-use fixed pricing" say first 50 TB / Month of Storage used costs \$0.150 per GB (S3). The popularity of the pay per use pricing scheme can be attributed to its simplicity and customers and providers can make payment predictions with ease (Weinhardt et al, 2009). However, in terms of efficiency benefits, research indicates that dynamic pricing can be more efficient (Anandasivam & M. Premm, 2009), (Mihailescu & Teo.Y, 2010).

Dynamic pricing involves real-time adjustment of prices of a product or service by interpreting the value these customers attribute to a product or service (Reinartz, 2001). The concept of dynamic pricing has been applied in the utility industry, particularly in the electricity distribution industry (Baughman & S. Siddiqi, 1991). Various models have been developed for dynamic pricing: Inventory based models, data-driven models, game-theoretic models, machine learning models and simulation models (Narahari et al, 2005). There are several works that have studied dynamic pricing in the context of cloud computing. Andrzejak demonstrates how users should bid optimally on Spot (a dynamic pricing scheme) instances based on their individual objectives (Andrzejak et al, 2010). Javadi et al have provided a statistical modeling of spot prices in a public cloud environment (Javadi et al, 2011) by studying Amazon spot price traces. Research on dynamic pricing schemes has attracted the industry to implement and use dynamic pricing model through their spot pricing scheme. The literature review also indicates that there are no works on bidder behavior and bid decision making in the context of a cloud spot market.

Spot Instances enable users to bid for excess/ spare/ unused capacity, i.e. the capacity that remains with the cloud provider after fulfilling the on-demand and reserved instance demands. The cloud vendor determines and publishes the spot price based on the current supply and demand. Hence the spot price also fluctuates periodically depending on the supply and demand for Spot Instance capacity. In a spot pricing scheme, if the user's bid price exceeds the current spot price, the instance is allocated until either the user chooses to terminate upon task completion or the termination is initiated by the vendor upon the spot price increasing above the bid price.

From the above section we can say that the spot market is like a uniform price auction of multiple units of a homogeneous good, where each client bids for a single good which is the spot instance. The provider chooses the top N bidders. These N bidders pay the price equal to the price bid by the Nth bidder. The value of N varies based on the supply (unused capacity at hand) and cannot exceed the available capacity. The provider sets the uniform price to the price declared by the highest bidder who did not win the auction (bidder number N + 1) and publishes it. The top N bidders are declared as winners and pay the published price. The spot market has also been modeled as a (N + 1)th price auction of multiple goods (Agmon Ben-Yehuda et al, 2011).

## Prisoner's Dilemma

Researchers have conventionally adopted the Prisoner's Dilemma (PD) as metaphor to characterize the pressure between group welfare and individual selfishness. It has been used in diverse fields such as the Theory of Evolution (Smith, 1982). The classical prisoner dilemma game is a non-zero sum game played by two players who can choose between two moves, either to cooperate with or defect from the other player. The game is called the prisoner's dilemma, because it is a generalization of the situation felt by a prisoner who can either defect by striking an agreement with the police and tell on his partner or choose to cooperate by not revealing anything about the crime. Mutual cooperation yields the highest total payoff, which is equally shared between the two players. However, individual defectors will gain more if the opponent

decides to cooperate. The premise of this game is that each individual rational player tries to maximize his payoff, which sets off the players as naturally selfish individuals.

	Cooperate	Defect
Cooperate	(R,R)	(S,T)
Defect	(T,S)	(P,P)

1'lg. J. Payoff matrix for a Prisoner Dilemma Ga	Fig.	3.	Payoff	matrix	for a	Prisoner	· Dilemma	Gan
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The dilemma arises when a rational player realizes that he cannot pick the best choice which gives him maximum payoff without knowing what the opponent will choose. Hence, the best strategy for a player is the one that increases the payoff to the opponent as well. Fig 3 shows the payoff matrix, which the players obtain based on their strategy and the opponent's strategy. Here, T indicates the Temptation to defect, R indicates the Reward for cooperation, P is the Punishment for mutual defection and S indicates the Sucker's payoff. For a game to be modelled as a Prisoner Dilemma, the game's payoffs must satisfy the conditions given by equations 1 and 2 (Axelrod, 1980).

T > R > P > S	(1)
R > (T+S)/2	(2)

## **Modeling Bid Decisions**

#### Dilemma faced by Bidders in a Spot Market

Consider the scenario of two bidders Player 1 and Player 2 bidding for computing resources in a spot market. The average spot-price is known and given. In this paper, we define high and low with respect to the average spot price; bid prices above (below) the spot price are considered as high (low). In the given case, the players have the option to bid higher than the average spot price or lower than the average sot price.

Clearly, there are four possible combinations of strategies:

- 1. (High, High) Both Player 1 and Player 2 bid a high value.
- 2. (Low, Low) Both Player 1 and Player 2 bid a low value
- 3. (High, Low) Player 1 bids a high value and Player 2 bids a low value.
- 4. (Low, High) Player 1 bids a low value and Player 2 bids a high value.



Fig. 4a. A representation of Bids vs Spot price at time t1 (Spot price = 0.15)



Fig. 4b. A representation of Bids vs Spot price at time t2 (Spot price = 0.17)

The spot price is determined based on the supply (the number of unused instances) and demand (the number of bidders and their bids). A (low,low) bidding decision by the bidders would induce a low spot price since it would make the cloud provider to reduce the spot price due to the fall in average bid price. Spot users can be called as price conscious users since the spot market generally guarantees a much lesser spot price as compared to the on-demand price. Such bidders who decide to bid low in an attempt to cooperate with other bidders in the system can be termed "Co-operators". Co-operators do not just think about their payoffs but also the group's (the other bidders in the system) overall benefit, which is achieved through a reduction in the average spot price. If most bidders decide to bid low, cooperation can emerge and push the spot price down. This could become a cyclical effect and in a system of co-operating bidders, the spot price can be brought down very close to the reserve price. However, some spot users might also want to enjoy relatively uninterrupted service. These bidders would take advantage of the opportunistic capacity by submitting a higher maximum bid price, since they often would pay the operating spot-price (which is the value of the lowest bid that satisfies the capacity) and not pay their bid price. Such opportunistic bidders can be termed as "Defectors". In a system of selfish bidders, everyone tries to Defect by bidding high and eventually may end up securing a spot but at the same time increasing the average spot price which is not beneficial to the individual as well as the group. In a two person game, if both players are defectors they would choose the (High, High) strategy and end up paying a higher spot price.

Let B<sub>L</sub> denote the bid by a bidder choosing the "low" strategy and B<sub>H</sub> denote the bid by a bidder choosing a "high" strategy. The opportunistic advantage achieved by a player bidding high when the other player bids low (since higher bidder still procures the spot at low price) is denoted by  $\tau$ . As discussed above such a bidder is called a defector. For example, In Fig 4a and 4b Bidder X is a Defector. The advantage stems from the fact that a high bidder continues to win the spot over longer periods of time since he is safeguarded by his high bid price. In addition this player enjoys the spot instance at a price much lower than his bid price since the spot price is determined based on the lowest clearing bid price. In the case of Bidder X, even with a change in the spot price at time t2 (see Fig 4b), he continues to enjoy the spot. On the contrary, a player bidding low is at a disadvantage when the other player has bid high since he/she faces higher chance of intermediate termination. Let us consider Bidder Y (see fig 4a and 4b), who is a co-operator/low bidder. At time t1 his bid is successful and he gets the spot instance, at time t2 the spot price increases, this pushes Bidder Y out of the system since Y's bid price falls below the current spot price. Y has to wait till the spot price falls below his bid price or choose to continue his computation task elsewhere. This disadvantage is denoted by  $\eta$ . For a spot user who has faced a termination before completion of his job, he may choose to a) wait till the price falls back below his bid price or b) continue his computing job on the on-demand instance. In this paper we focus on the second case b. Continuing his job on an on-demand instance would incur an additional cost Any bidder bidding in the spot market is faced with this dilemma and has to choose between Co-operation and Defection.

#### Modeling Bidder Decision Dilemma as a Prisoner Dilemma Game

In this section we model the dilemma faced by bidders in bid decision making by generalizing it as a twoperson prisoner dilemma game. Fig 5 gives the normal form representation of the two person prisoner dilemma game with payoffs derived for the current context (Sowmya & Sundarraj, 2012). When both players cooperate with each other placing a low bid, the resulting spot price determined by the cloud vendor will also be low, i.e when both players bid at B<sub>L</sub>, the resulting spot price cannot exceed B<sub>L</sub>, hence the payoffs in cell I (in Fig 3) for both players is  $-B_L$ . The negative sign indicates that it is a payment made by the consumer to the vendor. Similarly, when both players defect by bidding high (Cell IV), the resulting spot price determined by the cloud vendor is also high. Cells II and III capture scenarios where one player defects and other player cooperates. Since bidding for spot instances is similar to a (N+1)<sup>th</sup> auction, the lowest of the two bid values is finally chosen as the bid price. In this case the lowest bid price is B<sub>L</sub>. In addition the defecting player gets an advantage captured by  $\tau$  and the co-operating player gets a disadvantage  $\eta$ , as discussed in Section 3.

In fig 5 we extend the generalized normal form game given in fig 3 to characterize the Bidding Decisions of the Spot users. For the game indicated in fig 2 to be a Prisoner Dilemma game, the equations (3) and (4) need to be met. Equations (3) and (4) have been derived by rewriting Equations (1) and (2) with the payoff matrix given in fig 2.

		Player 2	
		Cooperate	Defect
		(place a low bid)	(place a high bid)
	Cooperate	$(-\mathbf{B}_{\mathbf{I}} - \mathbf{B}_{\mathbf{I}}) \mathbf{I}$	$(-B_L-\eta,-B_L+\tau)$
	(place a low bid)		II
er 1	Defect	$(-B_L+\tau, -B_L-\eta)$	$(-B_{\rm H}, -B_{\rm H})$
Play	(place a high bid)	III	IV

Fig. 5. Normal form Game capturing the Bidding strategies and payoffs

$$(-B_L + \tau) > -B_L > -B_H > (-B_L - \eta)$$
 (3)

$$-B_L > [(-B_L - \eta) + (-B_L + \tau)]/2$$
(4)

## Bid Decision based on History and PD parameters

In this section we determine the control limits for the bids given the spot price history parameters. Once the control limits are established any BH and BL within this band would result in a Prisoner Dilemma game. For determining this band we rely on the spot price history data and the bid distribution. We establish a set of propositions under which the game would meet the Prisoner Dilemma condition and simultaneously cover maximum percentage of the bids.

Let  $C_L$  denote the lower control limit and  $C_H$  denote the upper control limit. Let  $\mu$  and  $\sigma$  denote the average spot price and standard deviation correspondingly, computed from the spot price history. We introduce the PD factors  $\lambda_1$  and  $\lambda_2$ . The factors  $\tau, \eta$  are non-negative. We then define  $C_L$  and  $C_H$  as:

$C_L > \mu - \lambda_1 \sigma$	(5)
$C_H < \mu + \lambda_2 \sigma$	(6)

$$n > \tau > 0 \tag{7}$$

**Proposition 1:** If the sum of the PD parameters,  $\lambda_1 + \lambda_2 < \frac{\eta}{\sigma}$ , then the game depicted in Fig. 4. follows a Prisoner Dilemma.

If 
$$\lambda_1 + \lambda_2 < \frac{\eta}{\sigma}$$
, then we can say that,

$$-C_L + \tau > -C_L > -C_H > -\eta - C_L \tag{8}$$

From (7) we know that  $\eta > \tau$ , we can show that

$$-\mathcal{C}_L > \frac{\tau - \mathcal{C}_L - \eta - \mathcal{C}_L}{2} \tag{9}$$

From (8) and (9), we can infer that PD conditions indicated by (3) and (4) are met<sup>6</sup>.

Any bidder who chooses a bid value within the CL to CH band can consider himself as playing a Prisoner Dilemma game. He may then decide to cooperate by picking up a bid value less than  $\mu$  or decide to Defect by picking up a bid value greater than  $\mu$ . If the bid distribution is given, we can then estimate the ratio of co-operators vs defectors in that setup. In a single shot prisoner dilemma game mutual defection is the Nash equilibrium. As per game theory, rational, self-interested bidders should converge on the Nash equilibrium solution.

## **Data Analysis**

Comparing the equilibrium solution discussed in the previous section with the actual bidding strategies in real-time is critical to understand the bidder decision making behavior. Fig 1 provides a snapshot of Spot Bid distribution as a percentage of On-Demand prices as published by Amazon EC2. We can infer from the chart that, a significant number of bidders are bidding either close to or above the on-demand price itself. This bid distribution is used to generate the sample bid price for our analysis.

Fig 2 gives the spot price history over a period of one month for a standard Linux instance. The on-demand price marked by dotted lines is 0.26/hr in this case. It can be observed from the chart that most of the times the spot price is below the on-demand price and at times the spot price shoots up much higher than the on-demand price. We now substitute the on-demand price in the bid distribution chart given in fig 1 to obtain the bids. Note that the height of each of the bar in fig 1 represents the percentage of bidders bidding in that range (as a fraction of the On-Demand price). The sample bid data is generated using the RANDOM function in Excel with the range as input for each band. The range is computed by substituting the on-demand price in fig 1. Next, the lowest band is picked up (30-39% band is the lowest band since there are no bidders bidding below this band) and we identify the lowest bid within this band from the generated bid sample. This bid is marked as  $C_L$ . Based on the conditions defined in section 4; we compute the corresponding value of  $C_H$ . This will ensure that the bidders within this band follow the Prisoner Dilemma Game. We then compute the value of  $\eta$  (on-demand price – bid price) for the low bidder and the value of  $\tau$  (bid price – the average spot price) for the high bidder.

We repeat the above exercise by picking up the lowest  $C_L$  in the subsequent band (40-49%). This process continues till we reach the band containing the average spot price. For each of these combinations of  $C_L$ and  $C_H$  the percentage of bids falling within this band is computed. This gives us the percentage of bidders in each band who satisfy the prisoner dilemma condition. The matrix given in fig 6 summarizes the results. The rows indicate the low bidder bands and columns indicate the high bidder bands. A Y/N in each cell indicates whether that  $C_L$  - $C_H$  band satisfies the PD conditions. In addition the percentage of bidders bidding within that band are listed in the corresponding cells.We pick up the  $C_L$  and  $C_H$  values corresponding to the cell with the maximum percentage of bidders satisfying the PD conditions. The band 0.078- 0.26 qualifies as the maximum band which covers about 65% of the bidder sample. We call this percentage of bidders as the PD%. The remaining 35% who do not meet the PD conditions are termed as the Non-PD%

<sup>&</sup>lt;sup>6</sup> Detailed proof will be included if required in the later version of the paper.

$C_{H \rightarrow}$	0.234	0.26	0.286	> 0.286
CL				
$\downarrow$				
0.078	Y	Y	Ν	Ν
	61%	65%	NA	NA
0.104	Y	Y	Ν	Ν
	52%	56%	NA	NA
0.13	Y	Y	Ν	Ν
	47%	51%	NA	NA
0.156	Y	Y	Ν	Ν
	33%	37%	NA	NA
0.182	Y	Y	Ν	Ν
	19%	23%	NA	NA
0.208	Y	Y	Ν	N
	10%	14%	NA	NA

Fig. 6. Matrix Representation of different bidder bands

Within the PD% of bidders identified in the previous step, the percentage of cooperators vs the defectors is computed, i.e out of the 65% who meet the prisoner dilemma conditions, the bidders whose bid values are below the average spot price are earmarked as co-operators and the bidders who bid above the average spot are price are earmarked as defectors. From this data the ratio of co-operators vs defectors is computed.

In this case, our analysis indicated that 79% of the bidders played a Co-operate strategy as opposed to 21% who played a Defect strategy. The co-operate strategy seemed to be the strategy chosen by a majority of the bidders. These results are in contrast to that proposed by the classical prisoner dilemma in game theory. As per game theory, any rational, self-interested bidder would Defect by bidding high since mutual defection is the Nash equilibrium in a single shot Prisoner Dilemma game.

## Implications

## The single shot Prisoner Dilemma game

Lack of Coherence. This irrationality in decision making of the bidders modeled by the single shot prisoner dilemma game in the previous section, could be attributed to bidder's cognitive biases such as, Mental Accounting. Mental accounting involves the assignment of activities to specific accounts and spending is constrained by implicit or explicit budgets (Thaler, 1985). A consumer making a useful decision to bid for a spot may set a lower/upper bound on useful price granularity in that market. A low bidder may perceive the spot instance less reliable as compared to that of an on-demand price and hence set a very low upper bound for the spot instance.

*Interpreting the Non-PD%.* The presence of certain percentage of bidders who do not satisfy the PD conditions and who bid higher than the on-demand price attracts discussion. These bidders can be seen as extremely loss averse. Loss aversion is the behavioural tendency of individuals to perceive losses as more substantial when compared with gains of the same objective magnitude. Dittrich et al claim that an actual loss will change bidding dispositions more than an equally large gain due to loss-averse behaviour of bidders (Dittrich et al, 2011). For example, when we examine the chart given in fig 5, we can observe that at times the spot price spikes up much above the on-demand price. Extremely loss-averse bidders would tend to safeguard themselves even against these momentary spikes by bidding at very high prices.

#### **Repeated Game and Cooperation**

Presence of repeated users in a spot market may lead to evolution of cooperation; hence the co-operation may be due to the fact that they are bidding in multiple rounds, which can be modeled as a repeated or an iterated prisoner dilemma game. There are results which indicate that repetition yields co-operation in a Prisoner Dilemma game (Axelrod R. , 1984; Axelrod R. , 1981). The equilibrium strategy for the single shot PD game is simply defection; as explained in previous sections, this is true whatever the composition of opponents may be. However, in the iterated-PD game the optimal strategy depends upon the strategies of likely opponents, and how they respond to defection and cooperation. The best strategy was found to be tit-for-tat. The tit-for-tat strategy involves cooperation in the first iteration of the game; after that, the player does what his or her opponent did on the previous move, by co-operating if the opponent cooperated and defecting as an indicator of punishment if the opponent had defected. Co-operation tended to be collectively stable in an iterated prisoner dilemma game.

During the course of the bid decision making process, the bidders who value the future may realize that mutual co-operation will yield greater benefits in the long run and start bidding low, in the case of such an event the overall spot price set by the vendor starts to decline. This can cause a cyclical effect and in a market comprising of strategic bidders the spot price can eventually be as low as the vendor's reserve price. Even when the discount parameter (indicates how much a player values the future) is high enough to attract reciprocal cooperation there is still a question of whether and how cooperation might kick-off. In the current case of bidding for spot instances, there is a degree of predictability, since the spot price history data for the last three months is publicly available. These history parameters could serve to trigger co-operation. This can be considered as a form of herding. Dholakia and Soltysinski, provide evidence of herd behaviour bias in online auctions. In online auctions, bidders would herd behind other bidders even when observed choices did not reveal private information (Dholakia & Soltysinski, 2001).

#### Conclusions

In this paper we have modelled the strategies of bidders in a spot market as a single shot normal form game. We have then established the band of bid values for which the game is equivalent to the prisoner dilemma game and covers majority of bidders. We then analyze the results by applying it on real-time data from the spot market. Based on the observations we provide the results and implications for group bid decision making with specific focus on irrational bidders and their cognitive biases.

As part of future work we intend to model this game as a repeated game with multiple iterations as well as an n-person PD game. We are also looking at the impact of cognitive biases on the decision making process in order to explain what could be termed as "irrational" behaviour of the bidders (at least in terms of the PD model). Bidding strategies in the presence of irrational bidders could be a potential future research area. We also intend to study the factors that contribute to the non-PD%. The perspective of vendors in determining the spot prices by observing the strategic bidding behaviour of bidders is another potential area for future research.

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# Resolving the Criteria Influence by Flexible Elicitation in Group Decision

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**Abstract**: This paper presents a Group Decision approach for integrating two or more decision makers in a situation related to a multicriteria decision making (MCDM) problem resolved by an additive aggregating model. The main concern of this approach is related to the elicitation process of scaling constants for the additive model, by using a flexible elicitation process.

Keywords: Flexible Elicitation; Additive Model; Group Decision; Multicriteria Decision Making (MCDM).

## Introduction

This paper presents a Group Decision approach for integrating two or more decision makers in a situation related to a multicriteria decision-making (MCDM). The problem is resolved by using an additive model for aggregating criteria, based in a flexible elicitation process.

One of the most relevant issues in Group Decision MCDM additive-based models is the elicitation of the constant scales. That is, the specification of the influence of the criteria. The MCDM additive model has some basic assumptions point out in several previous studies (Fishburn, 1967; Keeney, 1972; Keeney and Raiffa, 1976; Keeney1992). A survey shows some useful characteristics of additive models (Stewart, 1992). Many studies are found on eliciting scaling constants or weights of criteria in an additive model. The swing approach is one of the most applied procedures (Edwards and Barron1994; Barron and Barrett, 1996).

A few studies were conducted based on experimental analysis of the main elicitation procedures (Weber and Borcherding, 1993; Borcherding et al, 1991; Poyhonen and Hamalainen, 2001). Some elicitation of weights uses a complete evaluation (Keeney and Raiffa, 1976; Edwards and Barron1994). Others approaches use partial information (Edwards and Barron1994; Barron and Barrett, 1996). The SMARTER method (Edwards and Barron1994) is based on partial information.

The main concern of the approach discussed in this paper is related to the elicitation process of scaling constants for the additive model. A flexible elicitation process is applied in order to analyze the criteria influence.

## MCDM Additive Model

The additive model is represented in equation (1), with normalization for criterion weight (ki) according to (2).

$$v(x) = \sum_{i=1}^{n} k_i v_i(x_i)$$

$$\sum_{i=1}^{n} k_i = 1$$
(2)

The elicitation of may be carried out based on several different procedures as already pointed out. The tradeoff procedure (Keeney and Raiffa, 1976) is based on comparison of consequences by the DM (decision maker). It considers tradeoffs on criteria and it has the strongest theoretical foundation (Weber and Borcherding, 1993). That is why the flexible elicitation procedure is based on the tradeoff approach, including the use of partial information in a particular way.

Some approaches, based on partial information, use robust analysis in order to evaluate alternatives. This may provide a recommendation adequate for a large weight space. However, in some situations, it may not

be appropriate for the DM's preferences. This is one of the issues considered in the flexible elicitation process.

## Resolving Criteria Influence by Flexible Elicitation in Group Decision

The tradeoff procedure seeks for consequences with indifference preference relation in the format shown in Figure 1, in which the first bar diagram shows the "consequence 1", with a particular value of price and worst performance in all other criteria and the second bar diagram shows the "consequence 2" with the best on-time delivery (0.98) and worst performance in all other criteria.



Fig. 1. Decision support system for flexible elicitation procedure.

Figure 1 illustrates the use of a decision support system applied to analyze the supplier selection problem proposed by Xia (2007). The first ordered criterion is Price and the second is on-time delivery. First the DM evaluated a situation similar to that shown in Figure 1, in which the consequence 1 has the best price (\$40) and the consequence 2 has the best on-time delivery (0.98). Then, the DM chose the consequence 1. In the supplier selection problem proposed by Xia (2007), the DM would be indifferent between the consequences 1 and 2, if the Price is \$49.29 in the consequence 1.

In Figure 1, the consequence 1 has a Price of 50.28 and the consequence 2 has the best on-time delivery (0.98). Therefore, the DM chooses consequence 2. The tradeoff procedure asks as many questions as necessary in order to obtain the value of price (x) for indifference between consequences 1 and 2.

The flexible elicitation procedure seeks for values of x' and x", such that x' > x > x". In this case, the DM has only to give preference relation information, which requires less cognitive effort than indifference relation information. On the other hand, only inequalities are obtained.

The procedure considers after each interaction with the DM a calculation step, in order to evaluate if a solution may be possible, with the available information. For this calculation step a set of linear

programming problems are considered. Therefore, the process is conducted in a way of requiring a minimum effort from the DM.

This flexible elicitation approach when applied to a group of DMs reduces the time and effort of the actors in the decision process and possible conflicts, since it avoids seeking specific parameters for each one of them. However, this is not possible in the case of a great disagreement among the DMs.

The approach is implemented into a decision support system (DSS), which uses this flexible elicitation approach, involving minimum effort by the Group of DMs. For this reason, a more reliable elicitation procedure can be carried out, since requiring less effort implies in dropping errors.

## Conclusions

This approach presented is related to a flexible elicitation procedure for group decision with MCDM additive model. The concept of flexible elicitation is introduced in order to reduce the effort taken by the group of DMs. This overcomes some drawbacks related to the classical tradeoff elicitation approach for weights.

The flexible elicitation process has been applied for group decision in a preliminary analysis. It is still a work in progress and a few issues are still under investigation. The main concern is related to considerations on strong disagreement among DMs. In this case, a subset with a few alternatives may be given for a final analysis.

Acknowledgments. This work had partial support of CNPq (Brazilian research council).

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# PART V E-NEGOTIATION

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# Starting from Scratch: A multi-stage analysis of remote e-negotiations

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**Abstract**: In this paper we investigate the drivers of the substantial and relational outcome in one-shot cross-cultural remote e-negotiations. The investigation is based on a simulation of an integrative, multiissue negotiation. The findings particularly point to the meaning of the pre-negotiation stage during which the negotiation setup is arranged by the parties.

Keywords: negotiation, communication, electronic negotiations.

The development and increased availability of internet based communication technologies has enabled geographically dispersed individuals to connect and exchange information easily and cost efficiently. Despite widely recognized importance of face-to-face meetings, current extensive usage of electronically aided communications media by individuals and organizations is expected to increase in the future (Harvard Business Review Analytic Services 2009).

Therefore it is not surprising that this topic has also attracted the attention of negotiation scholars and resulted in multiple studies which can be categorized into two major streams. The first of them focused primarily on designing effective and efficient electronically aided negotiation support systems and/or e-negotiation systems and explored their impact on negotiators behavior (e.g. Nyhart and Goeltner, 1987; Lim and Benbasat, 1992; Bichler at al, 2003; Insua et al., 2003; Kersten and Lai 2007). The other stream compared negotiators' behavior and performance in negotiations conducted in various communication modes (e.g. Moore et al., 1999; Morris et al., 2002; Thompson and Nadler, 2002; Pesendorfer and Koeszegi, 2006).

These studies investigated the benefits and risks of information technology and improved our understanding of the general behavioral differences between the negotiations conducted in various communication modes, primarily face-to-face vs. email negotiations. However, we still know very little about the drivers of individual remote negotiations and individual differences in substantial and relational outcomes in given remote negotiation settings. Based on our experiences we believe that there are indeed large disparities regarding the performance of different individual negotiations in given remote settings. But why do some negotiators perform better than others? What are the individual success drivers in remote negotiations? Against this background, this paper does not focus on the design of remote negotiation settings, but on the individual behavior in given remote negotiation settings.

Our observations in this research project are based on a simulation of a multi-issue scorable integrative negotiation concerning an acquisition of a family owned production company by a private equity investor. The two key issues to negotiate are the acquisition price and the extent of layoffs. Teams of two (sometimes three) test persons negotiated from geographically dispersed locations with other teams of similar size. Although the selection of the communication mode was completely up to the teams, due to the geographical distance it was highly unlikely for the teams to negotiate face to face. Test persons within the teams were at the same location and typically knew each other before. However, they did not know their counterpart teams so there was no individual or team reputation (Gilck and Croson, 2001) and no people-specific routine (Kesting and Smolinski, 2007) could be developed. The negotiation was the only systematic contact between the teams so that the future relationship was also irrelevant. There might have been some culture-specific stereotypes since the teams were based in specific countries (Denmark, Germany, Japan), but test persons were often from other countries (actually, test persons from 17 different countries have been involved in the simulations). After receiving the email addresses of their counterparts (and the role play instructions), test persons had to start the negotiation process from scratch and work their own way from there. They had to establish the contact with their counterparts and to set up the negotiation, including agreeing on communication channels and arranging communication sessions, if desired. Test persons were free in their (joint) choice of a communication channel. In our simulations they used email, chat, voice, video and

combinations thereof. Our findings are based on 60 negotiations, involving about 250 participants. Data have been collected based on a multi method approach consisting of questionnaires and written journals. The questionnaires look into the categories: pre-negotiation, communication, negotiation style, and outcome (substantial and relational). The journals consist of free text answers to questions regarding the negotiation style and the development of the relationship between the parties.

First of all, we found evidence supporting the observations of recent studies by Morris at el (2002) and Galin at el. (2007) that in remote negotiations the subjects are more likely to demonstrate hard and positional negotiating style. Second, similarly to Drolet and Morris (2000) we observed that electronic negotiations were characterized by lower levels of trust and worse quality of the relationship between negotiators than the negotiations conducted face-to-face. Most importantly, however, in our study we were confronted with very intriguing findings concerning the relationships between the elements of consecutive phases of the negotiation process which shed the light on the mechanics of the investigated negotiation process.

Specifically we found: (i) Significant disparities in the performance of different negotiation dyads using the same negotiation channels, pointing to the relevance of the drivers of individual remote negotiations and individual differences in substantial and relational outcomes and therefore also to the relevance of this study. Even within the same settings individual differences matter. (ii) The relevance of the pre-negotiation phase for the process and the outcome of the negotiation. The first impression was important for the relational outcome of the negotiations. The difficulties to agree on a communication channel were important for the quality of the communication and for the substantial outcome. These findings do not regard the communication channels as such, but the individual preferences for the communication channels. They are related to what Geiger and Parlamis (2011) found with regard to email affinity. (iii) Inverse correlations between the negotiation style of the negotiating parties. It seems that in remote negotiations there is a large disparity between self-awareness and awareness of the others. These findings are in conflict with the observation of a convergence of negotiation styles in a face-to-face context. (iv) The relevance of the negotiation style. We found some drivers for the negotiation style in the pre-negotiation phase. The styles as such were an important driver for the relational outcome. (v) A missing relation between the substantial and the relational outcome. Surprisingly the satisfaction with the substantial outcome was not related to the substantial, but to the relational outcome.

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## The effects of using a bid generator in reverse multiattribute auctions

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**Abstract**: In this paper we analyze the results of a multi-attribute auction experiment conducted via the Imaras electronic auction system. In this experiment the auctioneers were divided into two groups. One of these groups was offered an additive supportive tool that allowed for automatic generation of bids. We examine differences in the performance and the bidding style of the auctioneers from these two groups as well as differences in behavioral factors describing the system evaluation, use and usefulness.

Keywords: multi-attribute auctions, electronic auctions, auction support, multiple criteria decision making.

## Introduction

A multi-attribute auction is an economic mechanism, which supports exchanges of goods or services defined by multiple attributes. In contrast to the traditional single-attribute auction, in which the sole issue is price, in the multi-attribute one there are many issues specified by the bid-maker (e.g., product quality, price, terms of payment, terms of delivery). The bids submitted by the bid-takers have to specify the levels of each issue. Auction rules must also define: (1) the protocol (either a one-round or a progressive auction); (2) additional qualification criteria for bids; and (3) the withdrawal policy. Furthermore, one of the most important elements of the auction rules is the winner determination rule (Teich et al. 2004; Bichler and Kalagnanam 2006).

It is relatively easy to select the winning bid in the single-attribute auction, e.g. the bid-taker chooses a bid of the lowest price. Such a selection is not obvious, if multiple issues are taken into consideration. That is because the bid-maker faces a multiple criteria decision problem, the solution of which depends on both intrinsic and subjective structure of preferences and the method used for the preference elicitation and value function construction. In this context, several preference aggregation methods have been proposed (see, e.g., Che 1993; Teich et al. 2001; Padhi and Mohapatra 2010).

Information on bid-maker's preferences and value (scoring) function can be made public or kept private. In most multi-attribute auction mechanisms the bid-makers are given the bid-taker's value function either explicitly (Bichler 2000; Bellosta et al. 2011) or partially (Beil and Wein 2003; Adomavicius et al. 2012).

When value function is public, the bid-makers know the bid-taker's evaluation of their bids. In such a situation the bidding process is similar to the single attribute, however, every bid-maker has to solve a bicriteria problem: the bid-taker's value function and the bid-maker's value function. When the bid-maker's preferences are not disclosed the problems is complicated because the bid-makers are unable to determine if they make bids that are better or worse for the bid-taker. In such situations, bid-makers can unintentionally make reverse concessions (i.e., propose bids that are better for them and worse for the bid-taker than their previous bids), win-win concession (bids that are better for both the bid-taker and the bid-maker) or lose-lose concessions (bids that are worse for both the bid-taker and the bid-maker). The problem of unintentionally made reverse concessions is discussed in negotiation context (Bichler et al. 2003; Filzmoser and Vetschera 2008; Wachowicz and Wu 2010). It results from the different structures of preferences of a buyer and a seller that often are not strictly opposite.

The latter question is not trivial, especially when a seller wants to plan her bidding strategy that includes consecutive concessions for the forthcoming auction rounds. If the auction is conducted via an electronic web-based system, such as those offered by Ariba, IBM (Emptoris) or PerfectCommerce, additional supportive mechanisms may be applied to prevent sellers from making reverse concessions or to suggest the 'optimal' mix resolutions levels within the bid (Beil and Wein 2003). If the buyer's preferences must be kept private, such supportive mechanisms cannot be used. However, other tools that help sellers to identify various bidding possibilities within their own scoring spaces can be implemented. One such tool is a bid

generator implemented in Imaras auction support system (Kersten et al. 2013), which helps bidders to determine various bids of equal value (score) to them. Technically, the generator builds a list of offers that consist of various mixes of issues' options but result in the same or similar value calculated according to the seller's value function. Sellers use the generator to identify alternative bids, which are indifferent for them but are (typically) of different value for the buyer. Submitting these alternative bids the sellers may try to assess the buyer's value function and seek win-win bids, e.g., bids that are feasible and require the smallest possible concession.

The motivation for this study was to determine if a decision support tool such as the Imaras bid generator affects the bidding process and its results. In this paper we present results of the auction experiment in which the Imaras system was used. We discuss differences between behaviour, performance and system use of two groups of bidders: (1) bidders who could access the generator; and (2) bidders who could not access the generator. The paper consists of four more sections. Section 2 briefly describes the Imaras system and the experiment. Section 3 compares two auction types, those with the generator and those without. Bidders' assessment of the system and the bidding process is discussed in Section 4 and the conclusions are given in Section 5.

## Imaras - the system and the experiment

The Imaras system uses an iterative reverse auction algorithm which allows bid-takers to keep their preferences secret (Kersten and Wu 2012). The system has been used in lab and online experiments. The participants are students of different degree programs and different universities. For the purpose of online experiments several process rules were adopted - they maintained the auction and allowed those students who began late to bid.

#### Imaras auctions

The Imaras auction process is of a fixed length and it is divided into rounds. The round time can be fixed or flexible. In the latter case, the round time depends on bidders' actions, e.g., a new round begins a fixed after a fixed time, which follows the second bidder's a bid in the round. This allows the auction to continue. Bidders are informed via email if the round deadline was set. When a round deadline is reached the system moves to the next round. After each round a set of limits (constrains) is defined and shown to bidders to direct them to submit bids that will be better for the buyer. Bidders can also submit multiple bids during the round. Bidders can also see the current best bid for a buyer.

In each round bidders may submit a single or multiple bids—in the discussed experiment they could submit multiple bids. There are also different options for information disclosure; for example, either all bids are shown or only the winning bid is shown or no bid is shown.

In the case of flexible round time, the auction terminates when either its deadline is reached or the best possible bid has been submitted.

The Imaras bidding page is shown in Fig. 1. Section A contains general information about the auction with the navigation bar on the left-hand side of the screen. Sections B and C show tabular and graphical presentation of the bidding history. Section D shows a bidding construction tool, which is a series (3 in the figure) of drop down lists from which the bid-maker can select one of the acceptable alternatives. The bid generator is shown in Section E. In Fig. 1 only the input box (highlighted) in which the bid-maker enters the desired scoring value is shown. Before this box there is information about the maximum value that can be entered; the value shown is repeated below, i.e., (maximum 75).

The bid obtained through the drop-down lists (D) or the generator (E) is shown in Section F. Below is a button to submit the bid.

The scoring function is defined on all alternatives in the decision space. A seller and a buyer have a rating value associated with each option available on each attribute. The scoring function (rating) for each alternative (a combination of options selected for each attribute) is defined as a sum of ratings of options, according to the principles of simple additive weighting (SAW) method (Keeney and Raiffa 1993). The scoring function is quasi-linear and it is standardised to interval [0, 100].

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7	20 (\$/40)	68 (\$/kl)	24%	69	Your bid	10 Rating 73	
7	20 (\$/kl)	70 (\$/kl)	30%	75	Your bid	50 (#0	
6	24 (\$/40)	60 (\$Al)	32%	D 70	Other's bid		
5	26 (\$/M)	60 (\$AI)	30%	73	Other's bid		
4	29 (\$/kl)	70 (\$AI)	30%	86	Your bid	10	
4	30 (\$.40)	66 (\$Al)	34%	81	Other's bid	P	
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*Fig. 1.* Screenshot of Imaras bidding page: general information (A), tabular bidding history (B), graphical bidding history (C), bid construction (D), bid generation (E), and bid submission (F).

The part of the page which bidders use to formulate and generate bids is shown in Fig. 2. Fig. 1 shows the situation when the generator is available but not used. Fig. 2, Section E, shows the result of the generator usage. The bid-maker entered value 48 (maximum was 50) and Imaras displayed seven alternatives in the table. Note, that only three alternatives yield value of 48, one alternative yields value of 49 and three alternatives a value of 47. This is because the generator searches seven alternatives yielding the required value and if there are fewer, then it selects alternatives with value as closed to the required one as possible.



Fig. 2. Screenshot detail: bid construction (D), bid generation (E), and bid submission (F).

The bid-maker selected the fourth alternative from the top of the table (indicated in column Select), which then is shown in Section F so that it can be submitted.

## Experiment design

An online auction experiment was conducted with 76 students from a university in Poland in the fall of 2012. All participants were divided into 24 auction instances with three sellers in each and one instance with four sellers. Thirteen auction instances were set up with the generator in the system and twelve without.

Four participants did not make any bids, therefore the number of sellers in four instances was lower. These instances were removed from further analysis, leaving 21 instances with three active sellers.

Generator was:	Available	Not available
No. of students – sellers	40	36
Demographics (%)		
Age group		
– 25 and younger	78	67
- 26-30	20	18
– 31 and older	2	15
Gender (female)	63	44
Experience with system (no)	100	100
Experience with task (no)	77	72
Expectations		
Task difficulty (scale 1-7)	4.5	4.4
Aspiration level rating	63.7	64.0
Reservation level rating	43.2	41.0

Table 1. Participants' demographics.

#### **Business case**

A procurement case was used in the experiment. This case involves a milk producing company (buyer) which requires a logistics provider (seller) to sign a contract for transportation services. The company approached several providers and invited them to participate in an auction. The transportation service contract contains three attributes, the values of which need to be established: standard rate of transportation, rush rate for unexpected delivery, and penalty for non-delivery or delivery of spoiled goods. Although all three attributes are expressed in monetary terms, they cannot be added up because they are in non-linear relationship for both the buyer and the sellers Furthermore, the preferences for each of the attributes differ among the sellers (for detailed description see Kersten, Vahidov et al. 2013).

In order to make the case easy to understand, the quasi-linear scoring function was interpreted as profit. In the case, the function was not given explicitly, instead a spreadsheet-like profit calculator was inserted.

## Results

The overall results are discussed in Section 3.1, followed by a discussion of the generator usage in section 3.2. Section 3.3 compares bids made with and without the generator.

#### **General results**

Overall results from the experiment are shown in Table 2.

Eleven sellers (31%) did not use the generator despite the fact that this tool was available. There were two winners (18%) in this group. In comparison, ten bidders out of 25 (i.e., 40%), used the generator and won the auction. The small dataset does not allow to test the significance of this difference. However, the fact that the relative number of auction winners is higher when bidders use the generator than when they do not use it is interesting and should be verified with a larger dataset. We may hypothesise, however, that the generator increases bidders' effectiveness.

To test the effect the generator use on outcomes we grouped sellers who did not use the generator together regardless of the availability of this tool. Table 2 shows that there were no significant differences in general results between the sellers who used the generator and sellers who did not, with the exception of the average number of bids. The sellers who used the generator submitted significantly more bids (p = 0.037) than the sellers who did not use generator (9.8 vs. 6.7). There were no significant differences in outcome variables between the winners who used and those who did not use the generator.

Generator was	: Available		Not available
No. of instances	12		9
Avg. no. of rounds	5.8		5.7
	Used at least once	Ν	lot used
No. (%) of sellers	25 (69)	11 (31)	27 (100)
- No (%) of winners	10 (83)	2 (17)	9 (100)
Avg. no. of bids / bidder	9.8		<b>6.7</b> ^
- Submitted by winners	13.1		8.3
Avg. no. of single seller's bids per round	1.9		1.6
- Submitted by winners	2.2		1.7
Avg. seller's profit	11.5	1	5.6
Avg. buyer's profit	66.7	5	5.3
No. (%) of Pareto-optimal agreements	4 (40)		1 (9)
No. (%) of non Pareto-optimal agreements	6 (60)	10	0 (91)
- % of dominating alternatives	0.1		4.0

Table 2.	Overall	results.
	0000000	10500005.

Significance compared to sellers who used generator:  $\uparrow p \le 0.05$ 

Interestingly, the winning sellers who used the generator, achieved lower profit than those who did not (11.5 vs. 15.6). The auctions in which the winning sellers used the generator resulted in a higher profit for the buyer than the auctions in which the winners either did not or could not use the generator (66.7 vs. 55.3). These results may be due to the larger number of bids made when the generator was used (see Table 2), the ease in bid formulation and the use of profit value in bid construction.

The number of winning bids which are Pareto-optimal is higher when the generator was used by winners than when it was not used (40% vs. 9%).

#### Generator use

In order to gain insight into the way the generator was used and into the effects of using it, we first compared bids made with and without the generator in those auctions, in which the generator was available. Bid generator is a tool, which makes bidding easier. Instead of deciding one every attribute value and checking its impact on profit the tool allows to generate seven alternative bids for the same or very close profit value. It is not only easier to formulate a bid but it also facilitates control of the profit value, which is the key measure for the sellers.

When a tool is very easy to use and it provides its user with some additional value, the possibility to generate several alternatives yielding the same profit, then such a tool may be overused with negative consequences. Consider the following situation. One seller submits a bid from among bids yielding the same profit value (called here equal bids), which yields the highest profit for the buyer. This seller reasons that in such a way she may achieve high profit herself and win because her bid also yields high profit for the buyer. If other

bidders act similarly, then the admissible bidding set (set from which bids can be selected) may contract very quickly. It is thus possible that the generator's unintended consequence is such contraction of the admissible bidding set that there are only few admissible bids towards the end of the auction. This situation could explain why profit was lower when the tool was used than when it was not used.

The frequency of the generator use and the contraction of the number of equal bids are given in Table 3. First we divided the action process into the following four periods: (1) from the first round up to 25% of rounds; (2) from 25% to 50%; (3) from 51% to 75% rounds (inclusive); and (4) from 76% up to the last round of the auction. We excluded two auctions from this analysis because they has fewer than four rounds.

The difference in the proportion of usage of the generator between the four periods was not significant when all four periods were compared jointly ( $\chi^2(3, N = 273) = 5.956$ , p = 0.113). The pattern of the generator usage indicates that initially its frequency increases but then it drops down in the last period (76-100%). These changes are, however, not significant with the exception of the difference in use in the first and third period; in the latter the generator was used significantly more often than in the former ( $\chi^2(3, N = 136) = 5.802$ , p = 0.016).

	0 - 25%	25 - 50%	50 - 75%	75 - 100%
	Bids made	with generator		
No. (%) of bids	29 (33^)	31 (38)	26 (54)	23 (41)
Avg. no. of equal bids	18.2	11.0	2.5	1.6
	Bids made n	vithout generator		
No. (%) of bids	59 (67)	50 (62)	22 (46)	33 (59)
Avg. no. of equal bids	19.5	12.1	6.1^	6.6*

<b>Table 3.</b> The impact of the generator use on the equal bids spa	ace.
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Significance of bids made with and without generator:  $\hat{p} \leq 0.05, *p \leq 0.01$ .

Table 3 also shows that the average number of equal alternatives (i.e., alternatives with the same rating) for the seller who used the generator to make a bid did not significantly differ from the case when the generator was used neither in the first period (p = 0.776) nor in the second period of auctions (p = 0.665). In the third period, the average number of available alternatives when generator was used was significantly lower (p = 0.023) than the number of alternatives available when it was not used (2.5 vs. 6.1). In the last period of auctions the average number of admissible equal bids was also significantly lower (p < 0.001) for bids made without it (1.6 vs. 6.6).

The difference in the number of equal bids suggests that generator usage impacts the size of the set of admissible bids. This size is determined by the winning bid; after every round the set of admissible bids is contracted: all alternatives which are worse for the buyer than the winning bid are dropped. To determine if the generator affects contraction of the admissible set we selected the winning bids. Because we considered only the winning bids, the small number of observations did not allow us to use four periods, instead we divided the process into two periods (1) from the second round to the middle and (2) from the middle to the end.

	Second round to middle	Middle to end	
	Winning bids made with generator		
No. (%) of winning bids	9 (45)	8 (33)	
Avg. no. of alternatives	847	86#	
	Winning bids made without generator		
No. (%) of winning bids	11 (55)	16 (67)	
Avg. no. of alternatives	1285	610+^	

Table 4. The impact of generator use on the bidding space.

Significance of bids made with and without generator:  $\hat{p} \leq 0.05$ .

The frequency of the generator use to make winning bids and the contraction of the admissible bidding set are given in Table 4. There were 3374 admissible alternatives at the begging of each auction. In the first half of the auctions, average size of the set did not significantly differ regardless of whether or not the winning bid in the previous round was made with or without the generator (847 vs. 1285). The reason why these numbers are not significant is due to the outliers.

In the second half of the auctions in which the generator was used to make winning bids the admissible sets were contracted to 86 alternatives (p = 0.010), when winning bids made without generator the sets were contracted to 610 alternatives (p = 0.046). This difference is significant (p = 0.011). This may be the reason for the reduction of the winning sellers' profit: towards the end of the auctions, in which the generator was used, sellers had very few alternatives to choose from.

#### Bids made with and without the generator

The generator was used by the sellers wanted to select a bid out of several alternatives with the same or very close rating. One question is whether the selected bid was on average better for the buyer when the generator was used than when it was not used. To measure how good the choice of the alternative was for a buyer we used a normalized distance D (a) in the buyer's rating between the submitted bid and the best alternative for a buyer that has the same rating for a seller:

$$D(a) = \frac{R^{max}(a) - R(a)}{R^{max}(a) - R^{min}(a)} D(a) = \frac{R^{max}(a) - R(a)}{R^{max}(a) - R^{min}(a)}$$

where R(a) is the buyer's rating of the alternative  $a, R^{max}(a)$  and  $R^{min}(a)$  are ratings of, respectively, the best and the worst available alternative for the buyer with the same rating for the seller.

The distance is equal to 0 for the best bid for the buyer and 1 for the worst alternative. This distance was calculated only when more than one alternative with the same rating for the seller was available.

To compare the distribution of bids by their rating for the buyer, we grouped bids into four groups based on the distance to the best alternative for the buyer D (a). The first group includes bids with the distance value from 0.75 to 1 (the worst alternatives), the second group includes bids with the distance value from 0.5 to 0.75, etc. The four categories, the best and worst alternatives, and a bid made in the category [0.25; 0.5) are shown in Fig. 3.



Fig. 3. Selection of the best bid for a buyer.

The average distance to the best bid when the generator was not available was not significantly different (p = 0.659) from the case when the generator was available (0.60 vs. 0.62) (see Table 3). In auctions when the generator was available the average distance to the best bid was significantly lower (p = 0.003) for bids made with the generator than for bids made without the generator (0.51 vs. 0.66).



Fig. 4. Selection of the best bid for a buyer.

This result is interesting, but we do not know the reasons underlying it. Note, that the bidders with the generator do not know anything more about the buyer's preferences than the bidders who did not use the generator. The difference between these two groups of bidders is that using the generator makes it easier to obtain several alternative bids with the same rating. Also the generator makes bid formulation easier and this may be the reason why bid-makers, who used it, submitted more bids than these who did not use it. The final result was not beneficial to the latter bid-makers. Although the use of the generator led to bids yielding higher score for the buyer and not worse for the seller, the winners who used it made more bids than winners who did not use it. Therefore the former's profit was lower than the latter's (see Table 2).

The distribution of bids made with or without the generator in the four groups is shown in Fig. 4. This distribution is significantly different ( $\chi^2(3, N = 243) = 11.908$ , p = 0.008) when the generator was available. Significantly more bids in the "best for the buyer" group were made using the generator than when it was available but not used (37% vs. 19%). Significantly fewer bids were made in the "worst for the buyer" category with generator than without (37% vs. 53%). We can conclude that when using the generator the bidders selected better bids out of alternatives with the same rating for them than when they did not use it.

The distributions of bids made without the generator was not significantly different ( $\chi^2(3, N = 381) = 5.113$ , p = 0.497) between the situation when it was available and when it was not available. Similarly, the distribution of bids when the generator was available and when it was not available was not significantly different ( $\chi^2(3, N = 406) = 2.267$ , p = 0.519). These results indicate that when the generator was used, then the bids were better for the buyer than when it was available but not used. If however, the generator was not available, then the bids were not worse for a buyer than in the case when it was available but not used.

## Behavioural aspects of bidding with and without the generator

After the experiment, the sellers were asked to fill out a questionnaire. We compared responses given by the sellers in two treatments. The results are shown in Table 5. Answers were coded between -3 (strongly disagree or not satisfied) and 3 (strongly agree or satisfied).

	Generator was available			Generator was not available		
	Overall	Winners	Non-winners	Overall	Winners	Non-winners
Satisfaction with an outcome achieved	-2.08	-0.43	-2.76+	-1.61	-0.43	-2.36+
Satisfaction with negotiators own performance	-0.79	0.29	-1.24	0.61^	0.71	0.55^
Satisfaction with experience gained	1.25	1.14	1.29	1.22	1.43	1.09
Satisfaction with personal achievement	-0.33	0.00	-0.47	0.22	0.14	0.27
The system was helpful in achieving my objectives	0.21	0.71	0.00	0.00	0.71	-0.45
The system was helpful in improving my performance	0.38	0.57	0.29	0.61	0.86	0.45
The system was helpful in reaching an outcome faster	0.54	0.71	0.47	0.33	0.71	0.09
The system was helpful in managing the process	0.79	0.43	0.94	0.33	0.29	0.36

<b>I ADIC 3.</b> I $0$ si-antiton community of biances scipper for manife and the antiton system	Table 5. Post-auction	evaluation o	f bidders	' self-performance	and the auction	n system.
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Significance compared to negotiations with generator:  $^{p} < 0.05$ ,

Significance compared to the winners: + p < 0.05

We found no significant difference in responses given in the two treatments with the exception of satisfaction with own performance. The sellers were significantly less satisfied (p = 0.021) with their own performance when the generator was available, than when it was not available. There were no significant difference (p = 0.698) in the responses to this question between the winners in two treatments. Non-winners were significantly less satisfied (p = 0.014) with their own performance when the generator was available than when it was not available.

A possible interpretation of the higher satisfaction with own performance for non-winners when the generator was not available is the difference in complexity of the bidding process with and without it. When the process was easier (with the generator), the sellers were more disappointed not to win an auction. When it was harder to bid (with no generator), then they appreciated their performance higher.

In both treatments the winners were significantly more satisfied with the outcome than non-winners (p = 0.021, when the generator was available; p = 0.015, when it was not available). This is not surprising.

## Discussion

The alternative bids generator was designed to provide bid-makers with a support tool that makes the bidding process easier and more efficient. Another purpose of this tool was to help bid-makers to be able to generate alternatives based on their score (profit in our experiment). The results from our experiment are mixed. The tool had no positive effect on the final result. The average profit of the winning sellers' who used the generator was 26% lower than the average profit of the sellers who did not use it (see Table 2). This may be one reason for the generator users to be less satisfied with their performance, than winners who did not use the generator. On the other hand, however, the generator had a positive effect on the average buyers profit because it was higher by 21% than the average buyers profit when the generator was not used.

These results suggest that market-makers and bid-takers should include such a tool in multi-attribute auctions but bid-makers should refrain from using it. This conclusion is only tentative and it must be verified.

We think that the generator may be useful for the buyers, but the implications of its usage need to be clearly explained. One reason is that the use of the bid generator has a positive impact on auction efficiency; 40% of the winning bids are Pareto-optimal as opposed to 9% when it was not used. This is also reflected in the fact that the winning bids which were not Pareto-optimal are closer to the efficient frontier when the generator was used; on average 0.1% of alternatives dominate the winning bid as opposed to 4.0% when the generator was not used.

One of the possible reasons why the generator did not have a positive impact on the final results is that bidmakers used this tool often in the first half of the auction but much less so in the second half, and virtually not at all in the last two rounds (see Figure 4). We found that when the bids were made with the generator, then they were better for the buyer than the bids yielding the same profit for the sellers, who did not use it. This suggests that the generator helps bid-makers to select, from among bids of equal profit, the bid that is better for the buyer. This feature could lead to the sellers achieving higher profit when they use the generator than when they do not use it, except for the fact that the generator users make more bids. The overall result is that they make bigger concessions than those who do not use the generator.

Acknowledgments. This work has been supported by the grants from the Natural Sciences and Engineering Research Council of Canada (NSERC) and Concordia University.

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# Agenda Negotiations in an Electronic Negotiation Support System

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## The Necessity of Electronic Agenda Negotiations

"The agenda is one of the most important structural aspects of any negotiation as well as a significant determinant of negotiating power and influence." (Pendergast, 1990, p. 135)

Given the importance of setting an agenda for upcoming negotiations, there is a current lack of a clear understanding how setting the agenda actually influences negotiations. We define the agenda as the negotiation attributes such as the price or the colour of the object under negotiation. We distinguish between value negotiations and agenda negotiations. In value negotiations, negotiators can only exchange offers which contain values for the before mentioned attributes, e.g. '2000 Euro' for the price attribute or 'red' for the colour. In agenda negotiations, negotiators can exchange offers which extend or reduce the agenda, e.g. add or remove an additional attribute such as 'delivery.

The agenda can be defined in two ways. Firstly, it can be pre-defined before starting the negotiations. Second and more realistically, the agenda is defined and also modified during the preparation and the actual conduct phase of negotiations. In face-to-face negotiations, it is common practice to negotiate the agenda during the whole negotiation process (Pendergast, 1990). An evaluation of different electronic negotiation support systems (NSSs) has shown that a flexible support for a dedicated agenda negotiation process is hardly implemented so far. We suppose that the integration of such a process will take effect in the usability of NSSs as well as in the results of negotiations conducted. In more detail, we expect a process allowing timely flexible agenda negotiation strategies such as how and when to make concessions. Our research questions are: (1) how to enable electronic agenda negotiations and (2) what is the influence of agenda negotiations on subjective and objective outcome dimensions. To this end, we develop a framework for agenda negotiations on a theoretical basis. Furthermore, we conduct laboratory experiments to gain insights into this research area.

## A Framework for Agenda Negotiations in Electronic Negotiation Support Systems

Based on the underlying design science methodology (Hevner et al., 2004), we use information about the environment of agenda negotiations to provide relevance as well as surrounding theories to provide rigor of the approach. In order to build a relevant artefact, negotiation experts were asked for their specific requirements in an electronic agenda negotiation component in several interviews. These requirements have been collected and weighted according to their number of occurrence and background information in the literature (Pendergast, 1990; Balakrishnan et al. 1993; Raiffa 2007; Keeney and Raiffa, 1991). The most important requirements of the resulting ranking have been implemented in the framework. These include (i) reducing cognitive complexity of agenda negotiations by means of a clearly defined negotiation protocol that strictly separates agenda and value negotiation, (ii) decision support as a way to present utility information to the respective negotiators to further reduce complexity and (iii) providing an easy to understand visualisation of the negotiation agenda, its changes and the negotiation process.

To build a rigorous artefact, our framework has been designed alongside several theories centred on communication support. The prevalent approach focuses on the Language/Action Perspective (LAP) (Flores and Ludlow, 1980) as a way to structure the communication between negotiators. LAP uses the Speech Act Theory (Searle, 1969) as a foundation, which defines a speech act as the smallest unit of communication consisting of a specific content and mode. According to the Theory of Communicative Action (Habermas, 1982), LAP states that people act through language in order to reach mutual

understanding. Winograd (1988) describes a method to develop information systems based on such interaction sequences modelled as a state machine.

Using this method we defined several speech acts in agenda negotiations such as "Agenda Request", Agenda Offer", "Agenda Counteroffer", etc. based on the information gathered in expert interviews and literature. We modelled an agenda negotiation strictly separate from the underlying value negotiation in order to reduce complexity and foster usability. In every state of the negotiation, there is only a limited set of possible interactions (i.e.: speech acts) until the negotiation reaches a certain end state where no further interaction occurs. We implemented two different protocols (cf. figure 1), namely a flexible negotiation protocol which allows negotiators to request an agenda negotiation at any point in time and a fixed agenda negotiation protocol which allows only one agenda negotiation at the beginning.



Fig. 1. Negotiation protocol for agenda negotiations modeled as a state machine according to Winograd (1988).

## **Explorative Evaluation**

According to the applied design science approach, we evaluated the generated framework by implementing an instantiation as prototypical component of the NSS 'Negoisst' (Schoop, 2010). This instantiation was evaluated according to research question (1) with a negotiation experiment including 14 subjects. In a questionnaire usability, process complexity and the fulfilment of the previously stated requirements for agenda negotiations were evaluated. All in all, the instantiation was perceived to be fulfilling the requirements, hence usability and cognitive complexity turned out to be major factors that had to be improved for further successful usage of this instantiation.

Therefore another iteration of the build-evaluate process of design science was conducted. We used the additional requirements and experiences of our test persons in this pre-test to modify the framework as well as the instantiation focusing on usability and reducing cognitive complexity. This was done by simplifying the negotiation protocol and navigation within the instantiation as well as by providing additional information about the status of the (agenda) negotiation. You can see for example the "Complex Negotiation Overview" or the improved "Agenda" that states changes on each agenda issue immediately in figure 2.

Complex Ne	agotiation Overview			
+ Electron Agenda	Negotiation			
History				
Nov 1 New A Nov 2 Agence	9, 2012 3:05:58 PM <u>Welcome</u> (Mr/Mrs Verhoeven) genda Negotiation 0, 2012 9:35:28 AM First agenda offer (Mr/Mrs Verhoeven) Ia Offer Ige			
Sender:	Mr/Mrs Verhoeven, Student(21)	Agenda		
Receivers:	Mr/Mrs Schultz, Electronic King Inc.(21)			
Received:	Tuesday, November 20, 2012 9:35:28 AM CET	<ul> <li>NegotiationAgenda (complex)</li> </ul>	6	۲
Title:	First agenda offer	Data_recovery_costs (categorial) <sup>new</sup>	s and a second	۲
Туре:	Agenua cinel With this message you commit to the agenda details proposed, these will be transferred to a preliminary agenda.	Data_recovery_time (categorial) <sup>new</sup>	ø	۲
II A		Delivery_costs (categorial) <sup>new</sup>	s de la companya de l	۲
Dear Mr/Mrs S Hereby you re Mrs Verhoeve	chultz, cieve my first agenda offer for the negotiation. Hope hearing from you soon with a counter offer. n	Replacement_laptop (categorial) <sup>new</sup>	Ø	۲

Fig. 2. Negoisst interface in agenda negotiations, second development iteration.

## **Empirical Evaluation**

After these further developments, we conducted a laboratory negotiation experiment. The objective of this experiment is to answer research question (2) regarding the negotiation outcome dimensions. Therefore we developed the following hypotheses:

- 1. A flexible agenda negotiation protocol leads to an increased
  - a. likelihood for agreements.
  - b. likelihood for more efficient agreements.
- 2. Decision support in value negotiations with agenda negotiations leads to an increased
  - a. likelihood for agreements.
  - b. likelihood for more efficient agreements.
- 3. Decision support in value negotiations with a flexible agenda negotiation protocol leads to an increased
  - a. likelihood for additional agenda negotiations.
  - b. likelihood for agreements.
  - c. likelihood for more efficient agreements.

To test these hypotheses we set up an experiment with about 170 master students enrolled at the University of Hohenheim and the University of Tilburg. These participants were recruited from negotiation courses. They received a system-briefing and were credited with grades as an incentive. The case used for the present study represents a business case and the participants were given 14 days to finish the negotiations.

To answer the presented hypotheses, participants were divided into four treatments. Treatment one had decision support enabled and the possibility to request an agenda negotiation whenever they wanted to. Treatment two also had the infinite possibility for Agenda negotiations but without decision support. In treatment three only one agenda negotiation in the beginning of the negotiation process was possible. During the value negotiations, participants of this treatment were provided with the decision support. In treatment four participants could jointly define the agenda within the negotiation dyad only before starting the actual negotiations without any decision support in both phases.

The results of the experiment will be presented at the conference.

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# Text Mining and Electronic Negotiations – Methodological Issues and Challenges

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## Introduction and Theoretisation

In the recent years of research on electronic negotiations, there has been an increased focus on the communication processes that shape such a negotiation. Compared to the classical decision-theoretic perspective, researchers sought to understand how the negotiation communication itself is affected by the shift to an electronic medium and how the communication process during the negotiation influences its efficiency and effectiveness. Most of the methods used in this context (e.g. Content Analysis (Köszegi and Srnka 2007, Weingart et al. 2004)), are conducted manually, and therefore are laborious and cumbersome.

Applications of text mining methodologies can help to alleviate this problem, theoretically providing capabilities to extract meaning and crucial elements in negotiators' communication in a (semi-)automated way. Social Information Processing Theory (Walther and Parks 1992) suggests that social cues – which are perceived as being one of the most important factors to build rapport, trust and mutual understanding between the negotiators – are conveyed directly through the exchanged messages, when the communication medium is shifted to a text-only situation, such as electronic mail or text-based negotiation support systems. One idea behind an application of text mining (in this case text categorization, specifically) is to potentially identify communicational structures or patterns, that relate to the success or failure of a negotiation. Furthermore, it may be possible to use this inherent communication structures to automatically predict negotiation success. A similar approach has already been taken by Sokolova and colleagues, with promising results (Sokolova et al. 2012, Sokolova and Szpakowicz 2007).

Following this idea, we applied text categorization to a corpus of negotiation data, which has been collected in several negotiation experiments over the recent years. We expected the negotiations to contain recognizable and, especially, learnable communication features relating to their success or failure.

## Applying Text Categorisation

## Preprocessing

Our given dataset consisted of 2495 messages from electronic negotiation experiments (all of the same experimental case, a joint venture negotiation between two companies). Of these 2495 messages, 1685 messages belonged to successful negotiations, whilst 810 messages were taken from failing negotiations. Sokolova and Szpakowicz (2007) categorized their messages on the negotiation level (and some subsets, such as the first or second half). Since our data set was considerably smaller, we decided to classify at the single message level in order to create more data points for training purposes. So the basic categorization problem contained two possible classes (success or failure of the negotiation) into which each message was classified.

Since all negotiation messages were taken from the same experimental case, we originally expected casespecific terms, such as the aliases of the negotiators, locations and names of the companies not to have any influence on the categorization results. However, these specifics attributed to a large amount of noise in our first tests. Therefore we decided to use Named Entity Recognition to get rid of this noise. We unified the names of persons, companies and locations via replacement with tags. For automated recognition of these names, we used the Stanford NER (Finkel et al. 2005) package.

Further preprocessing steps included the removal of terms occurring only once, lowercasing of the negotiation texts and the removal of non-alphanumeric characters.

We used a standard, multinomial feature vector (indicating word counts in the documents instead of only presence and absence) as the representation for the data set. Concerning term granularity, we decided to use

bi- and trigrams in order to retain some of the contextual information for the terms, in order enhance the ability of the model to recognize the rather complex textual constructs we expected as being critical concerning negotiation success. In a last preprocessing step, we applied Chi<sup>2</sup> Feature Selection (e.g. described in Manning et al. 2008), filtering out the top 2000 features concerning significance for the class decision.

#### Results

Different common classifiers were applied to the data set, namely Support Vector Machines (linear Model) (Cortes and Vapnik 1995), Naïve Bayes (Maron 1961), Decision Trees (Quinlan 1986) and several kNN-classifiers (Cover and Hart 1967) of which 3NN provided the most meaningful results. We used the classifiers in their respective implementations in the WEKA toolkit (Witten and Frank 2005). The obtained categorization results are depicted in Table 1, showing Accuracy, F-Measures and the kappa statistic, as well as Precision and Recall scores for the respective categories.

	SVM	NB	DT	3NN	Base
Accuracy	0.685	0.685	0.653	0.665	0.675
F-Measure	0.656	0.669	0.624	0.559	0.499
Pr. Success	0.72	0.734	0.704	0.679	0.675
Rec. Success	0.874	0.838	0.840	0.993	1
Pr. Failure	0.528	0.522	0.442	0.613	0
Rec. Failure	0.294	0.368	0.264	0.023	0
Kappa Statistic	0.189	0.223	0.116	0.022	0

Table 1. Categorisation results

Compared to the baseline, we found that the categorization yielded only slightly better and, partially, even worse results. Especially, we found that 3NN had severe difficulties in recognizing failing negotiations. Naïve Bayes performed best among these classifiers, although in terms of accuracy the result is only little above the baseline.

## **Conclusion and Future prospects**

The categorization results we obtained in our tests were rather discouraging. There is a multitude of possible explanations for this, mainly attributed to the specifics of the negotiation data and methodological problems.

Prior to the categorization application, we tried to assess characteristics of the negotiation data set, in order to obtain information on the necessary preprocessing methods. One of the main obstacles concerning the categorization results is the domain specificity of the negotiation messages, i.e. the fact that the messages are embedded into a specific negotiation situation, containing lots of words that directly relate to this specific case. Although these specific terms may not have a direct impact on success or failure (e.g. we expect all of the terms related to the negotiation issues to occur in successful as well as in failing negotiations), the large amount of these terms in the dataset is enough to greatly obfuscate the classification results, for example via an increase of the class skew effect. So in order to create a classification model that is independent of such an effect, we suggest these terms to be filtered out during the preprocessing phase. We already tried to alleviate this effect by the application of NER to the data set, but we found that this did not seem to be sufficient.

From a methodological point of view, a more elaborate preprocessing of the negotiation data is necessary, For example Sokolova et al. applied an informativeness criterion of negotiation data (Sokolova et al. 2012), as well as a reduction of negotiation actions to strategic steps (Sokolova and Szpakowicz 2007). In this context, the potential of dictionaries (e.g. words connected to the explication of emotions, trust or the conveyance of information) could be taken into consideration. Lastly, in order to gain a deeper understanding of the factual communication elements that relate to successful or failing negotiations, methods that focus more explicitly on the derivation of communication patterns or concepts could be applied to the negotiation data.

Still, the idea to automatically recognize potential failures of electronic negotiations is rather promising – especially if this is done during the ongoing negotiation process. A negotiation support system could intervene at this point and gather additional information on the conflict situation between the negotiators. Based on this information, different sorts of advice may be given to the negotiators, e.g. calling them to overthink their communication behavior, general negotiation strategic advice, or even the suggestion to prevent any further conflict escalation by the inclusion of a mediator.

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# Auctions and negotiations are comparable, aren't they?

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**Abstract**: Comparative studies of auction and negotiation exchange mechanisms are inconclusive. These studies have typically compared outcomes obtained from the two mechanisms. The question which this paper aims to address is the viability of outcome-based comparisons. Such comparisons assume that both mechanisms produce the same types of outcomes but their values differ. An argument can be made that this is not necessarily the case. Based on several experiments of multi-attribute auctions and two formats of multi-bilateral negotiations the paper argues that both mechanisms produce some outcomes which are the same but other outcomes which are qualitatively different.

**Keywords**: auctions, multi-attribute auctions, negotiations, multi-bilateral negotiations, socio-economic process, economic process, substantive outcomes, relational outcomes.

#### Introduction

Auctions and negotiations are well-established exchange mechanisms involving people, firms and governments. Proliferation of internet technologies and ubiquity of the web has led to numerous discussions, including discussions on the role of negotiations in business transactions. The initial sentiment was that auctions would be a new market-based negotiating paradigm and they would replace negotiating skills with market forces (Kumar and Feldman, 1998; Beam et al., 1999; Ströbel, 2000). A discussion during an e-negotiation workshop in Montreal on auctions and negotiations led to the recognition that not all electronic transactions can be coordinated through auctions (Kersten et al., 2000). The workshop resulted, among others, in a framework for the design of e-negotiations (Bichler et al., 2003).

Comparisons of auctions and negotiations are difficult because of significant differences in the assumptions underlying each mechanism, as well as differences in participants' knowledge and behavior. Auctions assume that bidders know the buyer's valuation (price) of the good and follow a strict and fixed protocol. They involve multiple bidders who compete for the same good or service. In contrast, negotiation mechanisms have significantly weaker assumptions; the key assumption is that the parties negotiate in good faith and that the parties have preferences allowing each to compare the alternatives. Furthermore, there is no limitation on communication and no assumptions about the sellers' knowledge of the buyer's valuation.

There are two broad types of negotiations, i.e., bilateral and multilateral, each type can be simultaneous or sequential. Bilateral negotiations have been experimentally compared with auctions (Gattiker et al., 2007; Neeman and Vulkan, 2010) and in the field (Bajari, 1998; Bonaccorsi et al., 2000; Bajari et al., 2009). These studies show that auctions are used when: (1) the exchanged goods (services) are defined by a single attribute (price); (2) several qualified suppliers are available; and (3) discussion on goods specification is not needed. Negotiations are used when these criteria are not met and when there is a strong possibility for future interactions.

Comparative studies of auctions and negotiations are inconclusive. In one of the first comparative studies, Bulow and Klemperer (1996) have shown that simple English auction with N+1 participating bidders (buyers) always yields higher revenue than a scheme they call "negotiation with N participants". Kirkegaard revised Bulow and Klemperer's theory and included non-cooperative bargaining with very limited communication protocol. Manelli and Vincent (1995) showed that the effects of auctions and negotiations vary according to situations; it is difficult to judge the effect of these two mechanisms on a given transaction without considering the overall context, including the goods, participants, market, and so on. An important conclusion in this study was that auction mechanisms are frequently inefficient in a procurement environment.

The difficulty in comparing auctions and negotiations is, among others, the use of different settings and protocols. One reason is that bilateral negotiations (i.e., 1:1) are compared with auctions with N bidders,

which removes competition among participants. Thomas and Wilson (2002; 2005; 2012) conducted several experiments in which both mechanisms were structurally similar, that is, there were N participants in auctions and N:1 participants in multi-bilateral negotiations. The results depended on particular experimental settings, however, the outcomes of auctions were not significantly better than the outcomes of negotiations. Thomas and Wilson experiments were very short (4 min.) and involved a single attribute good (price).

Auction and negotiation outcomes have been typically used to compare these two mechanisms. The question which this paper aims to address is the viability of outcome-based comparisons. Such comparisons assume that both mechanisms produce the same types of outcomes but their values differ. An argument can be made that this is not necessarily the case.

This paper reports on two studies in which multi-attribute reverse auctions and multi-bilateral negotiations were compared. Each process was conducted over a period of up to ten days. In the first study two experiments show that auctions yield better outcomes for the buyer than negotiations, resulting in a higher buyer's profit. Auctions were also found more efficient. One of the differences between these auctions and negotiations is that the negotiation protocol did not allow the sellers to obtain independent information about the best offer that the buyer received from one of the sellers. While this rule is typical for negotiations, in most auctions the winning (best) offer is displayed to all bid-makers (sellers). Availability of verifiable best offers increases mechanism's transparency and it could place auctions at an advantage over negotiations. This assertion led to the second study in which the system displayed best offers to sellers in auctions and in negotiations.

## Two studies

Several experiments in which participants used auction and negotiation web-based systems were conducted. These experiments and their results are briefly discussed in this section.

#### The case and two systems

The Milika case involves a producer of perishable goods (the buyer) and several logistics service providers. The producer wants to sign a contract with one provider only. The minimum quantity of goods to be transported is a fixed part of the contract. Additionally, there are three negotiated attributes, that is, standard rate of transportation, rush rate for unexpected delivery, and penalty for the non-delivery or delivery of spoiled goods. Each attribute has a discrete number of options, i.e. fifteen per attribute, which results in the total of 3375 possible agreements. All issues are fully specified and they cannot be changed during the experiment.

The system relies on a single criterion used to compare alternative bids and offers such as utility, production, cost and profit functions. In the Milika case the selected function is piece-wise linear and it describes profits of the buyer and the sellers. Profit function is different for different participants and its values (normalized between 0 and 100) are not disclosed to anyone.

The sellers are also given breakeven points below which their companies would incur losses. Thus, the sellers should be careful not to cross these levels. Their objective in both the auction and the negotiation is to obtain a contract that maximizes the seller's profit.

The systems used in the experiments were: (1) Imaras (InterNeg multi attribute reverse auction system); and (2) Imbins (InterNeg multi-bilateral negotiation system). Both systems were implemented using the Invite e-negotiation system platform (Strecker et al., 2006).

The systems' interfaces are very similar so that the impact of the IT artifact on the decision-making is minimized (Kersten et al., 2013). These are feature-rich systems reminiscent of situations one can encounter in real-life. The systems together with the case provide a realistic scenario in business context.

#### Study 1

We have conducted six different lab and online auction and negotiation experiments. The results of these experiments cannot be easily compared because of differences in: (1) the controlled variables, e.g., number of sellers (from two to six), number of alternatives (360 vs. 3375), and participation of software agents (in one experiment); and (2) the process design, (e.g., fixed and flexible rounds, introduction of video, tests,

and handouts). However, in all but one experiment, the sellers achieved very low profit and the buyers' profit was high. For illustrative purposes we selected two experiments; they are shown in Table 1.

In the auctions the sellers made more offers than in the negotiations. Their average profit was low, 3.9 in Experiment 1 and -7.4 in Experiment 2. In the latter experiment, the sellers, on average, won their auction bid a little below their breakeven value. In comparison, successful negotiators achieved a profit of 19.9 and 23.4, respectively in Experiment 1 and 2. In Table 1 we also observe that buyers achieved higher profit in auctions than they do in negotiations.

	Expe	riment 1	Experiment 2		
	Auction	Negotiation	Auction	Negotiation	
No. of instances	17	40	27	23	
No. of sellers	74	151	95	89	
No. of offers (avg.)	4.4	3.0	5.6*	3.1	
Agreement (%)	_	95	—	96	
Seller's profit	3.9	19.9	<b>-7.</b> 4*	23.4	
Buyer's profit	66.9	52.6	75.7*	47.1	
Dominating alt. (%)	6.4	1.9	4.0	4.0	

Table 1. Study 1: Two online experiments with non-verifiable offers.

\* Significance compared to negotiations, p < 0.01

Table 1 also shows that the two mechanisms' efficiency is measured by the percent of alternatives which dominate the agreements. These results are not conclusive. In Experiment 1, auctions were less efficient than negotiations (6.4% of alternatives dominated the winning bids vs. and 1.9% of alternatives dominated agreements), while in Experiment 2 both mechanisms were equaly efficient.

#### Subjective and objective concessions

An analysis of the results in Experiment 2 led to verification of a concession-making model in auctions and negotiations in which subjective and objective concessions were proposed (Kersten, Vahidov et al., 2013). The difference between these two types of concessions is the basis of comparison. A subjective concession is determined by two consecutive offers, i.e., made at t1 and t3 as shown in Fig. 1, both made by the same concession-maker. An objective concession is determined by two offers, the best offer on the table (market), which the concession-taker received at time t2 from any concession-maker and the offer made at time t3.



Fig. 1. Objective and subjective concessions.

Subjective concessions occur in bilateral negotiations, in which both the concession-maker and the concession-taker can compare offers made by the same concession-maker. In multi-bilateral negotiations, in which one side is represented by many and the other side by a single negotiator (the case in the scenario presented in Section 2.1), objective concessions are possible. Their use requires significant transparency of the process and fixed protocol, which typically are not employed. We know of only one negotiation study—

done by Thomas and Wilson (2005), in which objective concessions were made possible. In their study both the process and the systems were highly stylized and devoid of context.

Objective concessions are typical for these auctions in which the winning bid is shown to the bidders. Every bidder either submits a bid that is better (for the bid-taker) than the winning bid or drops out from the auction. The difference between the winning offer (on the market) and the submitted bid is the objective concession.

The sellers' profits given in Table 2 are the results of concessions they made; in the auctions the sellers' concessions were significantly greater than in the negotiations. The reason could be transparency: in the auctions the sellers knew the best bid, however, this was not the case in the negotiations. In the negotiations, even if the buyer sent information about the best offer she had received, this offer could not have been verified, hence the sellers may consider it as a ploy. This led us to design a negotiation experiment in which a version of the Imbins system displays the best offer on the table in the same way as the Imaras system does.

#### Study 2

The results of the second study (Experiment 3) are shown in Table 2. Column "Non-verifiable" results shows situations in which the Imbins system did not display the best offer; the buyer could have shown the best offer but it could not have been verified. The "Verifiable" column shows results of the multi-bilateral negotiations, in which the system displayed the best offer.

	Experin	nent 3
Best offers	: Non-verifiable	Verifiable
No. of instances	13	12
Seller	6	
No. of sellers	35	33
No. of offers (avg.)	4.4	4.0
No. of offers w/out message (avg.)	1.2	1.0
No. of messages w/out offers (avg.)	0.6	1.3
Agreement (%)	92	100
Seller's profit	22.3	19.1
Buyer's profit	48.0	53.3
Dominating alt. (%)	4.0	4.0
Buyer	rs	
No. of offers (avg.)	7.2	7.4
No. of offers w/out message (avg.)	1.5	1.0
No. of messages w/out offers (avg.)	1.4	2.9
Buyer's profit	48.0	53.3

Table 2. Study 2: Negotiation experiment with verifiable and non-verifiable offers.

There were no significant differences between the two types of negotiations, which contradicts our expectations. We expected the negotiations with verifiable offers to result in significantly better profit for the sellers than the negotiations with non-verifiable offers. The verifiable offer process is very similar to the auction process in terms of the winning offer display and fixed protocol which does not allow the negotiators to add or remove issues and their options.

The restrictions imposed on the negotiation protocol were severe but necessary. Fluid and evolving negotiation process with issues coming and going and preferences changing, cannot be compared with fixed protocol auctions. Verifiable offer negotiations have the same degree of transparency as auctions but they differ in the following three aspects:

- 1. The negotiating sellers are not forced to make positive objective concessions, i.e., make offers which are better for the buyer than the best offer on the table;
- 2. The negotiators can exchange messages with and without accompanying offers; and
- 3. The buyer can make offers.

The impact of the first difference need to be further studied, but it does not appear to have potential for changing the process because both sides know about the best offer. Hence, sellers who (would) submit an offer worse than the best offer (make negative objective concessions) would do it knowing that the buyer has a better offer on the table. There may be, however, a good reason for these seller to do so, for example, if they present/offer some additional benefits for the buyer in the message that accompanies the offer.

The free-text communication with the buyer and the buyer's interaction with the seller are the remaining two key differences between auctions and negotiations (with fixed issues and options). Table 2 shows that in both verifiable and non-verifiable negotiations the sellers sent messages to the buyers (there were as many buyers as instances). About 75% of offers were accompanied by messages. In addition, every seller sent, on average, 0.6 messages in non-verifiable and 1.3 messages, to which no offer was attached.

Buyers used their ability to communicate with the sellers, as shown in Table 2. In the negotiation with nonverifiable best offer they made 7.2 offers, of which, on average, only 1.5 were without a message attached. They also sent 1.4 messages without an offer. The results are similar in the verifiable negotiation, with the exception of messages sent with no offer attached—2.9 on average, i.e., over twice as many as in the nonverifiable negotiation. This difference was caused by two sellers who sent about four times more messages than other sellers. If we remove these two sellers from the dataset, then the averages are similar for both types of negotiations.

The number of offers made by the buyers is much greater than the number made by the sellers because buyers made offers to three sellers, per instance (the number of sellers shown in Table 2 is smaller because inactive sellers were removed from the analysis). Buyers could make an offer and send a message to any subset of sellers (one, two or three), but they often addressed their communique to a single seller.

The data shown in Tables 1 and 2 suggests that verifiable and non-verifiable negotiations produce similar outcomes and that disclosing the best offers does not significantly change the results. One could thus conclude that auctions yield better outcomes for the buyers and worse for the sellers, who must compete for the contract. This indeed would be the case, if the outcomes from auctions and negotiations were the same. In the next section we argue that this may not be the case and that the difference between the two mechanisms is in the presence of social aspects in one and absence of relationship in the other.

# Discussion

Auctions are *economic processes* in the sense that nothing except for the attribute values can be submitted. Auction outcomes are thus defined solely by the attributes defined by the bid-takers. These outcomes are known in negotiations as substantive; they are the issues which values are discussed over the course of the process and which constitute the agreement (Thompson, 1990).

In negotiation literature, substantive outcomes have been contrasted with relational outcomes; the roots of this distinction are attributed to an effort to contrast the economic perspective on negotiation with the psychological perspective (Bazerman et al., 2001; Gelfand et al., 2006). The argument which we posit here is that negotiations among market participants and businesses are socio-economic processes and that neither the "social" nor the "economic" aspects can be ignored.

The social exchange theory is concerned with the formulation and evolution of relationship between parties engaged in giving and getting "something", and the rules which govern exchanges between the parties (Cropanzano and Mitchell, 2005; Bottom et al., 2006). There are two main types of rules (Molm, 2010): (1)

reciprocity rules; and (2) negotiated rules. The negotiated rules are explicit and simple, they deal with bargaining in which reciprocity is not required. The reciprocity rules are implicit and govern different forms of relationships, which emerge during interactions among people (e.g., trust, empathy, and reputation).

The social exchange theory reduces negotiation exchanges to haggling or double auctions: "reciprocity is a trivial byproduct of a bilateral trade, and the same actions that reduce the risk of loss also increase gain." (Molm, 2003). However, even this narrow perspective on negotiation recognizes reciprocity as an important device used by the negotiators. An action by one party calls for some kind of a response by the counterpart, it creates an obligation. If it is clear that the party makes an effort, provides explanation, proposes a significant concession, and is genuinely interested in getting the contract, then it is only natural for the counterpart to reciprocate. This is one reason why buyers accept outcomes (lower profit) in the multi-bilateral negotiations, which are lower than in auctions.

Participants of our negotiation experiments play roles of buyers and sellers; they perform and interact with others. They may also discuss other issues (e.g., their interests, weather, and universities). The negotiations are anonymous at the outset, but the participants can exchange any information. Participants' discussions may have a subjective value for them. A person may not know her counterpart but during the ten-day long interaction may develop some affinity to him, which can lead her to make a bigger concession than she would have made if she felt animosity. This particular motivation for concession-making can be related to the experimental settings, however, in real-life situations we also observe parties trading off some substantive values in an effort to achieve higher relational values. In some job markets, for example, the employers engage in multi-bilateral negotiations with several potential candidates in order to determine their trustworthiness, fit to the position and the team, as well as professional skills. If they need to determine skills only, then auction often is the preferred mechanism (Schram et al., 2010). This implies that reciprocity need not be a "trivial byproduct" but a set of complex rules which are invoked when the negotiators realize the potential of achieving important relational outcomes.

Relational outcomes are inherently social and they can be achieved in negotiations. However, they cannot be achieved in auctions in which bid-makers do not interact with one another. This shortcoming of auctions has been recognized and led to augmentation of auction protocols, e.g., with post-auction negotiation in buyer-determined auctions (Engelbrecht-Wiggans et al., 2007).

While non-augmented auctions cannot produce relational outcomes, they can produce game-like outcomes, such as excitement (Adam et al., 2013). Auctions produce winners and losers, the outcome is a win or loss, which can be contrasted with agreement or disagreement achieved through negotiation.

The results discussed here are tentative and more work is required to validate them. They confirm theoretical results that auctions produce better substantive outcomes for bid-takers who decide on the exchange mechanism. The assumption is, however, that the bid-takers are not interested in any other outcomes, relational in particular. The results also point to the necessity to study communication between negotiators. Messages affect offers; if they are ignored then the changes in offers (concessions) cannot be explained.

The data obtained from verifiable and non-verifiable negotiation experiments is inconclusive; the differences in the buyers' and sellers' profit values are not significant. However, this difference is observable and therefore it may suggest that transparency is better for buyers but not necessarily for the sellers (Table 2). Because transparency has been found to have positive effect on trust and other relational outcomes (Hultman and Axelsson, 2007), in some situations verifiable-offer negotiations may be preferred over both auctions and non-verifiable negotiations.

Acknowledgments. We thank Dmitry Gimon for his help in data preparation. This work has been supported by the grants from the Natural Sciences and Engineering Research Council of Canada (NSERC), Carleton University, and Concordia University.

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# Information levels in additive group decision models under incomplete information: Bridging the cardinalordinal gap

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Keywords: Group utility; incomplete information; preference information; computational study

In the literature, several models for group decision making based on the additive aggregation of group members' utility or value functions have been proposed (Keeney and Kirkwood 1975; Dyer and Sarin 1979; Keeney and Nau 2011). These group aggregation rules usually are based on systems of axioms very similar to those formulated by Arrow (1963) for the case of aggregating ordinal preferences. In contrast to aggregation of ordinal preferences, aggregation of cardinal alues is thus possible in groups. However, it requires group members to specify their preferences in cardinal form, by assigning utility scores to alternatives. This could be difficult for group members, in particular if this information should be provided exactly.

Methods for decision making under incomplete information, which have already been suggested in the context of negotiation problems (Sarabando, Dias et al. 2012), could be employed to simplify this task for group members. They would actually allow information to be specified also only in ordinal form (i.e. as a ranking of alternatives), although this information could then be used to approximate a cardinal utility function. This concept can be applied at various levels along the spectrum between purely cardinal and purely ordinal information, for example, group members could also specify preference information not only as a ranking of alternatives, but also as a ranking of differences of alternatives, which would be one step closer to cardinal information. While it is obvious that providing information closer to exact cardinal utility values will increase the precision of preference statements at the group level, the strength of this effect is not clear.

Uncertainty about parameters of preference functions does not only concern the individual member's preference function. At the group aggregation level, weights of group members can also be considered as uncertain parameters. In a recent paper, Dias and Sarabando (2012) extended Arrow's non-dictatorship condition to the aggregation of cardinal preferences and showed that it can be represented as a constraint on weights of group member in an additive group utility function

In this paper, we report on a comprehensive computational study, in which we attempted to quantify the effect of providing different levels of preference information (exact cardinal values, rankings of differences between alternatives and rankings of alternatives), and of the imposition of different constraints on members' weights in an additive group utility function (equal weights, general random weights and random weights satisfying the Non-dictatorship condition) on outcomes at the group level. Relevant outcome dimensions analyzed refer to the structure of the group preference relation, building on concepts like necessary and possible relations as established in decision making under incomplete information (Dias and Clímaco 2002; Greco, Mousseau et al. 2008); as well as robustness of results, and the strength of impact of individual group members.

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# Incorporating Intertemporal Preferences in Electronic Negotiations for Computing Services: A Mechanism and Analysis

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**Abstract**: Literature on electronic negotiations traditionally provided the means to handle decreasing utility with reference to negotiation deadline. Delivery time differs from negotiation deadline in advance reservations, for example in the case of computing services. But, extant decision functions in multiattribute negotiations treat utility of issues as independent from delivery time and do not use empirically validated discount functions. Hence, such functions do not adequately represent certain behavioral aspects. To this effect, we propose a discounted utility function to capture the effect of delivery time. The hyperbolic discount function proposed from theory on Intertemporal choice explains a particular behavioral aspect known as decreasing impatience. In line with combined approaches for negotiation, we analyze the interactions between time discounting and concession functions using 324000 simulations.

Keywords: Electronic negotiations, Intertemporal choice, Utility computing, Trade-offs

## Introduction

Utility computing provides computing services on a subscription basis just like telephone, water, gas or electricity services. Advances in information and communication technologies have made this model viable and affordable. Industry reports estimate the revenues of cloud computing market, a form of utility computing to be around \$148.8 Bn by the year 2014. Cloud computing offers several advantages to consumers like the reduced operating costs, flexible provisioning and the improved ability to meet peak demands (Armbrust et al., 2010). Researchers have advocated the use of electronic markets incorporating auction and negotiation models, in the exchange of cloud services (Buyya et al, 2009). From the perspective of electronic negotiations, literature urges the need to consider behavioral aspects like goal setting, situation power, trade-offs, preferences and prejudices (Bichler et al., 2003; Luo et al., 2006; Kersten et al., 2008; Sundarraj and Mok, 2011). A behavioral aspect in the context of cloud computing, that needs to be modeled in electronic negotiations is the trade-offs in the choice of alternatives over time. For example, a consumer would face several choices that differ in both, price and delivery time such as \$10 for 5 hours, \$11 for 4 hours and \$12 for 2 hours and is indifferent. Such Intertemporal choices reveal several behavioral anomalies; one such anomaly is decreasing impatience, which is modeled using hyperbolic time discount functions (Loewenstein and Prelec, 1992). While the notion of discounting with respect of delivery time is acknowledged in the electronic negotiations literature (e.g., Fatima et al., 2004), discussion on the discount function is not available.

The contributions of this paper are three fold. First, we provide a utility function that incorporates the discounting effects of delivery time on price. Second, we use the hyperbolic discount function to generate price and delivery time trade-offs. Third, following approaches in negotiation literature (Ros and Sierra, 2006; Lai et al., 2006), we model a buyer-seller negotiation that combines trade-off and concession tactics. We experimentally analyze 324000 exchanges to study interactions between two discounting models (hyperbolic and exponential) that are empirically proven in intertemporal choice studies and a range of concession models (boulware, linear and conceder) that have been put forth in the literature (Faratin et al., 1998).

The organization of the paper is as follows. Section 2, provides a review of electronic negotiations behavioral perspective. Section 3, provides an overview of literature on Intertemporal choice. We propose a utility function that incorporates effect of time discounting in section 4. In section 5, we provide the negotiation mechanism used in our approach. In section 6, we discuss the experimental set up for simulated negotiations and present the results. This is followed by a discussion and implications of our work in section 7. Conclusions and scope for future work are presented in the last section.

## **Electronic Negotiations and Behavioral aspects**

Electronic negotiation systems (ENS) facilitate (email and video conferencing systems), support (negotiation and decision support systems) and/or automate activities (negotiation software agents) undertaken by the negotiators and/or a third party (Kersten and Lai, 2007). In the process of negotiation, negotiating agents follow a protocol that specifies the rules of interaction and strategy that specifies the set of actions (Lomuscio et al., 2001). Together, the negotiation protocol and strategy provides the agent, the "the capacity to interact" and the "capacity to represent and reason" respectively (Faratin et al., 1998). Negotiation strategies can be broadly classified as responsive or deliberative (Faratin et al., 1999). Examples of responsive strategies include time-dependent (Faratin et al., 1998) and market dependent strategies (Sim, 2002). Responsive tactics try to achieve success by providing concessions, making the offer more attractive to the opponent. On the other hand, deliberative tactics try to improve the negotiation outcomes by exploiting trade-offs among issues (ex: price and service time). Trade-off makes an offer more attractive to the opponent, without compromising the utility to the offering agent (Faratin et al., 2002). As research progressed, strategies to combine responsive and deliberative mechanisms were proposed (Ros and Sierra, 2006), in order to help negotiating agents in making an offer, a counter-offer or in evaluating an offer.

As pointed by Kersten et al. (2007), however, the "principal's" (i.e., human) characteristics or preferences must be considered by the negotiation system in order to be perceived as useful. On similar lines, Bichler et al. (2003) had argued that negotiation systems did not shown sufficient concern for user's needs and expectations. Similar concerns were expressed by Luo et al. (2006), who provided a method for acquiring user trade-off strategies and preferences. Sundarraj and Mok (2011) provided models for electronic negotiations to consider human elements like goal and situational power.

While these works are important, they do not consider the behavioral aspects involved in the trade-off between price and time. The notion of discounted utility was considered by Fatima et al. (2004), where utility of a negotiation issue was discounted as a function of time. But it is unclear, as to what underlying discount function was assumed. The constant discount function (Samuelson, 1937), which is simple mathematically, cannot represent certain behavioral aspects as seen in next section. The theme of this paper is based on a certain human aspect, namely the decision-making behavior, while making choices over time. Research on intertemporal choice (next section) offers certain functions which can model price and delivery time trade-offs. Price and Time trade-off is especially important in negotiations for grid or cloud services, where there is inherent conflict between the consumer and service provider over the allocation of a particular computing resource. Sample literature on price and delivery time trade-off in the context of grid, cloud or a web service include (Son and Sim, 2012; Yan et al., 2007; Zulkernine and Martin, 2011).

While there is need to incorporate a discount function that can accommodate behavioral aspects, studies that focused on trade-offs in negotiation literature either assumed a specific utility function (Luo et al., 2006; Son and Sim, 2002; Yan et al., 2007) or were not specific to negotiation attribute(s) for example say price and time (Faratin et al., 2002; Lai et al., 2006). The studies that incorporated price and time-tradeoff do not consider any underlying behavioral theory, and hence the models employed cannot be generalized. In an earlier work, a basic approach to combine hyperbolic model with concession tactic was proposed; however suitable utility function were not identified (Venkataraghavan and Sundarraj, 2012). We try to overcome these gaps, by using trade-off functions from literature on Intertemporal choice and adapt an existing utility function to incorporate the effect of discounting based on delivery time.

#### Intertemporal Preference and Discounting

Intertemporal choice is the decision involving trade-offs between time and cost or benefits. Frederick et al., (2002) listed several factors such as benevolent motives, self-restraint, desire for accumulation and the consequent discomfort in deferral, utility from anticipation of future consumption, abstinence as reasons for that would affect the utility of consumption at a future point in time. While most early work was on psychological aspects of discounted utility, a tractable economic model to explain intertemporal choice was first proposed by Samuelson (1937). The model was simplistic and amalgamated all these factors into a single time discounting fraction using an exponential discounting function. The exponential discount function, describes as to how the utility of an issue decrease with time. Using the discounted utility model, one may identify option pairs that offer equal utility to an individual. For example, using exponential discounting it is easy to identify that \$100 today offers the same utility as \$110 in an years' time (r = 0.1).

While, the early exponential discounting model was simple and convenient to use, it failed to explain a behavioral anomaly associated with preference over time. The anomaly is the non-stationarity or nonconstancy of time preference (Loewenstein and Prelec, 1992). Stationarity means that, preference over two delayed choices does not change if the delays are incremented by a constant amount. However, time preference is not stationary and is observed to switch when incremented by a constant delay (Thaler, 1981).Thaler, (1981) describes this inconsistency crisply: "a person might prefer one apple today to two apples tomorrow, but at the same time prefer two apples in 51days to one apple in 50 days". Loewenstein and Prelec (1992) proposed a generalized hyperbolic discounting function that is capable of handling this inconsistency. The difference between the two models is that, unlike exponential discounting, the ratio of discounting fraction is not constant between any two time periods in hyperbolic discounting.

Extending this argument to the context of procuring cloud services, the trade-off between price and time need not be constant and could change with time. A person who might prefer a pay higher for a service in 10 hours over 12 hours may not pay higher for a service in 20 hours over 22 hours (i.e., when the delays are offset by 10 hours each). Hyperbolic discount function is adept in handling this behavioral anomaly, where consumers exhibit a decreasing impatience with time. Decreasing impatience has been studied and established in a wide-range of contexts like durables. health, money, coupons, addiction, pain and life expectancy, a detailed note on which is seen in Frederick et al., (2002). We thus propose to use hyperbolic discount the utility of cloud-service over time and the other to generate price and delivery time trade-offs. We adapt an existing utility function to incorporate discounting effect of delivery time as described in the next section.

$$\varphi(\mathbf{d}) = (1 + \alpha \mathbf{d})^{-\beta/\alpha}, \qquad \alpha, \beta > 0 \tag{1}$$

Where  $\varphi(d)$  represents the discount factor at delivery time d.  $\alpha$ ,  $\beta$  are parameters of the hyperbolic discount equation that determine the convexity and departure from a constant discount function

#### **Discounted Utility Negotiation**

In this section, we discuss a popular utility function from literature on electronic negotiations, followed by our adaptation incorporate discounting effect of delivery time. This is followed by an illustrative example. Faratin et al., (1998) defined a scoring function to evaluate a multi-dimensional contract in their work of decision functions for negotiations. The additive scoring function V(x) for a negotiation agentdescribed in their work is as shown in eqn (1).

$$V(x) = \sum_{i \le j \le n} w_j V_j(x) \tag{2}$$

Where  $\mathbf{x} = (\mathbf{x}_1, \mathbf{x}_2, ..., \mathbf{x}_n)$  form the set of negotiation issues for the agent, and  $w_j$  is the importance of issue j. The weights of the agents are normalized and  $\sum_{i \le j \le n} w_j = 1$ . In turn, the utility of a particular issue (for ex: price)  $V_{price}(\mathbf{x}_{price})$  of a buying agent was modeled as a linear function as shown in eqn (2).

$$V_{price}(\mathbf{x}_{price}) = \frac{max_{price} - x_{price}}{max_{price} - min_{price}}$$
(3)

Where  $x_{price}$  is price level of the offer being considered and the  $[max_{price}, min_{price}]$  form the reservation level for price. The function used in eqn (3) is a linear function and does not incorporate the effect of delivery time on price. Later, Fatima et al., (2004), incorporated the effect of negotiation deadline on the utility of a particular issue as shown in eqn (4).

$$V_{price}(x_{price}, t) = V_{price}(x_{price}) \cdot (\varphi)^{t}$$
(4)

where  $(\varphi)^t$  stands for the discount factor of buyer agent a negotiation time  $t \in [1, T]$ , T being the negotiation deadline. We argue that while, this function is useful in evaluating the utility of an issue at any time t within the negotiation deadline, it falls short of addressing the problem where the utility of an issue is discounted with reference to delivery time. One may counter-argue that  $(\varphi)^t$  in eqn (4) be replaced by

 $\varphi(d)$  where  $d \in [D^{min}, D^{max}]$  represents the delivery time of the offer in consideration and  $D^{max}$  represents the reservation time for delivery. While such an argument holds true where preferences of *price* is independent of the *delivery time*, it does not hold true in scenarios where preferences of *price* is not independent of time.

In the scenario, wherein the utility of a bundle is determined by the price which is *not independent* of *delivery time*, we propose the function shown in eqn (5). Our function provides the utility of an offer for a particular price  $x_{price}$  and *delivery time*  $d \in [D^{min}, D^{max}]$ . Let  $max_{price}, min_{price}$  be the maximum and minimum price, the buyer agent **a** is willing to pay for  $D^{min}$ . Then for any *delivery time*  $d \in [D^{min}, D^{max}]$ , the maximum and minimum price, the buyer agenta, would be willing to pay is given by  $max_{price}.(\varphi)^d$  and  $min_{price}.(\varphi)^d$ . The minimum price, the buyer is willing to pay for a specific *delivery time* is gradually conceded during the progress of negotiation. The concession on minimum price and subsequently the offer price may be determined using any negotiation deadline based concession function discussed in Faratin et al., (1998). The discounted price adopted in a round *t* of negotiation is given in eqn. (6)

$$V_{offer}(x_{price}, d) = \frac{max_{price}(\phi)^d - x_{price}}{max_{price}(\phi)^d - min_{price}(\phi)^d}$$
(5)

The discount factor  $\varphi(\mathbf{d})$  at *delivery time*  $\mathbf{d} \in [D^{min}, D^{max}]$  is generated using the hyperbolic discounting function in eqn (1), the theory of which is described in the previous section. We use the generalized hyperbolic discounting function shown in eqn (1).

$$x_{price}^{t,d} = min_{price} \cdot (\varphi)^d + \left(max_{price} \cdot (\varphi)^d - min_{price} \cdot (\varphi)^d\right) \left(k + (1-k)\left(\frac{min(t,T)}{T}\right)^{1/\beta}\right)$$
(6)

We illustrate the application of hyperbolic discounting function to calculate the discounted utility using eqn (5) of a bundle with *delivery time* dependent price attribute using example 1. We also illustrate the generation of isoutility offers using hyperbolic discounting in the example. We acknowledge the fact, that there are methods such as random-offer generation discussed in Son and Sim, (2012). Further, we do not incorporate any similarity criteria method (Faratin et al, 2002) that would enhance the acceptability of bundle offered by one agent to another. We use example 2 to calculate discounted utility using eqn (4). The two examples highlight the differences between eqn (4) and eqn (5).

#### Example 1 - Price dependent on Delivery Time

Let us assume that following data is provided by the buyer. Buyer delivery time is in the range  $[D^{min}, D^{max}]$ . The minimum  $min_{price}$  and maximum price  $max_{price}$  at  $D^{min}$  is known. Deadline for negotiation is T. The parameters  $\alpha$ ,  $\beta$  of the hyperbolic discounting function representing the buyers' preference is known.

#### Algorithm:

- 1. Decide the number of offers along with delivery time to be proposed.
- 2. Calculate the discount fraction  $\varphi(d)$  for with each offer based on the delivery time using eqn (1)
- 3. Calculate the maximum and minimum price range for each offer: maximum price for given time- offer is  $max_{price}$ .  $(\phi)^d$  and minimum price is  $max_{price}$ .  $(\phi)^d$ .
- 4. In any given round of negotiation, the price to be offered is found using eqn (6).
- 5. The utility of an offer is calculated using eqn (5).

Negotiation Round	Offer 1	Offer 2	Offer 3	Offer 4	Offer 5
	d = 2 hours	d = 4 hours	d = 6 hours	d = 8 hours	d = 10 hours
	$(\phi)^d = 0.93$	$(\varphi)^d = 0.87$	$(\phi)^{d} = 0.83$	$(\phi)^d = 0.81$	$(\phi)^{d} = 0.79$
$max_{price}.(\phi)^d$	\$9.33	\$8.71	\$8.36	\$8.12	\$7.94
$min_{price}.(\phi)^d$	\$7.46	\$6.96	\$6.69	\$6.50	\$6.35
Round 1 <i>x<sub>price</sub></i>	\$7.46	\$6.96	\$6.69	<b>\$6.5</b> 0	\$6.35
$V_{price}(x_{price}, d)$	1.00	1.00	1.00	1.00	1.00
Round 2 <i>x<sub>price</sub></i>	\$7.93	\$7.40	\$7.11	\$6.90	\$6.75
$V_{price}(x_{price}, d)$	0.75	0.75	0.75	0.75	0.75
Round 3 $x_{price}$	\$8.40	\$7.83	\$7.52	\$7.31	\$7.15
$V_{price}(x_{price}, d)$	0.50	0.50	0.50	0.50	0.50
Round 4 $x_{price}$	\$8.86	\$8.27	\$7.94	\$7.72	\$7.55
$V_{price}(x_{price}, d)$	0.25	0.25	0.25	0.25	0.25
Round 5 $x_{price}$	\$9.33	\$8.71	\$8.36	\$8.12	\$7.94
$V_{price}(x_{price}$ , $d)$	0.00	0.00	0.00	0.00	0.00

Table 2: Offer price, Delivery time and Offer Utility across negotiation rounds

We illustrate the calculation of discounted utility of price using an example. Let the buyer's *delivery time* be  $d \in [1,10 \ hours]$ . Assume that the buyer is willing to pay a maximum price of \$10 for 1 hour and minimum price of \$8 for 1 hour. So  $max_{price} = $10$  and  $min_{price} = $7 @ d = 1 \ hour$ . Let the parameters of the hyperbolic discounting function representing the buyer behavior be  $\alpha = 1, \beta = 0.1$ . Let the deadline for negotiation be T=5. For sake of convenience, we assume that 5 offers are proposed in every round of negotiation with a fixed *delivery time* of 2,4,6,8 and 10 Hours. In our example, we assume k = 0 and  $\beta = 1$  to model a linear concession. The discount factor  $(\varphi)^d$  at d = 2,4,6,8 and 10 Hours using *step 1* of algorithm is found to 0.93, 0.87, 0.83, 0.81 and 0.79 respectively. Knowing  $(\varphi)^d$  the maximum and minimum price the buyer is willing to pay for a particular *delivery time d*, calculated using *step 3* is found to be (\$9.33,\$7.46), (\$8.71,\$6.96), (\$8.36,\$6.69), (\$8.12,\$6.50), (\$7.94,\$6.35) respectively. The offer price for each offer at a round  $t \in [1, T]$  is then calculated using a negotiation decision function using *step 4*. The utility for various offers across each round is calculated using eqn (4) *step 5* of algorithm. Table 1 provides the discount rate, offer price, offer time and offer utility for 5 different *delivery time and price* combinations across 5 rounds of negotiation. For the purpose of comparison with example 2, let us note the utility of the offer (10 hours, \$6.75) from Table 1 (shaded for reference). The utility of the offer is 0.75.

#### Example 2 - Price independent on Delivery Time

Let us assume that buyer provides a delivery time in the range of  $d \in [1,10 hours]$ . The price range is [\$8, \$10] and the maximum number of rounds in negotiation is 5. Let us assume that negotiation settles in second round and concession is linear in case of delivery time as well as price. The price in the offer would be \$8.5 and delivery time would be 4 hours using linear concession, assuming delivery time offered in round 1 was 2 hours. Assume discount factor be 0.79 (maintain parity with example 1) calculated using an exponential discounting function at time t = 8.5 for some r. The utility of price in this case, calculated using eqn 4 is Utility = ((10-8.5) / (10-8))\*0.79 = 0.5925.

The examples reiterate that discounted utility calculated in cases where price is dependent on delivery time (example 1) is different from the case where it is independent of time (example 2). In this section we have provided a discounted utility function in eqn (5) which is suitable in cases where price is dependent on delivery time. Further, we also illustrated the application of hyperbolic discounting in generating offers of isoutility.

# **Negotiation Mechanism**

In the previous section, we introduced a function in eqn. (4) that is capable of handling discounted utility of price with respect to delivery time. In our approach, we integrate *delivery time* trade-offs and *concession based* negotiation models using the combined approach prescribed by Ros and Sierra (2006). While, they proposed a mechanism with *smart trade-off tactic*, our addition to literature is the use of a discount function namely *hyperbolic discounting* from the theory of Intertemporal choice, to capture the discounting effect and to generate price and delivery time trade-offs. In terms of application, the combined strategy approach was proposed as a mechanism in trading cloud computing service by Son and Sim (2012). However, trade-off between price and time-slot discussed in their approach was derived using an additive function, which might rarely reflect a consumer behavior. A brief outline of the combined approach prescribed in Ros and Sierra (2006) adapted here to include hyperbolic discounting is presented below.

- 1. While negotiation deadline is not reached, agent 'a' proposes iso-utility offers, attributes of which are *delivery time* and *corresponding price*. Iso-utility offers are generated using hyperbolic discounting tactic.
- 2. If offer is not accepted by agent b, agent b proposes a counter-offer(s).
- 3. If the counter-offer(s) are not acceptable, agent 'a' proposes a new set of iso-utility offers after conceding utility through time-dependent tactics.
- 4. Agent b accepts or proposes new set of counter-offer(s).
- 5. If agreement or negotiation deadline is reached, terminate process. Else, go to step 3.

We have proposed a combined strategy with a new discounting function, which is useful in generating tradeoffs as well. As is the case with any combined strategy, the negotiation outcome is affected by trade-off as well concession function. This leads us to the following questions in a system of two agents, a & b.

- 1. What is the effect of an agent *a*'s discounting behavior on the utility of the agent *b*?
- 2. Given a particular discounting behavior of an agent '*a*', which conceding strategy of agent *b* offers the best utility to agent *b*?

We try to answer these questions through simulation based experiments in the next section.

# **Experimental Set-up and Simulations**

In order to answer questions discussed above, a single buyer and seller agent system was considered and simulations, representing several different negotiation contexts were performed. Table 2, provides a summary of the negotiation contexts that were modeled. The choice of data for simulations closely follows and expands upon those used in Deveaux and Paraschiv (2001) and later adapted in Sundarraj and Shi (2012). We used new additional inputs as required, for example the parameters of the discounting function. The simulation was designed as a factorial experiment. The factors were concession behavior, discounting behavior, maximum and minimum delivery time and maximum and minimum price at minimum delivery time. Discounting behavior was modeled using exponential and hyperbolic functions with three levels each. Similarly concession behavior was modeled using three levels, covering a wide-range of conceding, linear and boulware strategies. This yielded 324 unique combinations (6 x 6 Discounting modes and 3 x 3 Concession modes). A total of 324000 data-sets (1000 random sets per unique combination) were used in simulating a bilateral negotiation between seller and buyer using the combined negotiation mechanism discussed in previous section. Maximum number of negotiation rounds was set at 10 for buyer as well the

seller. Table 2, provides the summary of experimental data. The aggregated result of the experiment from the perspective of seller agent is presented in Table 3. Please note, in our representation of utility, it is not restricted to upper bound of 1.0.

Parameter	Unit	Buyer	Seller	Distribution
Delivery time and Price				
Max Delivery Range	Hours	[11,20]	[11,20]	Uniform
Min Delivery Range	Hours	[0,10]	[0,10]	Uniform
Max Price at Min Del. Time	\$	[300,600]	[300,600]	Uniform
Min Price at Min Del. Time	\$	[100, 250]	[100, 250]	Uniform
Discounting Behavior				
Function		Hyperbolic, Exponential	Hyperbolic, Exponential	
Hyperbolic Parameters		$\beta = 0.1$	$\beta = 0.1$	
	$\alpha^{low} = [1.00-3.00]  \alpha^{low} =$		$\alpha^{\text{low}}$ =[1.00-3.00] $\alpha^{\text{med}}$ =[4.00-	Uniform
		α <sup>med</sup> =[4.00-8.00]	8.00] $\alpha^{\text{high}} = [10.0-30.0]$	Uniform
		$\alpha^{high} = [10.0-30.0]$		Uniform
Exponential Parameters		$r^{low} = [0.01 - 0.08]$	$r^{low} = [0.01-0.08]$	Uniform
		$\mathbf{r}^{\text{med}} = [0.10 - 0.15]$	$\mathbf{r}^{\text{med}} = [0.10 - 0.15]$	Uniform
		$\mathbf{r}^{\text{high}} = [0.20 - 0.30]$	$\mathbf{r}^{\text{high}} = [0.20 - 0.30]$	Uniform
Concession Behavior				
Function		Polynomial	Polynomial	
Parameters		k = 0	<b>k</b> =0	
		$\beta^{Boulware} = [0.10-0.80]$	$\beta^{\text{Boulware}}=[0.10-0.80]$	Uniform
		$\beta^{\text{Linear}} = [0.81 - 1.20]$ $\beta^{\text{Conceder}} = [1, 21, 10, 0]$	$\beta^{\text{Linear}} = [0.81 - 1.20]$ $\beta^{\text{Conceder}} = [1, 21 - 10, 0]$	Uniform
		p = -[1.21-10.0]	p -[1.21-10.0]	Uniform
Round in Negotiation		10	10	

Table 2: Experimental Data for Negotiation Simulation

Buyer Time Preference and Concession Strategy											
			Exponential Discounting			Hyperbolic Discounting			Average U <sup>S</sup>		
			Boulware	Linear	Conceder	Average U <sup>SN</sup>	Boulware	Linear	Conceder	Average U <sup>SN</sup>	
e and sy		Boulware	1.40	1.78	3.31	2.17	1.71	2.16	3.86	2.58	
Preferenc on Strateg sponential scounting	ential nting	Linear	1.35	1.69	3.23	2.09	1.59	2.04	3.82	2.48	2 29
	xpone iscou	Conceder	1.19	1.48	3.29	1.99	1.51	1.89	3.91	2.44	2.2)
Time	ШО	Average U <sup>SE_B</sup>	1.32	1.65	3.28	2.08	1.60	2.03	3.86	2.50	
eller Coi		Boulware	0.82	1.09	1.96	1.29	0.87	1.12	2.01	1.33	
Ň	olic ating	Linear	0.65	0.93	1.91	1.17	0.71	0.98	2.00	1.23	1 20
Hypert	yperl	Conceder	0.55	0.75	1.87	1.06	0.60	0.79	1.99	1.13	1.20
	Η̈́́́	Average U <sup>SH_B</sup>	0.67	0.92	1.91	1.17	0.73	0.96	2.00	1.23	
		Average U <sup>S</sup>		1.	62			1.	86		1.74

Table 3: Seller's Utility Matrix

Table 3, provides the average utility received by the seller, when the seller adopts a particular concession strategy across his time preferences (discounting behavior) that could be constant (exponential discounting) or decreasing (hyperbolic discounting). First, we try to answer question 1 posed in the previous section. It is evident from Table 3 that the buyer's time preference behavior affects seller's utility. For example, when the buyer exhibits an exponential discounting behavior, the seller's average utility is 1.62. However, seller's utility increases to 1.86, when the buyer exhibits a hyperbolic discounting behavior. The improvement in utility for the seller could be attributed to the nature of hyperbolic discounting behavior. In hyperbolic discounting, the discount rate decreases sharply in intial rounds of negotiation when compared to later rounds. The results follow the same trend when the seller exhibits hyperbolic discounting. Utility received a by exponentially discounting seller (2.29) is higher than a seller with hyperbolic discounting behavior (1.20). The findings are supported by statistical tests, shown in table 5.

While it is clear that, time preference of buyer affects the utility of seller, the second question we posed was if it is possible for the seller to improve his utility, given the time preference nature of the buyer? In table 4, Average USN provides the average utility of seller for a particular concession strategy across various time preferences of the buyer. For example, utility is 1.84 vs. 1.65 when the seller adopts a boulware vs. conceding strategy. It is also evident from table 4 that boulware strategy is the dominant concession strategy irrespective of the buyer's time preference. Statistical tests in table 5, support these findings. Assuming that adaptive strategies are not employed by the buyer i.e. the buyer does not adopt different concession strategy irrespective of his buyer's time preference in situations that closely resemble studied conditions.

		Buyer Time Preference	;	
		Exponential	Hyperbolic	Average U <sup>SN</sup>
	Boulware	1.72	1.95	1.84
Seller Concession Tactic	Linear	1.62	1.85	1.74
	Conceder	1.52	1.78	1.65
	Average U <sup>S</sup>	1.62	1.86	1.74

Table 4: Seller's Concession Tactics and Utility

Hypothesis (Useller   Case I vs. Useller   Case II)	USeller   Case I	USeller   Case II	P-Value (0.01)
USeller   BHyp > USeller   BExp	1.86	1.62	0.000
$UExp\_Seller \mid BHyp > UExp\_Seller \mid BExp$	2.50	2.08	0.000
UHyp_Seller   BHyp > UHyp_Seller   BExp	1.23	1.17	0.000
UExp_Seller   BExp > UHyp_Seller   BHxp	2.08	1.23	0.000
UExp_Seller   BHyp > UHyp_Seller   BExp	2.50	1.17	0.000
USeller   SExp > USeller   SHyp	2.29	1.20	0.000
USeller   Boulware > USeller   Linear	1.84	1.74	0.000
USeller   Linear > USeller   Conceder	1.74	1.65	0.000
USeller   Boulware > USeller   Conceder	1.84	1.65	0.000
	Hypothesis (Useller   Case I vs. Useller   Case II) USeller   BHyp > USeller   BExp UExp_Seller   BHyp > UExp_Seller   BExp UHyp_Seller   BHyp > UHyp_Seller   BExp UExp_Seller   BExp > UHyp_Seller   BHxp UExp_Seller   BHyp > UHyp_Seller   BExp USeller   SExp > USeller   SHyp USeller   Boulware > USeller   Linear USeller   Linear > USeller   Conceder USeller   Boulware > USeller   Conceder	Hypothesis (Useller   Case I vs. Useller   Case II)USeller   Case IUSeller   BHyp > USeller   BExp $1.86$ UExp_Seller   BHyp > UExp_Seller   BExp $2.50$ UHyp_Seller   BHyp > UHyp_Seller   BExp $1.23$ UExp_Seller   BExp > UHyp_Seller   BHxp $2.08$ UExp_Seller   BHyp > UHyp_Seller   BExp $2.50$ USeller   SExp > UHyp_Seller   BExp $2.29$ USeller   Boulware > USeller   Linear $1.84$ USeller   Linear > USeller   Conceder $1.74$ USeller   Boulware > USeller   Conceder $1.84$	Hypothesis (Useller   Case I vs. Useller   Case II)USeller   Case IUSeller   Case IIUSeller   BHyp > USeller   BExp $1.86$ $1.62$ UExp_Seller   BHyp > UExp_Seller   BExp $2.50$ $2.08$ UHyp_Seller   BHyp > UHyp_Seller   BExp $1.23$ $1.17$ UExp_Seller   BExp > UHyp_Seller   BHxp $2.08$ $1.23$ UExp_Seller   BHyp > UHyp_Seller   BExp $2.08$ $1.23$ UExp_Seller   BHyp > UHyp_Seller   BExp $2.50$ $1.17$ USeller   SExp > USeller   SHyp $2.29$ $1.20$ USeller   Boulware > USeller   Linear $1.84$ $1.74$ USeller   Linear > USeller   Conceder $1.84$ $1.65$

**Table 5:** Summary of Statistical Analysis

## **Discussion and Implications**

Our proposal to incorporate hyperbolic discounting serves two objectives. One, it provides a method to incorporate time preferences and evaluate utility. Second, it may be used to generate price and delivery time trade-offs. In our paper, we have proposed a non-additive function (eqn 5) to calculate the utility of an offer, where an attribute namely price is dependent on another attribute namely delivery time. The utility of an offer can be calculated, if discounting function of a consumer is known. We have used a combined strategy approach (Ros and Sierra, 2006) to model the negotiation event. As shown in figure 1, the discounting function (exponential or hyperbolic) determines the combinations of price and delivery time that offer isoutility in any round of negotiation. The drop in utility conceded by an agent is decided by the concession function used in negotiation. The advantage of value function described in the paper is in that it serves two purposes namely calculation of utility and identification of trade-offs. However estimating the parameters of the discount function is a non-trivial task. Further, exploring utility space in characterized by non-additive functions is computationally complex. As part of future work, we intend to look into possible additive transformations in literature (Clemen, 1996; Keeney and Raiffa, 2003). On the benefits to sellers, the experimental results suggest that sellers derive more benefit while negotiating with impatient consumers (hyperbolic discounting behavior). One plausible implication is that in a market, dominated by such consumers, seller agents can benefit by not conceding on price as much as they would in case of patient consumers (refer table 4). Tomak and Keskin (2008) theoretically established that monopolists can benefit from pricing higher in markets with present-biased consumers. However, their work is restricted to a twoperiod model in monopolistic setting in presence of network externalities.

Incorporation of hyperbolic models would increase the acceptability of negotiation support systems; as such models are more representative of consumer behavior. Researchers in the past (Kersten et al., 2007; Bichler et al., 2003, Luo et al., 2006; Sundarraj and Mok, 2011) have called for development of models reflecting facets of human aspects. Time preference functions can be readily integrated into existing approaches that try improve the negotiation outcome like the combined strategy approach proposed by (Ros and Sierra, 2006). Electronic negotiations for cloud (Son and Sim, 2012; Sim, 2010) including those using non-additive functions (Macias and Guitart, 2010) or web-services (Yan et al., 2007) with possibility of delivery time and

price trade-offs are prime candidates where time discounting functions could be used. Our utility model can be incorporated into electronic exchanges for trading cloud services, where conflicts on time between buyers and service providers are inherent (Buyya et al., 2009). Other potential areas for time- preference functions based electronic negotiation is e-commerce that involve decision making on choices over time, like in the case of purchase of music CD's(Hantula, 2005).



Figure 1: Iso-Utility Curves of a buyer across rounds of negotiation

#### Conclusions, limitations and Future Scope

Traditionally, models for negotiation incorporated effect of negotiation deadline on the utility of an issue. In this paper, we proposed a utility function to capture the effect of delivery time on a negotiation issue, namely price. In order to model the discounting effect, a hyperbolic discounting model that is widely used to model a consumer's devaluation of utility with time was proposed. In line with the combined strategy approach for negotiation, the application of hyperbolic time discounting model in conjunction with a concession model was described. Further, the approach was deployed in an experimental setup and the results of 324000 simulations were analyzed. Results in the studied context, indicate that utility of seller is higher in the context of contexts where consumer's exhibit hyperbolic discounting behavior. On limitations of this paper, while we generated trade-offs based on the hyperbolic discounting model, we did not explore similarity criteria (Faratin et al., 2002) approaches that could realize a joint gain for both the negotiation agents, adaptive strategies (Zulkernine and Martin, 2011) or learning approaches (Zeng and Sycara, 1998; Coehoorn and Jennings, 2004; Sundarraj and Shi, 2012) that can improve the outcome of an agent. Further, possibility of approximation of the non-additive value function has to be considered. In order to generalize the results, the studied has to be extended to situations with asymmetric preferences of buyer and seller. Preference elicitation mechanisms that could identify time discounting behavior as part of negotiation support systems could be a logical extension of our work.



Fig. 2. Global Cloud exchange and market infrastructure for trading services (Source: R. Buyya et al, 2009)

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# Multi-Actor Multidimensional Quality of Life and Sustainable Impact Assessment – Discussion Based on a New Interactive Tool

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Keywords: Multi-Actor, Multidimensional Assessment, Quality of Life, Sustainability

Measuring Quality of Life (QoL)/Sustainability requires a multidimensional evaluation, that includes various non-economic dimensions and there is incommensurability among them. Sustainability concerns are related to the effects of the present trends on the Quality of Life in the future (see [Munda 2008]).

In a former work [Clímaco and Craveirinha 2012] we have shown the reductive character of the scalar indices proposed in this context, suggesting a non-compensatory interactive system.

We discuss such system in the framework of the aggregation of several dimensions of Quality of Life/Sustainability showing its adequacy to the multi-actors case.

Reducing the multidimensional evaluation of objects to a scalar by recurring to aggregation procedures enables, the ranking of those objects, but it is our conviction that these procedures are reductive since, even in the cases where the used aggregation rules are technically acceptable, they involve a subjective character and often an ideological charge. So, the contents and the architecture of those indices are conditioned by the ideological/interest positions of the involved politic, economic and social actors.

In this regard, for example, [Stiglitz et al., 2009] discuss the necessity of statistic institutes making available data/results of adequate inquiries having in mind multi-methodological developments on the conceptualization and evaluation of QoL/Well-Being and Sustainability, aiming at replacing the mono-rationality of GDP by more accurate aggregate indicators and/or by the direct analysis of dashboards of multidimensional measures. The explicit consideration of multidimensional dashboards is the framework of our proposal.

In the last few years many International Institutions and Specialized Consulting Firms have proposed the use of interactive multidimensional dashboards, concerning Quality of Life and Sustainability Issues. Just as examples we refer to two of them.

The first example is the famous MDG – Millenium Development Goals - Dashboard of Sustainability. Details can be seen in http://esl.jrc.it/dc/ and http://en.wikipedia.org/wiki/Dashboard\_of\_Sustainability where the authors explain the popularity of the use of dashboards by NGOs and development practitioners, attested by a Google search for Millennium Development Goals indicators in 2008. The second example is the Sustainability Dashboard Tools , LLC, presented in (http://www.green2sustainable.com/) with the purpose of assisting organizations of all sizes with the challenges of sustainability reporting and help them in creating a culture of sustainability.

Our proposal considers explicitly a multidimensional dashboard, integrating an interactive aggregating tool in order to open options of analysis. However, we do not follow the mainstream aggregation frameworks using weighted sums of normalized data regarding the considered dimensions, as for instance the Quality of Life "BetterLife Index" proposed by OECD in 2011. As we shall explain later we opt by a noncompensatory tool thence avoiding the most negative aspects of the additive model.

The software of support to our proposal, [Clímaco et al., 2011], is based on an interactive implementation of the conjunctive method, enabling the consideration of up to three performance thresholds, having in mind to classify the objects under evaluation. The following figure enables presenting its interactive dashboard/control panel. In the top left a system of "elevator boxes" enables the fixation of thresholds for

the various dimensions. In the bottom one find the matrix of the objects under evaluation with the corresponding performance on each dimension/attribute. In general, dimensions, the evaluation of which is either quantitative or qualitative, are admitted.



Figure 1

On the right the profile, concerning the evaluated dimensions, of each object is presented in a radar graphic, indicating in bold the object currently visualized.

The fixation of each of the three thresholds which bound the four performance levels may be carried out through the "elevators" (on the left) or through the sliding controls over the radar graphic, on the right.

The representation of the thresholds in the radar graphic is made using colored broken ring, not filled for the thresholds "acceptable", "good" and "very good". The thresholds for "acceptable", in red, delimit a region which corresponds to unacceptable objects (also called reservation levels).

Since the implemented algorithm uses the conjunctive rule, the objects will appear with the following colors: red if at least one of the attributes of the object does not reach the reservation level; orange if every attribute satisfies the reservation level but at least one attribute does not reach the "good" threshold; yellow if every attribute satisfies the "good" threshold but at least one attribute does not reach the "very good" threshold and green if every attribute satisfies the "very good" threshold.

A version of the program, showing explicitly the choices of each actor, whenever adequate, is under construction. Note that a specific process may involve actors with power of decision exercised in interaction with others, such as advisers.

Through an interactive manipulation of the performance thresholds the actors may acquire knowledge about possible variations in the classification of the objects under evaluation, in face of the required levels for each attribute.

Firstly and since, in the case of the proposed methodology, there is no inter-criterion aggregation, there is no need to reduce the various evaluation dimensions into the same scale thereby avoiding all possible associated distortions which we have referred to above. Furthermore, the described aggregation process is non-compensatory thence avoiding the problem that a weak performance in one dimension may always be compensated by a strong performance in another dimension. Moreover, in our case, there is no need to assume additive independence among the various attributes, an adequate property because that is a requirement too strong in this context.

A practical study of the application of this tool regarding the evaluation of Green Economy in the State of Rio de Janeiro was carried out and its results will be reported in a paper in preparation [R. Valle and J. Clímaco, 2013]. Here two points can be emphasised, the usefulness of the tool and the difficulty in calibrating reference values for the thresholds concerning the dimensions under evaluation.

Now, we refer to specifically the multi-actors case emphasising some remarkable aspects.

Note that several of the involved dimensions are non-economic and there is incommensurability among them. This raises various problems. Firstly, there may not exist consensus among the actors on which dimensions should be considered. Secondly the comparison of these indicators corresponding to different countries is difficult because of cultural diversity and sometimes also because of technical reasons. Moreover, in general, the selection of dimensions to judge sustainability should involve multidisciplinary scientific actors, several political actors and social actors (including institutions and citizens). See in this respect [Rametsteiner, Pulz], Alkan-Olsson, Frederiksen, 2011]. The participation of citizens in this context is still insipient, but new approaches have been proposed for this type of purpose. See, for instance, a proposal of using Web-based indicators, in [Malcevschi, Marchini, Savini, Facchinetti, 2012].

It must be remembered that the system here proposed is a user oriented tool, very simple, both conceptually and operationally, it is supported by graphical representations, and has great flexibility of use, for instance, interactive experiences to adjust thresholds can be done. The inclusion, or exclusion of dimensions is also very simple and it can be done temporarily, just for testing. So, it seems adequate for processes involving, in some extent, negotiation among actors, where communication and interaction/learning are crucial issues. Building, or adjusting the evaluation dimensions can profit from a multi-actor simulation of the consequences of different options using this system. In complex problems we believe that this kind of tools are mostly adequate for training and not for prescription of solutions, involving qualitative elaborations beyond the formal models. In [Stagl, 2004], she tells: "We have to learn to live in a complex world with uncertainties and unclear future", and we believe that schematic open and interactive systems can be useful for training people for thinking better. Furthermore, the proposed system can be useful not only for training the actors when choosing the evaluation dimensions, but, once the model is built, to contribute for the quality of life/sustainability assessment. In [Valle and Clímaco, 2013] these issues are discussed for a practical case study. Moreover, there are dependencies among dimensions and so among the corresponding thresholds, for instance positive and negative synergies may occur, and when negotiation is involved, as Kersten tells [Kersten 2004]: "The interpersonal character, the participants independence as decision making entities and their interdependence in their inability to achieve goals unilaterally contribute to the negotiation complexity". Of course the computational tool will not be capable of fully incorporate these issues, which have features eminently qualitative, also involving subjective aspects. Nevertheless it can be quite helpful since we will be able of introducing, in background, linear constraints involving threshold variations, therefore creating limitations on their variation/fixation. This future development is being implemented. We believe that in a second phase experiences will lead to its validation and adjustment.

Another key issue in multi-actor sustainability assessment is that, further than bounded rationality, we are faced with meta-rational problems, in the sense used by E.Said and D.Barenboim who, in [E.Said and D.Barenboim, 2004], characterize the holist character of musical interpretations. Beyond the proposed classification method, our system provides a visual holistic view of the objects under study giving an important global feedback from the system to the actors contributing to a global perception of the sustainability phenomena. This holistic perception of dashboards helps in a cautious consideration of the precautionary principle, and, as Mabey, in [Mabey, 1998], tells: "The precautionary principle is a complex guide to policy making and cannot be dismissed as inimical to considerations of economic efficiency..."

The presentation of this work will be supported by a software demonstration.

**Aknowledgement:** This work has been partially supported by the Portuguese Foundation for Science and Technology under project grant[s] PEst-C/ EEI/UI308/2011.

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# PART VI

# SOCIETY AND BEHAVIOR

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# The Power of Example: Closure and Common Ground

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**Abstract**: This paper suggests that for negotiation studies, the well-researched role of cognitive closure in decision-making should be supplemented with specific research on what sort of information is seized on as unambiguous, salient and easily processable by negotiators. A study of email negotiation is reported that suggests that negotiators seize on concrete examples as building blocks that produce immediate positive feedback and consequent utilization in establishing common ground.

Keywords: Cognitive closure, email negotiation, argumentation

## Introduction

This paper is about the movement from uncertain suspicion to common ground, arguably the central cognitive effort involved in any negotiation.

In a contract negotiation for the terms of a lease, where commitment means a contract for several years and for a great deal of money, one would not expect the parties' vague hopes and intentions to cut much ice. However, the mere expression of a hope to open a 'Kid's corner' playground in a shopping arcade seems to be enough to ease stranded negotiations back into the stream of dialogue. This paper seeks an explanation in the notion of cognitive closure, and argues that the beneficial effects of closure are much underrated.

Below, section 2 reviews the arguments for involving the notion of cognitive closure in negotiation studies, and establishes the importance of the notion of common ground. Section 3 reports a study of a simulation, analyzed for the effects of a particular feature that arguably plays the role of the bridge between the two, viz. the use of concrete examples. Section 4 discusses the outcome in the light of explanatory value.

## Background

Negotiation happens when two or more mutually dependent parties seek to distribute money, goods, services or other elements of value to them. There is no point in negotiating if a powerful party A can dictate to a powerless party B, or if there is no underlying conflict of interest, so that party A can freely take something they value from party B. But if there is a conflict of interest, it makes sense to find out what the other party values most, in the hope of finding compatible prioritization. This process is what is practiced in the training of negotiators.

In training, reasonably life-like negotiation is conducted under considerable uncertainty and without the benefit of a pay-off sheet. Therefore, when negotiators seek information about the partner's preferences, they also treat all information that is offered as arguments for a position potentially incompatible with their own interests.

#### Persuasion and argumentation

Much research on persuasion starts from the premise that there is a persuader and a target who may or may not process the arguments fully, as in the influential tradition from Petty and Cacioppo (1986). But in negotiation both parties are trying to persuade each other, with arguments whose basis may be not only incompatible but also incommensurable, like money and justice.

The double interactive role of persuader and target is a complicated communicative starting point for agreement – so much so that the presence of argumentation may in fact be a predictor of deadlock. Thus Roloff et al. (1989) show that the amount of persuasive argumentation is negatively related to integrative solutions; Bülow-Møller (2005) speculates that much argumentation is a symptom of a negotiator with a bad case.

However, a more satisfying explanation could be found in the processing patterns of argumentative negotiators: the more one party argues, the less time he or she spends listening. Parties who do not listen are unlikely to address the partner's prime concerns, and hence their self-directed argumentation is wasted.

But even for negotiators who do listen, there is uncertainty about the partner's intentions, a condition termed 'situational fuzziness' in van Kleef et al. (2010). This leads to biased listening, for negotiators are fearful of being taken advantage of, and may therefore be expected to seize on facts that confirm their skeptical beliefs, i.e. selectively focus on hypothesis-consistent evidence. Such 'seizing and freezing' forms the subject of research on various dimensions of closed minds, snap judgments and resistance, and the notion of cognitive closure holds considerable explanatory force for unnecessary deadlock.

#### **Cognitive closure**

For the present purpose, the body of research that underlies the prediction of early closure has developed the notions presented in Kruglanski and Webster (1996) and Webster and Kruglanski (1997). Again for the present purpose, the important notions are epistemic motivation, selective processing, and cognitive environment such as time pressure or cognitive busyness.

Epistemic motivation determines whether people engage in shallow (heuristic) or deep (systematic) information processing. High epistemic motivation leads to increased information search, and for negotiators this is an advantage. Thus persistent search for information has often been shown to lead to better joint outcomes (Ten Velden et al., 2010; for a recent negotiation overview, see also Thompson et al., 2010).

But the more the individual feels the need to get a firm answer, to disambiguate, or to see a structure, the stronger the likelihood of shortcuts. Crucially, for a complicated decision process like a negotiation, this applies not just once, but continuously: with many small judgments to make, like the decision to trust or not trust a particular move made by the partner, heuristics simplify the process.

When the starting point is a conflict of interests, selective processing of information may be expected along the lines of in-group bias and confirmation of beliefs. For the relative complexity of a multi-issue negotiation, there is a great deal of information to keep track of; belief-consistent evidence has been found to be more easily retained in memory, where ambiguous evidence would have delayed closure (De Dreu et al., 2008, Kardes et al., 2004).

Cognitive busyness is traditionally manipulated in the laboratory with tasks such as the retention of a 9-digit number (Palomares, 2011). While negotiators in reasonably life-like simulations are not under this kind of stress, they do try to juggle many different facts and considerations to achieve a sort of interactive, chess-like strategy, and can therefore be said to work under high cognitive load, which has high costs. For example, it leads to less discrimination in achieving closure (Halevy et al., 2006); under time pressure, negotiators tend to stick to pre-formed perceptions, e.g. of a fixed-pie scenario or a stereotype of the outgroup (De Dreu, 2003); and in conditions of cognitive busyness, creativity has been shown to fall (Chirumbolo et al., 2004).

It can therefore be assumed that a negotiation with complex options and high uncertainty will push the participants towards a desire for closure through heuristics and a search for closure along Kruglanski and Webster's original lines, viz. a strong influence by early anchors and stereotypes, less search for information and reduced perspective taking to understand the partner's view. Consequently, they will tend to seize on items that are salient and easy to process, thereby lessening the chance of integrative solutions.

Since this dismal prediction is not upheld for skilled negotiators, there must be other variables.

#### Constructing knowledge: Closure and common ground

I propose that if simulations of negotiation are conducted with high verisimilitude, i.e. with sufficient background detail, partly shared, partly private to one party, and if the case involves the option of some judicious logrolling of interests, rather than bargaining or reaching a logically correct decision, then it is possible to observe the process of joint knowledge construction in action. The closing of the mind, which has had such a bad press in negotiation studies, can then be shown to have a beneficial impact, as chunks of private information are offered and accepted and incorporated in the common ground that all negotiation tries to establish.

In particular the impact of concrete examples is interesting, representing as they do the recommendation of classical rhetoric to engage the audience by making it share visualizations. Salient examples are extraordinarily easy to process. If concrete examples can be shown to make a negotiator seize on a chunk of information offered by the opponent, even clearly in the opponent's own interest, then it must have disbanded the skepticism and the bias for confirmation. In other words, I propose that insufficient attention has been paid to the actual wording, i.e. the framing and the consequent selection of detail, that "sells" a chunk of information to a negotiation partner to the extent that it becomes common knowledge. This I shall illustrate with the results of a simulation.

# The Study

The simulation was a variation of the Harvard case "Discount and Hawkins", where the problem is the wording of a lease, setting out rights and obligations concerning the "use and subletting of premises". With such a case, the product is less amenable to numerical analysis than bargaining for profit. The research here focuses on the negotiation dynamics rather than the result, as some of the solutions were considered sub-optimal (in the sense of sloppy formulation of conditions or lack of care with all relevant points). However, if the parties agreed on the issue in question, it is scored as "settlement".

The players represent a developer of a projected shopping centre and the proposed anchor tenant. Briefly, it is in the tenant's interest keep all possible freedom to withdraw if revenue is disappointing, either through terminating the lease or by subletting their space in part or completely. For such an anchor tenant the space is considerable and the investment in the location is part of a national policy.

Meanwhile, the landlord must have the security of a long-term lease in order to finance the venture at all, and he or she must control the mix of tenants, partly for the sake of the other tenants (to curb internal competition), partly to retain the targeted customers, which means that the right to sublet is a delicate matter.

Each party starts from their own standard lease, which, unsurprisingly, privileges their own interest in this matter; these versions have been exchanged and form part of the shared information, so both parties are aware of the exact nature of the conflict. The rent per square metre is not an issue, nor is there any forecast of income – the only figures in the simulation concern the length of the contract.

Tenants hold private information about the future plans for the national chain they represent in the kitchenand-bathroom textile business. In the material issued to tenants, uncertainty about consumer preferences plays a major role, particularly in the long run; tastes and novelty in ten or twenty years' time are hard to predict, and hence an argument for flexibility. The landlords have detailed knowledge of their smaller tenants, whose leases are shorter, but whose customer base should nevertheless not be cannibalized by a large company; therefore, they want their major tenant to stay firmly in their present business. They also have reason to fear for the ambience of the shopping centre if undesirable tenants move in, and to forestall this eventuality they insist on a clause that allows them to screen candidates for sublet leases.

With this information, negotiators can stay at an abstract level and argue that for a fruitful relationship, their respective basic needs are flexibility, at least long-term flexibility, and stability, at least, short-term stability, and work for a compromise; or they can delve into their information and divulge examples, as a way of legitimising their claims and building trust.

#### Participants and medium

From a cohort of 86 voluntary international business school students, collected from classes over two years, 38 dyads produced useable transactions, negotiating over email over a period of two weeks.

The medium of email is not unproblematic for negotiations. The leanness of the medium has been charged with several factors leading to impasse, among them the tendency for conflicts to get out of hand with a faceless Other (Friedman and Curral, 2003), distrust of motives (Volkema and Rivers, 2008), even 'sinister attribution bias' (Thompson and Nadler, 2002), and lower outcome satisfaction (Purdy et al., 2000). On the other hand, the medium is well suited to the exchange of drafts of text, as it affords what Dennis, Fuller and Valacich (2008) call 'reviewability' and 'revisability': the negotiator can keep track of what has been exchanged far, and it is possible to read over one's response and edit it before pressing 'send'.

However, the greatest danger to a useful outcome may lurk in the turn-taking structure of the emails, since the medium seems to discourage diagnostic questions. On the mail, negotiators tend to heap up their concerns and suggestions in messages that are too long to answer comfortably, a characteristic known as 'bundling', which is apt to stimulate self-serving, cherry-picking answers (Friedman and Currall, 2003). A series of exchanges detailing why the writer cannot accept the other party's suggestion and adding a slightly modified suggestion of one's own may be called 'double monologue' rather than dialogue, and it will typically display versions of early closure.

However, picking the medium of email was a conscious choice, not just for the ease of reference, but for the explicitness it entails. Suggestions and uptake are clearly documented in the texts - what could be accomplished with nods or back-channelling noises in face-to-face interaction must be acknowledged in writing. Secondly, if even in these somewhat inauspicious circumstances the opponent's concrete examples are picked out and integrated, they can be taken to represent real common ground.

#### Results

While the case concerned both the use and subletting of the premises and the length of the contract, concrete examples were limited to the former, and 'successful settlement' was therefore only judged in relation to this issue.

Of the 38 negotiations, 27 contained concrete examples; 24 of these led to settlements, while 3 led to impasse. Further, 11 scripts contained no examples; of these 9 contained no settlement on the issue, while 2 scripts contained no examples but settled anyway.

Table 1. Examples and settlements					
	With ex	Without ex			
Settlement	24	2			
No settlement	3	9			
Total	27	11			

In a 2x2 contingency table, Fisher's test yields a two-tailed P value of less than 0.0001, which is clearly significant.

The extracts below illustrate the positive dynamics; the quotations bear the stylistic hallmarks of email (not proof-read for spelling and grammar) and of non-native English (instances of inaccurate vocabulary, which does not seem to have caused any misunderstanding, however). The concrete examples are highlighted.

#### Example 1

(from Mess3, tenant).[ ... ] For instance, western regions are currently trying out the Kids' Club House, a space in the shop set aside for children to be supervised while parents shop. With such restrictions, [tenant] would have to ask the landlord's approval everytime a new innovation is conceived for the market, making the process slow and bureaucratic. [...]

(from Mess4, Landlord] Thank you for your email. I now feel I have a much better understanding of your point of view of this case.

I can see how it is important for [tenant] to not be constrained in developing its retail concept. Innovation is important to maintain a novelty attraction in the shopping centre that will draw customers. However [... 2 lines...] Is there any way we could extend the clause and make it more specific? This could be an inclusion of some frame for the use of the premises, for example that it cannot be changed to a fundamentally different area of retailing, say a hardware store or electronics [...]

(from Mess5, Tenant] Thank you for your prompt reply. I'm very happy you understood the concerns of my client about the deal. I'm much more optimistic about it, now. To be sure we don't aim for fundamentally different areas, so what I suggest [...]

Importantly, in all successful transactions with examples, the opponent's example is acknowledged in the very next turn, in 8 cases also with repetition of the example:

#### Example 2

(from Mess2, Tenant) [...] We are aware that you need some security in terms of knowing who you are subletting to, and which products will be sold, in order to finance your project. Unfortunately you must understand that a clause as proposed would potentially block are business from development, if a change was deemed "not in a manner consistent with the kitchen and bathroom textiles retail operation described in the lease".

If you have a look at shops today you will see a development where shops add or remove products according to the market. Lets make a fictional extreme example: lets say people suddenly stop wanting curtains in their kitchens, but want aquariums to cover their windows. this would deprive us of a product to sell, but we would also not be allowed to sell aquariums as this might not coinside with the desciption of our business anno 2013.

(from Mess3, Landlord) Thank you for your reply. We are glad to hear that you are still onboard and that we are working towards a common best for both of businesses.

We have drafted up some points that we would like to hear your stand on:

- In case you can't utilize the full store-space you'll sublet it to us and we will find a suitable tenant for the excess space.
- You should of course be able to cater customer demands, and since one of your strengths lies within simulation of housing environments we will be able to make that work, including aquariums. This can be used to show people how an aquarium can complement their kitchen or bathroom environment. We grant you full right to fill your simulated living spaces with different accessories, but are not able accommodate your request for total freedom regarding product mix [...]

#### Discussion

Such exchanges show that examples are not only processed, but accepted and integrated. On this basis, I speculate that concrete examples lead to the kind of beneficial closure that translates from a situation of uncertainty to one of certainty-that-opponent's-motives-are-not-bad.

#### Settlement with examples

It is noticeable in the corpus that the tenants use examples of their hopes, i.e. plans that represent a departure from their current exclusive focus on bathroom and kitchen textile; while the landlords used examples of their fears, i.e. worst case scenarios of tenants that could be let in if subletting was out of their hands. It is likely that this difference stems from the nature of the conflict, inasmuch as the landlord is trying to limit the tenant's freedom.

In this sense, giving examples functions as accounts, "a linguistic device employed whenever an action is subject to valuative inquiry" (Scott and Lyman, 1968). Thus, landlords account for their restrictions by inviting the tenant to share a scenario where the shopping centre is invaded by dealers in pornography or weaponry if the tenant sublets uncritically, and, equally legitimately, the tenants invite the landlord to share a scenario where they exceed their current limits by establishing a supervised playground for children, follow consumer trends in incorporating non-textile kitchen and bathroom furnishing, or equally un-threatening initiatives. In other words, the shared scenario represented by the concrete example functions as an argument for the proposition "I have our joint best interest at heart", and this induces trust.

#### Impasse with examples

However, examples are not a panacea for a conflict of interest: there are cases of examples that fail to move the partner. This requires explanation.

It was argued above that examples are part of statements that function as arguments for the two sides' interests in flexibility and stability, respectively. In argumentation terms, opponents in a debate lean on

'presumptive reasoning' (Walton, 1990): they assume that after an argument has been proposed, the burden of (dis)proof lies with the opponent, so that unless it is specifically defeated, the argument should stand. However, there is a difference between debates over single issues and a negotiation, where equally legitimate arguments point in opposite directions for the two parties trying to persuade each other.

An argument is classically evaluated in terms of epistemic acceptability (is it credible?), relevance (does it address the conflict?) and sufficiency (is it enough to tip the balance?) (van Eemeren et al., 1996). Since these criteria are subjective (Kock, 2007), it seems that some negotiators assign less value to the examples than others (i.e., the examples may be both credible and relevant, but judged to be insufficient to overcome basic skepticism and tip the balance.) It is possible that such at most partial acceptance is related to the individuals' need for closure; this was not examined in the present case.

Secondly, it would have been perfectly possible for (insensitive) negotiators to give concrete examples of some plans that did not address the partner's concern; in theory, tenants could have had a brief that included, say, the establishment of a beer garden with facilities for very large dogs. In such a case the example would not have served as an argument for the underlying proposal of joint interest, but rather as an easily processable confirmation of initial distrust. There are no examples in the corpus of such ill-chosen examples, which presumably means that participants are well aware of the argumentative pull of their choices. In other words, it is not just the presence of examples, but of examples relevant to the exploration of common ground, that is conducive to settlement.

#### Conclusion

The general tendency illustrated in this study is that while the use of examples is neither necessary nor sufficient for immediate settlement, their presence is positively associated with settlement. Their function seems to be to contribute to over-all certainty, i.e. to the dismissal of suspicion, so that dialogue continues on a basis of trust. In contrast, negotiators who stay at the abstract level, like "we must be flexible enough to move with the times", fail to allay fears. Thus, in negotiation theory terms, the examples seem to shift the locus of the conflict into grounds that can be managed (Putnam, 2010).

It is this acceptance of the import of the examples as arguments that I suggest should be seen in the light of cognitive closure. It is the cognitive movement from 'Oh', via 'Aha', to 'Well, fair enough' that I regard as instances of beneficial closure: a snap judgment so that once instances like 'a playground is a good idea' or 'pornography is a bad idea' have been integrated by the both parties, the wider issue of intentions is no longer open to discussion.

It should be stressed that we are dealing with one factor among many, and that such 'little closures' do not in themselves decide the outcome of a negotiation. However, I would like to suggest that this particular factor has not been examined, and that it contributes to our understanding of the cognitive processes that shape decisions.

#### Reservations

Clearly objections can be raised about the cognitive processes of students who have, after all, been briefed with facts about a fictive world. For development, a full project should seek evidence outside the laboratory of the classroom.

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# Saying and Doing: Understanding Pre-Negotiation in Complex Business Negotiation

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**Abstract**: Pre-negotiation is widely recognized as fundamental to increase negotiation effectiveness; yet little is known about pre-negotiation planning for real inter-organizational transactions. I propose a rigorous qualitative research design rooted in real organizational data from multiple sources facilitating plausible and credible holistic understanding of the research phenomenon. The proposed design demonstrates the weakness in relying on an open-ended survey as the sole data source to understand an internal-organizational phenomenon.

Keywords: Inter-organizational negotiation, methods and techniques, real organizational setting, qualitative research, business.

## Introduction

Most scholars agree that planning and preparation is a key to negotiation effectiveness (Ghauri and Usuiner, 2003; Lewicki et al., 2010; Fells, 1996). Furthermore, business negotiators and negotiation practitioners from both Europe and US agree that planning is the foundation for any successful negotiation (Watkins, 1999; Rackham and Carlisle, 1978) and that planning skills are the most important traits one can possess (Karrass, 1970).

Still to a large extent research has so far focused on what happens at the negotiation table. However the atthe-table negotiation is only the later part of a larger process needed to resolve conflicts (Saunders, 1985) and little is known about what is actually planned for negotiations (Jordan and Roloff, 1997). Therefore negotiation researchers are expressing the need for more in-depth studies to advance the understanding of how inter-organizational pre-negotiation is being conducted (Peterson and Shepherd, 2010). This paper aims to redress the balance from a methodological perspective.

I consider our lack of understanding of how real life inter-organizational pre-negotiations are conducted a critical gap in the literature. This paper discusses the options that are open to scholars who seek to acquire rich and rigorous data from practitioners, proactively managing the threats to reliability and validity during the research process rather that in an evaluative manner (Morse et al., 2002).

In comparison to quantitative research, qualitative research often performs better with regard to context realism (Creswell and Clark, 2007). In the following I shall describe a computer aided qualitative research method using a constructivist thematic analysis triangulating data from an open-ended survey, with a 13 months longitudinal single case study of a complex negotiation and participant observation from "living" in the organization for 24 months, in order to raise some fundamental research questions. The method forms the basis of my PhD thesis; therefore, examples of on-going research applying the proposed method will be discussed. The hope is that this conference paper will inspire more negotiation researchers to embark into qualitative research to further advance our knowledge on negotiation (Buelens et al., 2007).

# **Pre-Negotiation**

While preparation and planning are critical elements of negotiation (Thompson, 2009; Ghauri, 1986), the pre-negotiation phase has not been thoroughly studied by scholars (Roloff and Jordan, 1991), still most academic text books devote a chapter to the topic including checklists and descriptive advice, e.g. Thompson (2009). Furthermore, Fisher and Etrel (1995) dedicated a whole book to the pre-negotiation phase based on the framework of the seminal book *Getting to Yes* (Fisher et al., 1991).

In their review of the pre-negotiation literature Peterson & Lucas (2001) proposed a conceptualization of the pre-negotiation phase into four components. The first component in the framework, Information Gathering, focuses on collecting information from the other party including their BATNA (Fisher et al.,
1991), issues and underlying interests. The second and third components, Formulation and Strategy Development, are planning activities involving BATNA assessment, development of reservation price (Raiffa, 1982), goal setting and development of a plan to reach the defined goals. The fourth and last component, Preparation, is concerned with development and rehearsal of the customer presentation in addition to the logistical concerns.

Other studies related to pre-negotiation exist within e.g. the area of international business negotiation and diplomacy (Zartman 1989; Saunders 1985), but none of these addresses the activities undertaken during the pre-negotiation and hence the understanding of how negotiators and negotiating team plan and prepare for their negotiations.

## **Proposed Research Design**

The method described in this paper is designed to understand *How inter-organizational negotiators and their teams plan and prepare for customer negotiations*, in other words a model of the activities negotiators conduct in their preparation for the at-the-table negotiation.

Interviewing is probably the most used and recognized method of data collection in qualitative research (Mason, 2002). To answer the above mentioned research question this method is especially advantageous to understand issues that are not amenable to observation like reconstructing pre-negotiation events and individual preparation. In addition and from a practical perspective interviewing is less intrusive and makes it possible to reach a larger group of respondents compared to participant observation. For our purpose, it is my belief that the same advantages can be obtained through an open-ended survey if the challenges of response rate and quality of the answers are overcome. Furthermore the open-ended survey will significantly lower the time investment per respondent due to the fact that transcription is done by the respondent.

The open-ended survey, or a series of interviews, would however not allow us to fully understand *How inter*organizational negotiators and their teams plan and prepare for customer negotiations as the respondents will not be in a position to report *What they don't know they do* (e.g. unconscious activities) and *What they don't know they don't* do (e.g. recommendations found in the literature and not performed by the respondents). Furthermore, no matter the number of participants in a survey, their knowledge of the research subject, their cognitive capacities or the quality of the analysis, the survey will capture perceptions, attitudes and verbal report about the subject and not provide any evidence of these event and behaviours taking place. Consequently it is necessary to complement the survey with a case-study, what will provide this evidence through participant observation and other sources (Yin, 2009).

I therefore claim that to fully understand this *How* research question one needs to understand not only *What they know they do* and *What they know they don't do*, which typically can be generated from an interview or an open-ended survey. This important step will however not enable me to entirely understand the research question as we have not captured *What they don't know they do and What they don't know they don't do. What they don't know they don't* 

	Data Sources:			
Knowledge acquired:	Primary:	Verification:		
What they know they do:	Survey	Participant Observation + Case Study		
What they know they don't do:	Survey	Participant Observation + Case Study		
What they don't know they do:	Case Study	Participant Observations		
What they don't know they don't do:	Literature vs. all sources	All sources		

Table 1. Inquiry Overview

Consequently the design will be a qualitative sequential design that will allow the researcher to collect a rich and strong array of evidence. From a constructivist perspective and in the context of the company the sequence of the study will firstly execute and analyse the survey, and secondly apply the model generated from the survey as a framework to analyse the case study, in other words a nested arrangement with an explanatory embedded single-case study within a survey (Yin, 2009). Participant observation outside the case study will primarily be used to cross examine the findings.

The method applies the constructivist perspective being a more appropriate perspective than the positivist perspective when answering the *How* question (Buelens et al., 2007). Furthermore, the proposed methodological triangulation will enhance the reliability of the study as a consequence of the cross inquiry between the data sources (O'Donoghue, 2003; Yin, 2009). In addition the selected sources are relevant to answer the posed research question (Yin, 2009).

In this paper I describe a practical example of how a rigorous open-ended survey can be designed, executed and analysed. From the results of the survey I will show concrete examples demonstrating where the survey failed to capture key activities performed by negotiators.

## The Context

The Company is presently operating in a buyer's market with fierce competition from other global players. With over-capacity in the market the BATNA of the seller (the Company) is *not to sell* and consequently underutilize the available production capacity. The reservation price of the negotiators is defined by the negotiator mandate assigned to the negotiation team by management during the sales process gate meetings. The negotiators are involved in multiple negotiation in parallel each with a team involvement of approximately 3 months to 2 years. Members on the negotiation team are 2-7, but mostly 3; Sales, Legal and Service. For the Pre-Negotiation meetings the number of participants is 2-10 approximately.

## Challenges of Doing Real Life Research in a Closed Setting

Customer negotiations are a sensitive subject due to the financial importance of the outcome for both the negotiators and the company. The monetary size of the transactions are often double or triple digit million € and the responsible sales manager will most likely only close a few deals per annum. Consequently this is a closed setting (Bell, 1969) with a high tension situation for the negotiators making access to the negotiations a significant challenge for the researcher. The researcher, thanks to the support of the business school and the company, adopted an insider approach to mitigate the challenge and transferred from the company Head Quarter to a Sales Business Unit reporting to the Head of Sales. The insider role status frequently allows for more rapid and complete acceptance by the participants typically resulting in greater depth in the data (Dwyer and Buckle, 2009). Coming from Head Quarter and reporting to the Head of Sales was helpful in terms of visibility and gatekeepership (Bryman and Bell, 2007), but created another challenge in terms of loyalty. Few negotiating teams would be interested in having a sort of spy from management in their negotiations (Bryman and Bell, 2007). This challenge was dealt with through a clear and public agreement with management emphasising contribution to science as the purpose of the research and that observations would remain confidential between observer and participants. Still it is not enough for the Head of Sales to give an instruction to let the observer participate; negotiators need to see the benefits of having the participant observer (Informal interview with A). According to informal interviews the reason for the reluctance from the negotiators may stem from the fact that the Company's negotiations are of very large sums and much is at stake for the negotiator in terms of remuneration, reputation and job security (Informal interview A and B). I chose to take a humble approach where I spent all my time in the office helping out wherever possible and at the same time developing a customized high level negotiation skill course tailored to the needs of the negotiators. The purpose of these actions was to create trust and respect which hopefully would lead to access to the negotiations. According to informal conversations with negotiators who participated at the negotiation course the above measures quickly established me as a helpful and competent negotiation advisor and soon I was invited to several negotiations both as an observer and as an advisor. According to the negotiators another key reason for me being accepted was my personal experience as a negotiators over many years, this made me like one of them (Retrospective field notes).

Being an insider has not only advantages but also drawbacks. Where the primary advantages of being an insider are the on-going access to closed settings and greater depth in the data; as a participant-as-observer (Gold 1957) the primary drawback is to lose the sense of being a researcher and become wrapped-up in the

world for the negotiators. Hence the act of reciprocity through teaching and advising was separated from the observation whenever possible. Agreement was made with the negotiation teams that if they would like my advice I would give it only at the end of the pre-negotiation meetings and thereby interfering as little as possible with the field. The positive and negative elements of becoming an insider must obviously be evaluated, in the case of the reported study the choice was relatively simple as not being an insider probably would have made the data collection problematic if not impossible.

## **Open-ended Survey**

On the basis of 68 open-ended surveys from negotiators within the company, the study will embrace a rigorous thematic analysis within a social constructivist paradigm (Braun and Clarke, 2006) to generate a model of *How negotiation teams prepare and plan for their inter-organizational negotiations*.

## Survey Data Collection

The survey respondents were selected according to two firm inclusion criteria, firstly they must continuously be participating in pre-negotiation planning and preparation (not necessarily at-the-table negotiation) and secondly they must have successfully completed the internal 2-day negotiation training taught by the author. By this selection criteria I use purposive sampling (Creswell and Clark, 2007; Kemper et al., 2003) and the respondents are hence expected to have both experience in pre-negotiation planning and preparation and basic negotiation skills. Response rates is a well-known issue when making survey research, which was mitigated by offering the survey only to respondent who had participated and completed the mentioned negotiation training.

The company was at the time of the survey going through a period with high degree of uncertainty primarily due to predicted severe layoffs. A condition that underlines and possibly aggravates the issues of honesty and willingness to respond. The chosen remedy was to underline the fact that the survey is confidential and exclusively for academic purposes. Furthermore I used a non-company e-mail to send out the survey in addition to eliminating the company name throughout the survey. Moreover, the author talked and e-mailed privately with more that 50 of the potential respondents after the launch of the survey with the purpose of increasing the number of completed surveys and the quality if these.

An important element of timing concerns the knowledge, perception or experience we wish to measure with our survey (Druckman, 2005). The experiences we are looking for in this survey are occurring on a continuous basis and not related to one single event, but this is not the case for the negotiation knowledge as the training takes place only once, which led me to launch the survey as soon as my sample size was above 100. Still it is important to identify a period where the respondent is more amenable to collaborate (Druckman, 2005), for this reason the survey was launched on April 11th 2012 - after the closing of first quarter and in the middle of the week, where the respondents are expected to have less work pressure. At the time of the launch of the survey all respondents had received the negotiation training within the last 14 months.

The final number of complete surveys was 68 out of 101, far above the defined minimum of 50. The length of the respondents' answers to the 13 open-ended questions ranged from 78 to 900 words, with an average of 370 and a standard deviation of 203. The 68 respondents who completed surveys are functionally distributed with 35 (51%) from sales, 15 (22%) from service, 12 (18%) from legal contracting and 6 from other areas (9%). 50 of the respondent are working in the South region (Mediterranean and South & Central America) and 18 in the North region (UK, Denmark and Sweden). 10 (15%) of the respondents were female; 58 (85%) were male.

## Survey Development

The purpose of the survey is to make the respondents speak aloud about their experiences, which entails that my questions were open-ended questions. No questions related to age, gender, education, seniority etc., were asked as the configuration of the survey using www.surveyXact.com and the access to the company employee database gave me the identification of the respondent and thereby all relevant non-confidential personal information.

With the research question in mind the survey questions were developed after extensive negotiation and pre-negotiation observations in the company over a period of 15 months. The initial questionnaire was

reviewed by four people from the company who all qualify as having extensive experience with Prenegotiation planning and preparation (2 sales, one legal contracting and one other). On the basis of their inputs the survey was amended when considered appropriate by the author. As a concluding pilot test the survey in its final web format was sent to two Sales Managers from the company and one negotiation academic and deriving minor amendments were made.

## Survey Coding and Data analysis - Thematic Analysis

Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data. It minimally organizes and describes the data set in rich detail. However, frequently it goes further than this, and interprets various aspects of the research topic (Boyatzis, 1998). The development of the themes themselves involves interpretive work and produces not just a descriptive analysis but rather a theorized analysis (Braun and Clarke, 2006). Computer Assisted Qualitative Data AnalysiS (CAQDAS) tool ATLAS.ti was used to manage the survey data and code generation, and to support the thematic analysis through various data queries applying Boolean and proximity operators (Saldaña, 2009; Susanne Friese, 2012).

Acknowledging that pre-existing theories and models drive the entire research (Mason, 2002), together with my inclusive and comprehensive focus on interpreting what the data is telling me rather than exclusively adapting to theoretical frameworks (Braun and Clarke, 2006), calls for a method that allows for both deductive and inductive coding. Thematic analysis was chosen as it presents a good fit to my data source and my research question through its capacity to generate salient themes and categories, and it allows for both deductive and inductive coding. There are 6 phases in thematic analysis (Braun and Clarke, 2006) as shown in the table below.

Phase		Description of the process		
1.	Familiarizing yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.		
2.	Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.		
3.	Searching for themes:	Collating codes into potential themes, gathering all data relevant to each potential theme.		
4.	Reviewing themes:	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis.		
5.	Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.		
6.	Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.		

Table 2: Phases	of thematic	analysis from	Braun and	Clarke (2006)
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After the first reading of the material and before commencing the initial coding generation a series of deductive codes deriving from the work of Peterson and Lucas (2001) and from Dual concern theory (e.g., Blake and Mouton) were introduced as free codes serving as my sensitizing devices (Blumer, 1954; Patton, 2001). Besides the mentioned deductive codes the data was coded inductively and with an open mind applying both descriptive coding (Saldaña, 2009; Miles and Huberman, 1994) and In Vivo coding (Saldaña, 2009; Charmaz, 2006). This coding process was already part of the analysis (Miles and Huberman, 1994), as the data was organized into meaningful groups (Tuckett, 2005). Focus was on giving full and equal attention to the full data set with the purpose of identifying aspects which could form the basis for themes in the subsequent steps of the analysis (Braun & Clarke, 2006).

Recognizing that qualitative analysis guidelines should allow for flexibility (Patton, 2002) the phases 3, 4 and 5 were conducted more as a recursive process (Braun and Clarke 2006) moving back and forth between the phases. During the second cycle process the codes were equally amended, merged and generated as part of the cyclical coding process (Saldana 2009). Focused coding was used to derive the most salient themes (Charmaz, 2006) as this type of coding is a recommended way to extend the thematic analysis (Saldaña 2009). In addition CAQDAS programs like ATLAS.ti lend themselves very well to focused coding since they simultaneously enable coding, category construction and analytic memo writing (Saldaña, 2009) and they help systematise and order data, enabling a more thorough and reliable analysis (Ghauri, 2009).

## Survey Results

As a result of the iterative thematic analysis coding process (Boyatzis, 1998) with the purpose of identifying the most salient categories I arrived at the coherent and distinctive classification model. The model consists of 5 themes, 14 categories and 28 sub-categories, and contains a mix of inductive and deductive rooted categories (Friese, 2011).

Despite the high numbers of respondents and their long and exhaustive answers, the comparison between the model and the recommendations found in the negotiation literature showed that many activities acclaimed by academics and practitioners where not mentioned by any or only by a few of the participants. Even-though Charmaz (2006) suggests frequency of codes as a rule of thumb when developing categories, it is still the researcher who decides if a code should become a (sub-)category or not (Friese, 2011). Therefore a number of additional categories were added to the model as they were considered very important as a result of the literature review compared to the model, e.g.:

#### 1. The negotiation style of the other party

Negotiation literature is emphasising the importance of knowing the typical negotiation style of the other party (Raiffa 1982). Still and contrary to expectations only two of the 68 respondents (R5 and R64) mentioned this activity.

#### 2. Customer Issue Prioritization

To be able to negotiate efficiently it is in your interest to know which issues are of high priority to the other party as well as to yourself. Having this information will allow you to engage in logrolling – a systematic concession making in accordance with parties' different priorities (Froman and Cohen, 1970). Even though issue prioritization is fundamental to successful negotiation outcomes, only 2 respondents (R36 and R43) address customer issue prioritization in the whole survey.

#### 3. Opening offer

Who should make the opening offer first? - the customer or the seller is an important consideration for the negotiators (Galinsky and Mussweiler, 2001), however no respondents considered this question as part of the pre-negotiation preparation.

The above exemplifies activities of *What they don't know they don't do* identified as a result of a thorough review of the literature. These findings were consequently created into additional deductive categories.

The participant observation made prior to conducting the survey equipped me to identify further shortage in the model build with the survey results. These shortages are expressions of *What they don't know they do* – activities I have observed being done, but few or none of the respondents mentioned these in their answers, e.g.:

## 1. Option scenarios for the buyer

Where 15 of the 68 respondents reported activities related to building scenarios to understand the consequences of the different scenarios from a self-concerned perspective, not one person reports on the consequences from the customer perspective, contradicting to my own observations which show that negotiators mostly  $d_0$  take into account the impact on the customer's financial model using a specific tool developed for this purpose.

#### 2. Discloseable, Confidential and Missing Info

The negotiation literature recommends that one should develop a plan to achieve the missing key information from the other party (Young et al., 2011). Participant observation has confirmed that it is occasionally discussed as part of the pre-negotiation planning, but surprisingly no quotations from the respondents mention this activity.

The listed examples of *What they don't know they don't do* and *What they don't know they do* represent important additions to model of the pre-negotiation phase that have only been included into the model as a result of a thorough review of the literature and triangulation with participant observation, and thereby demonstrating the need for additional data sources to fully understand *How negotiators conduct their pre-negotiations*.

## Case Study

The distinct advantage of deploying a explorative case study in this project stems from the fact that we have to do with a study that seeks to answer a *How* question in a contemporary set of events over which the investigator has little control (Yin, 2009). According to Yin to conduct a case study is to make an "empirical

inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident" (2009). Hence, this case study will enable me to obtain a thorough understanding of real life pre-negotiation planning and preparation and encompassing activities and thereby create context dependent knowledge (Flyvbjerg, 2006).

Where the answers from the survey are most likely subject to the influence of illusory superiority bias (Hoorens, 1993), the case study observations will allow for the understanding of a real life phenomenon and its pertinent contextual conditions (Yin, 2009) and thereby validate the survey findings from the perspective of the researcher over the duration on the negotiation. Further it opens up for understanding *What they don't know they do* through observations of interactions and other sources e.g. e-mails, and thereby contribute and most likely expand on the pre-negotiation framework developed through the analysis of the survey data.

## Site and Case Selection

As mentioned previously I will focus on an exploratory single case study which makes the choice of case of high importance. Four criterions were identified: The case should be representative, critical, have potential to become longitudinal, and participants and management should be supportive of the research. The rationale for the choice of case was to identify a negotiation case that would be representative for the industry with the purpose of capturing circumstances and conditions of a typical negotiation (Yin, 2009). According to Flyvbjerg (2006) various strategies of case selection are not necessarily mutually exclusive and may provide a unique wealth of information as one obtains various perspectives and conclusions on the case according to whether it is viewed and interpreted as one or another type of case. With this in mind another selection criterion was added, the critical case criterion that would allow me to make the logical deduction: If this is (not) part of the pre-negotiation for this case, then it applies to all (no) cases. The third selection criterion was to identify a negotiation with potential to become longitudinal, which would allow for studying the same case at various points in time and thereby see pre-negotiation preparations for different types of agendas with different participants (Yin, 2009). The fourth and final criterion is the interest of the participants in the research, as data collection is highly dependent on their collaboration and their willingness to include the researcher in all the information exchange.

The chosen negotiation took place in France and using conference calls, with participants from USA, Europa, Asia and Africa. The rationale behind this decision in terms of the four criterions was:

- 1. The case is representative, as the customer belongs to the largest customer segment and has already a significant installed base with various suppliers in various regions in the world. Furthermore the customer segment is estimated by the company as one of the most attractive segments due to expected future investments and strategic fit (Internal documentation A).
- 2. The case is critical in the sense that the team has worked together during many negotiations and know each other very well. In addition the manager is very dedicated to team collaboration and participants are thorough and dedicated to pre-negotiation according to my knowledge from the trainings and in comparison to other observations made over the previous 12 months. This makes the case critical in the sense that we can draw the logical deduction: If this activity is not part of the pre-negotiation for this case, then it does not take place.
- 3. The case has potential to become longitudinal as it is highly complex and only in the initial phase prior to the first face-to-face negotiation.
- 4. The case has support from management and participants, as the local management expressed their desire to become sponsors for the research (Bryman and Bell, 2007). Furthermore participants, after a 4 days prenegotiation and face-to-face first round negotiation and post-negotiation in February 2012, all expressed their interest in continuing the research.

With above argumentation the case was selected although I did not fully commit to the project until I had collected the minimum necessary data.

## Case Study Data Collection and analysis

The chief sources of evidence in the case study are participant observations of negotiations, pre-negotiation planning and preparation, and in-depth interviews with seller participants, supplemented by other sources such as documents, e-mails, direct observations, photos etc. All participants signed a consent document which has allowed me to record all internal meetings and conference calls. In addition participants were very disciplined giving me access to documentation and I was copied in most correspondence, something that

had shown to be complicated in the previous negotiations where I participated. All data is saved in a chronological case study diary including the audio files.

The transcription of audio recordings together with the other sources of evidence will undergo a thematic analysis with the support from ATLAS.ti as described in the survey chapter. For the analysis of the case study the model developed in the previous step will be used as the analytical lens to corroborate the findings from the two studies.

## Conclusion

The research design described in this paper demonstrated congruence between the method and the research question by means of selection of appropriate data sources (open-ended survey, participant-observation and case study) and analytical procedures adapted to the research question and the methodical assumptions. Consequently methodological coherence was achieved (Morse et al., 2002).

Challenges of doing real life research in a closed setting were considered with the purpose of getting the best possible access to the field and thereby ensure an appropriate sample (Morse et al., 2002). Moreover, and to further ensure the appropriateness of the sample, purposive sampling was applied to the survey and strict selection criteria developed for the case study.

The used thematic analysis follows a detailed yet flexible recursive process involving both deductive and inductive coding followed by theme creation and definition. This careful description of the phases used in data analysis demonstrates a high degree of clarity (Braun and Clarke, 2006) allowing for replication by other researchers. Using CAQDAS to support the coding and analysis, allowed for a more through, transparent and reliable analysis and thereby adding further rigour to the research design.

Due to the nature of a doctoral study, the data coding and themes identification was done by one person only and the analysis was discussed with the supervisor. This process allowed for consistency but failed to provide inter-rater reliability (Armstrong et al., 1997). Furthermore with the necessary resources the research design could be amended to apply a multiple case design and thereby decrease the vulnerability and further strengthen the finding of the study (Yin, 2009). A multiple case study design at the expense of the survey would however not have led to satisfactory results, as richness in respondent's answers in terms of number, functions and nationality could not have been reached.

Still with the mentioned limitations in the design, I argue that the presented research design rooted in real life data has demonstrated rigour throughout the process and thereby ensured both plausible and credible outcomes central to all research (Hammersley, 1991; Yin, 2009).

Moreover, and perhaps more important, the paper has demonstrated that open-ended survey and possibly interviews despite their advantages and strengths cannot give the full answer to the given research question. The holistic inquiry approach to understanding which knowledge can be acquired by which source as shown in table 1, visualizes for this study the need to use observation to understand *What they don't know they do*. Furthermore and also part of table 1, validity through triangulation between the survey results and the participant observation, identified activities that should have been included in the survey answers – *What they know they do* – but were only captured through participant observation, again justifying the need to rely on more data sources.

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## An analysis on Unstated Concern and Stated Thought during a Discourse in Public Issue

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**Abstract**: In Japan, special committee in local transportation policy is often organized. In such the committee, the participants are expected to propose their idea from a viewpoint of the community's benefit, but they often insists on their own interest or benefit because they represent each of stakeholders. This study purposes to clarify the participant's unstated concern and stated thought during a discussion, by comparing interviews about their unstated concern with stated thought at the discussion. A word-to-word network analysis made by the frequencies of co-occurrence is applied to clarify the structure of concern. Through the statistical analysis by ordered responded probit model, several significant factors that influence participant's evaluations of a discussion are clarified.

Keywords: discussion experiment, interview survey, text mining

## Introduction

In Japan, local bus management policies are threatened due to the increase of elder people and to the acceleration of migration from depopulated area to urbanized area. Most of the bus transportation in local area suffers from unprofitable service with lower demand. Though the number of those who live in such area is small and decreasing, they have an earnest necessity to maintain the bus lines for their daily life because not a few numbers of elder people cannot drive by themself. In order to meet their demand with lower operation cost, a special committee by the local stakeholders including inhabitants, government and the bus service provider is often organized to discuss a community transportation policy.

The participants of the committee are expected to represent their organization or sector, and they are often motivated by private concerns representing the sector they belong, rather than common community goodness. In such discussion, some of differences among the participants in the subjective importance on the discussion theme are welcomed, because the discussion is made to clarify the overlooked issues in the service provision. Therefore, the various interests would contribute to fulfill the committee task about careful consideration for each stakeholder's benefit. On the other hand, the discussion such that the participants mainly hang up on the private concerns rather than community goodness would create additional conflictive issues. In this case, the other important task of the committee to find out a feasible community transportation policy is not achieved. The barren discussion should be avoided because it wastes the precious discussion time with exhausting the participants, which would result in the unfeasible proposal. In order to improve the discussion and proposal quality for the community issues, the discussion management of the moderator should be carefully designed.

Several basic rules in discussion management which should be kept by the moderator are already known. The Robert's rules of order in discourse include following four rights with four rules as: right of majority, right of minority, right of individuals and right of absences, with rule in separation of single issue to be discussed, rule in single issue not to be repeatedly discussed, rule in majority decision and rule in necessarily number of participants, respectively (Robert et al.; 2004). There are many other rules in discussion, for example, fairness among participants, management of individual talks, management of discussion purpose and preparation in meeting materials (Berg, 2009). Parallel to the conventional "static" rules that can be fundamentally applicable for any situation during the discussion, some of "dynamic" rule is strongly effective to induce a profound understanding among the participants. One of major approaches along "dynamic" aspect of discussion focuses on dialogue between the successive utterances. Clifton and Frazier (2012) pointed out that a discussion can be decomposed into several dialogues, and "question-to-answer" combinations are especially important among them. In their analysis, the sentence structure of question with its answer is analyzed by using several stenographic records of discussion, in order to clarify the effective sentence structure to induce the clear-cut answer. Schallert et al. (2009) analyzed on-line communication records

focusing on the politeness expressions. They counted on the frequencies of words which includes "politeness expression" and then compared the synchronous / asynchronous modes of discussion. They concluded that "politeness" can improve the satisfaction of discourses.

The analysis in text or documents can be classified into following two approaches. One focused on the grammatical aspect that carefully deals with the relationship among the sentences is called as microscopic approach. The other focused on the frequency of words that effectively utilizes the techniques in natural language processing is called as macroscopic / statistical approach (Jackson and Schilder; 2006). The statistical approach would be effective in discussion analysis. Chen et al. (2012a) focused on the "social cue" which appears in the discussion about how to solve the mathematical problem by students. Social cue is defined as "agree / disagree" or "emoticon" to support for or to be against to the proposal. Their analysis on social cue clarified that positive and negative social cue often appear prior to the obvious supporting or opposition opinion, and a judicious use of positive social cue is useful to construct a new idea. Chen et al. (2012b) conducted further analysis on mathematical problem discussion. In this study, their interest was put on a new idea creation factors in the discussion. By applying a binominal logit model, the factors to influence on the idea creation are "justification comment" and "an evaluation of the proposal". They concluded that such the comment would contribute to find out the missing logic. Lu et al. (2011) studied about "justification comments" and other factors by using on-line discussion records about global environmental problem. By applying the binominal logit model for "evidence-based justification" and "explanation-based justification", they found that the "evidence-based justification" tends to be used in a disagreement or claim to the former opinion. Nussbaum (2005) also applied statistical test for discussion analysis in order to deepen the understandings of reasoning of each utterance, following by Tourmin's three levels reasoning (i.e. global claim, supporting ground and warrant) model (1958). For this purpose, he conducted on-line discussion experiment with several different instructions towards the discussion goal. The analysis clarified that a difference in global instruction to construct an agreement significantly influences on the discussion complexity and its contents, and the instruction to summarize a persuasive reason is often better in terms of the usefulness of the agreement, rather than that to find reasons as much as possible. Another result is that participants who frequently confirm the cognition among the other member tend to contribute to deepen the discussion, significantly.

Looking at the conventional studies, statistical analysis on the public discussion that the participant represents his / her ground is not so much accumulated. On the other hands, the statistical techniques in text analysis are effectively applied in some studies, especially for on-line discussion analysis using experimental data. However, conventional studies mainly focus on the "stated" thought, but do not care about "unstated" concern behind the utterances of the participants. In the discussion by representatives in public transportation policy, most of inhabitants are not specialist of transportation policy but they are expected to be a mediator to their sector, so that careful support about the unstated questions and ambiguous understanding at each of dialogues is desirable by a discussion manager.

This study purposes to clarify the correspondence between unstated concern and stated idea during a face to face discussion held for a community (common) issue, in which the participants represent each sector. For this purpose, we conducted a discussion experiment and an afterward interviews viewing the video recorded the discussion. A word-to-word network analysis about the frequencies of co-occurrence is applied to figure out the structure of the participant's concern based on the stated idea and unstated thought, respectively. Through the statistical analysis by ordered responded probit model, significant factors that influence participant's evaluations of a discussion are clarified. In this analysis, our main interest lies on the relationship between the acceptance of group conclusion and the characteristics of the utterance and recognition. Note that even some of non-language communication such as body languages or facial expressions during their talks are also important in face to face communication (Julian and Gomez; 2012), but these aspects are not considered in our analysis.

## **Face-to-Face Discussion Experiment**

In order to get discussion data with the participant's concerns under the controlled conditions, we conducted a discussion experiment with interview survey to look back their talk. Considering participant availability, all the participants were collected from undergraduate students in Hiroshima University. A discussion theme in the experiment was set by considering the following conditions: 1) a participant can get interested in the theme, and 2) the agreement of the discussion affects all the other members of the

participant's community. As the theme to fulfill a couple of conditions, we set it as "a possibility of carsharing system introduction at Hiroshima University" to discuss the pros and cons of introducing the alternative transportation system. Since our university is located at a suburban area with low public transportation service and most of students use private car, motorbike or bicycle for commuting, a design of car sharing system might be appropriate as the common issue for the student community.

A discussion group consisted of six participants and a facilitator. The number of participants in a group was determined by several trials, in order to continue the communication without any long intervals to wait the utterance. The participants were asked to join the discussion as representatives of their community. Prior to the discussion, we briefly summarized the policy background and proposed three alternatives. Two of them were how to introduce the car sharing system among the students, and the other was a no-introduction alternative. The task of the discussion was to choose one of them or to find another recommendation as the group conclusion.

In order to clarify whether the amount of information in meeting materials would influence on the discussion evaluation or not, two groups without common participants were prepared to make a difference. An informed group (group 1) was provided the detailed conditions of each alternative, while a less informed group (group 2) was provided only fundamental principle of each alternative. The difference was summarized in table 1. We asked three times of meetings for both groups, and hereafter, each time of meeting is referred as "wave". In each wave, a sub-theme related to the wave agenda was set. All the utterance in discussion experiment was recorded, and then an exact stenography of each meeting was made. Hereafter, we refer to the discussion stenography as utterance records.

Plan	Concept	Common information	Only provided for group 1
а	Car-sharing station on campus	<ol> <li>Charge structure</li> <li>Reservation and Use</li> </ol>	<ol> <li>Details of the system</li> <li>Background of car-</li> </ol>
b	Car-sharing station close to students' apartment	3. Comparison with the cost of a private car	<ul><li>sharing introduction</li><li>3. Examples and benefits</li></ul>
с	No introduction of a car-sharing system		Disadvantage to introduction of a car-sharing system

Table	1.	Summary	of	alternatives.
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Table 2. Flow of the discussion experiment

1. Self-introduction of participants 5 min.	
2. Explanation of a handout 10 min.	
3. Thinking about each opinions 5 min.	First wave
4. Discussion 50 min.	T list wave
5. Summarizing a wave conclusion 10 min.	
6. Questionnaire survey 10 min.	
7. Interview investigation for the first wave 90 min.	
1. Explanation of a handout 10 min.	Second wave
2. Thinking about each opinions 5 min.	

After each wave of discussion, we conducted a questionnaire survey about the evaluation of the facilitation process and the output of the discussion. An interview to ask their thought and feelings at the several "interview" points was done as follows: 1) watching the video recorded their discussion in the wave they finished, 2) posing the video at the interview points, and 3) asking about the unstated recognitions behind their talks for each interview points. The interview points selected by an interviewer to watch the video between the waves were the occasions in transition of topics or in the conflict of opinions. Therefore, the interview for the first wave was conducted at the beginning of second wave, and it for the second wave was conducted at the beginning of third wave, it was conducted later on, to the third

discussion. Such the style of interview can save time to look back the previous discussion at the beginning of new wave. Same as the discussion body, the interview was recorded to make exact stenography of their recognition. Hereafter, we refer to the recognition stenography as recognition record. Table 2 shows the flow of the wave-of-discussion experiment.

## Word-to-word Network Analysis

A word-to-word network is made by the frequencies of collocations in each pair of words. In the network, each node indicates an independent word (i.e., noun, adjective, adverb or verb), while each link indicates a tie of couple of these words with the co-occurrence frequency above the threshold. In our study, the counting was made for each 6 utterance record (i.e. 3 waves for group 1 and 3 waves for group 2) and for each 6 recognition record. The threshold is set for each record, to cover about 35% of whole ties of words appearing in each record. The width of link indicates the frequency of each tie. Since total frequencies of the tie on each figure are different between waves, or between utterance and recognition records, we standardized the links in each figure.

The pre-processing of text data was as follows. Firstly, couples of words tied in modifying-to-modified, subject-to-verb, or object-to-verb relationship were extracted in an identical sentence, and then the frequencies of these couples were counted. The frequencies of nouns were directly counted without making semantic groups, while verbs were counted in groups with similar meanings. The verbs were classified into about 40 groups. In this stage, we eliminated the words which did not make sense by each word. For example, postpositional particles (dependent word in Japanese) appeared in the picked up couples were eliminated. Comparing the two networks between the utterance (stated) and recognition (unstated) network, we classified the ties of words on each graph into four categories, by referring to uniqueness / commonness of these couples on both networks. Details of classification criteria are summarized in table 3.

For simplicity, we only focus on wave 3 for both groups. Fig. 1 to 4 shows the word-to-word networks in group 1. Fig. 1 and 2 show the networks which include common couples of words, in utterance record and in recognition record, respectively. In fig. 1, car-sharing, plan A, 24-hours, charge and 6-hours are strongly tied with feel / think, while in fig. 2, thick ties appear between myself, talk and feel / think, or between opinion and do / introduce. Note that looking on the right side of both figures arranging identical words between utterance and recognition, the connected couples of words are significantly different.

Fig. 3 and 4 show the networks which include unique couples of words, in utterance record and in recognition record, respectively. In fig. 3, feel / think gather strong connections between car, university, private car, profitability, public transport and plan B. Other strong connections are concentrated on 24-hours, plan B, 6 hours and car. In fig. 4, talk (as noun) and talk and say, idea and feel and think are strongly tied. Comparing with fig. 3 and fig. 4, nouns with concrete meaning (i.e. car, plan, hours...) tends to appear in utterance (fig. 3), while nouns with abstract meaning (i.e. ideas, discussion, material...) often appear in recognition (fig. 4). Note that the connection between persons A, C and chair (chairman) with feel and think appear in the recognition network in fig.4. It would be because the idea in utterance of these people is often recalled in their mind during the discussion. Comparing common words couple's networks in fig. 1 or 2 with unique words couple's network in fig. 3 or 4, the formers are much simpler than the latters.

Observed in Aggregated in	recognition record	recognition record and utterance record	utterance record
recognition record	unique couple of words in recognition record	common couple of words in recognition record	
utterance record		common couple of words in utterance record	unique couple of words in utterance record

Table 3.	Category	definition	in	word	couples
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Fig. 1. The utterance network of Group 1 in Wave 3 (common).



Fig. 2. The recognition network of Group 1 in Wave 3 (common).



Fig. 3. The utterance network of Group 1 in Wave 3 (unique).



Fig. 4. The recognition network of Group 1 in Wave 3 (unique).



Fig. 5. The utterance network of Group 2 in Wave 3 (common).



Fig. 6. The recognition network of Group 2 in Wave 3 (common).



Fig. 7. The utterance network of Group 2 in Wave 3 (unique).



Fig. 8. The recognition network of Group 2 in Wave 3 (unique).

Fig. 5 to 8 shows the networks in group 2. Fig. 5 and 6 show the networks which include common couples of words in group 2, in utterance record and in recognition record, respectively. In fig. 5, car-sharing is very strongly tied with feel / think, or do and introduce. Other strong ties appear between car-sharing station and feel / think. Fig. 6 shows very similar network structure with fig. 5, except the thick ties between time and feel / think only appearing in recognition network. Such the similarity would suggest that the participants deeply consider about the car sharing policy before their state of opinion. In fig. 7, car, plan B and residence are strongly tied with feel / think. On the other hand, the ties between idea or opinion and do / introduce, or between problem and feel / think are stronger in fig. 8. As same as group 1, the ties between persons C, F and feel / think appear in the recognition network in fig. 8 due to the frequent recall of their opinions by other participants.

The ties between myself and opinion or between idea and feel / think or do / introduce appear in some extent in the recognition network, and material appears only in the recognition network. These words in recognition network would suggest that participants consider or hesitate in their minds about how to express their opinion, by referring to the hand-out material in car-sharing system.

The findings in word-to-word network analysis can be summarized as follows. About the common words in group 1, the tied couples of words are significantly different between utterance and recognition. About the unique words in group 1, concrete words often appear in utterance, while abstract or conceptual words frequently appear in recognition. The names of some participants are often appeared in recognition network, so then the participants often recall their state in their minds, which is commonly observed in group 2. The network structure is more complex in the unique words network than the common. About the common words in group 2, the network structure is very similar between utterance and recognition, while about the unique words in group 2, the tendencies of words appearing in recognition network are different to utterance. We can point out about group 2 that the participants consider or hesitate in their minds about how to express their opinion, by referring to the hand-out material in car-sharing system. Note that the last consideration is not applicable in group 1.

## Statistical Model Analysis on Discussion Evaluation

In order to clarify the characteristics of utterance and recognition would affect the discussion evaluation indices, we applied a statistical model. We picked up the following four evaluation indices as the objective variables, which are related to discussion quality, namely 1) understanding, 2) interest, 3) atmosphere, and 4) deepness of the discussion. These are asked by a rating with four categories (ex.: no, slightly no, slightly yes and yes). Understanding is how adequately the participant figures out the topics. Interest is how actively the participant joins to the discussion. Atmosphere is how easily the participant states his opinion. Deepness is how profoundly the given theme is discussed in.

We applied ordered responded probit (ORP) model for each index (Maddala, 1986) ,which is often applied in the marketing or econometrics fields to find out the attributes of the good and its rating. Suppose dij is a dummy variable whether the respondent i (i=1,...,N) answer category j (j=1,...,J:  $d_{ij}$  =1) or not ( $d_{ij}$  =0), the probability to answer the category j by i  $P_i(j)$  can be formulated as eq. (1).

$$P_{i}(j) = \prod_{j} \left\{ CN(\theta_{j} - V_{i}) - CN(\theta_{j-1} - V_{i}) \right\}^{d_{ij}}$$

$$V_{i} = \sum_{k} \beta_{ik} x_{ik}$$

$$(1)$$

$$L = \sum_{i} \log P_{i}(j) = \sum_{i} \sum_{j} d_{ij} \log \{ CN(\theta_{j} - V_{i}) - CN(\theta_{j-1} - V_{i}) \}$$
(3)

where, CN() is a cumulative normal distribution function, Vi is an evaluation function of respondent i with explanatory variables xik, are the parameters in the evaluation function, while are the parameters in category threshold. Note that for the model identification, some of them are fixed as , : CN()=0 and CN()=1, so then only and are to be estimated. The parameters were estimated by maximum likelihood method with log-likelihood function in eq.(3).

Evaluations for these four indices are made for each participant, for each wave, so then the number of sample is 36 (= 6 participants \* 3 waves \* 2groups). The estimated parameters in four models are summarized in table 4. Explanatory variables in the models are follows: question to facilitator, proposal to participants, instruction from facilitator, couples of words appearing in recognition network, common couples of words and group 2 (less information group) dummy. Common couples of words in utterance and recognition records are the number of ties in the word-to-word network, and group dummy is set for group 2. All the other variables are recorded as frequencies. The first three variables are made from utterance record. Question to facilitator is only made from participants, while proposal to participants is made from both facilitator and participants. Couple of words in recognition record is an index to illustrate how the participants think and consider in their mind. On the other hand, common couple of words is made by referring to both records, by counting the couple of words appearing in both records. Hence, this variable indicates how the participants smoothly connect their thoughts and utterance during the discussion.

imates Estimates Estima	tes
963 + 0.908 * -0.02	.3
369 0.488 -0.45	3 *
.077 -0.232 * -0.00	19
.001 0.000 0.00	3 **
.967 1.590 6.03	8 **
.839 -1.975 * 1.13	7
052 2.064 -12.0	94 **
428 0.361 1.04	0
380 2.988 0.22	0 *
36 36	36
7 7	7
-49.91 -49.91 -49	9.91
-29.44 -23.77 -23	5.84
0.23 0.34 0	.30
	imates         Estimates         Estimates         Estimates $963$ + $0.908$ * $-0.02$ $369$ $0.488$ $-0.45$ $.077$ $-0.232$ * $-0.00$ $.001$ $0.000$ $0.00$ $.967$ $1.590$ $6.03$ $.839$ $-1.975$ * $1.13$ $052$ $2.064$ $-12.0^{\circ}$ $428$ $0.361$ $1.04$ $380$ $2.988$ $0.22$ $36$ $36$ $36$ $7$ $7$ $-49.91$ $-49.91$ $-49.91$ $-49.91$ $-49.91$ $-49.91$ $-29.44$ $-23.77$ $-22$ $0.34$ $0.52$

Table 4.	Parameter	estimates	of	discussion	evaluation	models

\*\* : significant at 1%, \*: significant at 5%, +: significant at 10%

Table 5. Parameter estimates in acceptance of group conclusion

Explanatory variables	Estimates	t-statistic	
Understanding	0.009	0.03	
Interest	0.018	0.05	
Atmospare	0.166	0.45	
Deepness	0.343	1.59	
Constant	-0.141	-0.15	
Sample size	36		
Number of parameters 5			
Initial log-likelihood	-49.91		
Log-likelihood at convergence	-34.55		
Adjusted likelihood ratio	0.19		

The goodness of model fit index in table 4 ranges from 0.23 to 0.36, so they are fairly good. Understanding for discussion is significantly lessened by increase of question to facilitator, and other variables are insignificant. Interest for discussion is significantly raised by increase of question to facilitator, and as same as understanding model, all the other variables are insignificant. Atmosphere of discussion is significantly raised by increase of question to facilitator and group 2 lessen the atmosphere by their increase. Finally, deepness of discussion is significantly lessened by increase of proposal to participants, while couple of words and common couple of words raise the evaluation by their increase. These results would suggest that understanding and interest is more difficult to find significant factors than atmosphere and deepness. In terms of atmosphere of discussion, active question from participants and less instruction from facilitator to the participants seem to be desirable. Deepness of discussion is much explained by recognition related index, rather than utterance related index. In our experiments, frequent proposal to participants is not desirable, and active recognition and frequent co-occurrence between recognition and utterance are desirable in deepness of discussion. Note that the group dummy is only negatively significant for atmosphere, but insignificant for others. It is worth referring that less informed participants (group 2) would not give lower evaluation in terms of discussion.

Table 5 shows the estimated parameters of ordered responded probit model which objective and explanatory variables are set as acceptance of group conclusion, and four indices of discussion evaluation, respectively. The model fitting is 0.19, which is not so high. Note that four parameters in discussion

evaluation are all positive but insignificant, the significant level of explanatory variables is highest for "deepness of discussion". Comparing two models in table 4 and 5, we can conclude that recognition of discussion participants would mostly influence on the deepness of discussion, and which have the highest significant level over four evaluation indices. This finding would be important in discussion management. For example, even the facilitator can manage the discussion with active participations, the deepness of discussion would not be raised among the participants, and the group conclusion made in the above discussion would not be highly evaluated by the participants. Of course, further study is required to confirm our findings.

## Conclusions

Since the community transportation management in Japan, typically for bus service, requires substantial discussion among stakeholders, the discussion management by local government becomes important. In order to shed light on this problem, this study conducted a discussion experiment for two groups. One group was provided more information about the policy alternative, but the other was not. The originality of our approach was to clarify the relationship between unstated thought (recognition record) or idea and stated discussion (utterance record). In order to clarify the difference between unstated thought and utterance, we applied word-to-word network analysis to these text documents based on frequency counts of co-occurrence of noun and verb groups.

The couples of words included in each record were classified into the following four categories to compare them as unique words counted in recognition records, common words counted in recognition records, common words counted in utterance records and unique words counted in utterance records. Comparing these word-to-word networks, several common and different characteristics in recognition and utterance network were clarified. About the common words in informed group, the tied couples of words were significantly different between utterance and recognition. The names of some participants were often appeared in recognition network, so then the participants often recall their state in their minds in informed group, which was also observed in less informed group. The network structure was more complex in unique words network, rather than common words network in informed group. About the common words in less informed group, the network structure was very similar between utterance and recognition. About the unique words in less informed group, the tendencies of words appears in recognition network were different to utterance. Therefore, the participants in the less informed group tends to consider or hesitate in their minds about how to express their opinion, by referring to the hand-out material during the experiment. Note that the last consideration was not applicable in informed group.

Ordered responded probit models to explain discussion evaluations by the characteristics of utterance and recognition records showed that understanding, interest and atmosphere were strongly affected by utterance characteristics, while deepness was affected by recognition characteristics. The most important finding of our experiment would be relatively high contribution of deepness of discussion to the acceptance of group conclusion. In case that the manager of discussion purposes to get the acceptable conclusion for policy alternative, a discussion management to achieve an active interaction which can get higher evaluations in understanding, interest and atmosphere from the participants would not be adequate. Instead, even the discussion seems not to be active, stimulating the consideration of participants would be desirable.

The remaining issues are as follows. Word-to-word network analysis should be revised. For example, an analysis focusing on question to answer relationship would be interesting. In terms of discussion conclusion acceptance, further experiment whether the audiences of the meeting accept the conclusion or not would give us more important insight about discussion management.

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# Evaluation for Workshop Discussion from the Viewpoint of Social Acceptability

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**Abstract**: This study proposes the method of quantitative analysis for evaluating Workshop discussion from the view point of public support. By introducing WS discussion into participatory planning process, there are two-stage management processes; management of planning process and management of WS discussion and some perception gaps such as between planners and participants are revealed. The major objectives of this paper are to make clear these gaps quantitatively and to establish a management solution for minimizing them.

Keywords: discussion in workshop, participatory planning process, social context, newspaper article

## Introduction

Many workshop (WS) discussions and public meetings have been held in participatory planning process. These WS discussions are expected to promote better understanding among citizens and to make a better decision in planning process. However, in WS discussion, some problems such as conflict of interests, misunderstanding and perception gaps between participants and planner, may hinder mutual agreement. In particular, when WS discussion is held in participatory planning process, there are also perception gaps between participants and perception gaps between participants in WS discussion. The plan proposed in WS discussion finally needs public support because the plan should improve social welfare.

Several studies have analyzed participants' utterance content and transition of their opinions quantitatively in public discussion. Jeong et al. (2007, 2008) proposed a new methodology to investigate the level of dialogue similarity and interest dissonance among participants in public debate objectively using first corpus of debate minutes. Nanba et al. (2010) proposed to develop the stylized procedure for text data mining, which can capture the opinion, context, and transition of them by using Markov transition analysis. In our previous study (Chosokabe, 2012), we proposed the methodology based on text mining for quantitative analysis in order to develop WS discussion.

These analyses make participants' utterance content clear, so it is easy for facilitator to understand participants' concern. However it has not been clear what ideas and opinions should be adopted for the plan. It has been also unclear how to apply WS discussion to participatory planning process in proper way. It really needs to discuss how to promote WS discussion and to manage participatory planning process.

This paper makes a point that two-stage management process is needed when WS discussion is introduced in participatory planning process. One is "Management of planning process," and the other is "Management of discussion." The evaluation methodology is also needed to detect perception gaps and to mitigate them. The major objective of this study is to propose two kinds of criteria; one is named "social acceptability", which suggests the possibility that the proposed plan will obtains public support and other is named "context maintenance rate", which represent effectiveness of WS discussion.

It is useful for facilitator and planner to develop criteria in order to evaluate WS discussion. They can coordinate participants' ideas and opinions better by using the criteria.

## Management of participatory planning process

## Management of participatory planning process

For introducing WS discussion into participatory planning process, its management has two aspects; "Management of planning process" and "Management of discussion" (Fig.1). Management of planning

process is to create socially significant alternative based on WS discussion. On the other hand, management of discussion is to facilitate discussion in order to make participants' opinions clear and to coordinate their ideas.

From the view point of "management of planning process," WS discussion is one component of participatory planning process. The contents discussed in WS discussion need to be adopted for planning effectively. This study refers to this management as step-by-step planning process, as shown Fig.1. This process has the following 4 phases: (i) hypothesis setting, (ii) first discussion, (iii) rephrasing and (iv) second discussion. Details of these phases are as follows.

## **PHASE 1: Hypothesis Setting**

First planners identify the issues to be discussed in participatory planning process. Then, planners generate some ideas to solve these issues, and also expect what residents think about the problems. In this study, these ideas and expectations are called "initial hypothesis". In this study, we assume that planners need initial hypothesis for better understanding of residents' concerns. Through participatory process, residents may lodge their objection to the hypothesis, and planners may modify the hypothesis. However, without any initial hypothesis, participants sometimes feel difficulty in understanding planners' intension. Finally, planners prepare a WS discussion for residents who live in the corresponding community.

#### PHASE 2: First discussion

WS discussion for residents is organized by planners. Through WS discussion perception gaps between participants' concern and planners' initial hypothesis are revealed. Residents may represent new concerns, which have not been expected by planners. Residents may also show the new perspective on the issue.

#### PHASE 3: Modification of hypothesis, Reconstruction of discussion

In order to mitigate perception gaps found at phase 2, planners should develop an argument. They need to facilitate mutual understanding and promote sharing of participants' concern. For this objective, it is important for a facilitator to reconstruct discussion. One of typical methodologies for reconstructing discussion is rephrasing statements so that it is easy to be understood.

#### PHASE 4: Second discussion

After bringing up some statements rephrased as sharing with the floor, these are given at Phase 3, planners set up the second workshop with residents. Planners and participants can cultivate a shared understanding of the local problem and issues through their discussion.

Some perception gaps mentioned in phase 2 are revealed by introducing WS discussion into participatory planning process. Fig.2 shows four types of perception gaps in society. When WS discussion is held in society, four types of perception gap are revealed as follows.

- (a) Gaps among participants of WS discussion
- (b) Gaps between planners and participants
- (c) Gaps between residents who participate in discussion (participants) and residents who don't participate.
- (d) Gaps between planners and residents who don't participate in discussion.

In many cases, planners are governmental officials or planning engineers and participants are residents. (a) and (b) types perception gaps are revealed through WS discussion. At the beginning of participatory planning process, planners have some ideas on how to solve these problems. On the other hand, residents have their own perspectives on the problem, interest and demand for community, which can be called "local concerns". Consequently there may be a perception gaps clear and to mitigate them, WS discussion is introduced in local society by planners.

In contrast, (c) and (d) types perception gaps are not revealed directly in WS discussion itself. Residents who don't /can't participate in it also have local concerns so that planner needs to consider them. Here, new types of perception gaps are assumed as follows (Fig.2).

- (c)' Gaps between participants and a media
- (d)' Gaps between planner and a media

(c)' and (d)' type's perception gaps are revealed by comparing the contents of WS discussion with the contents of media. This study assumes that a media reveals a social context so that local concern is involved in media. Both the structure and content of media narratives and the narratives of our daily discourse are interdependent, that together they allow us to frame and measure experience (Silverstone, 1981). We discuss the detail of the concept of context in 3.1.

By making (c)' and (d)' types perception gaps clear, (c) and (d) types perception gaps are estimated indirectly. If the content of WS discussion is similar with the media, it is suggested that there is no wide perception gap between participants and the general public. In other words, participants' concerns in discussion and public concerns are similar so that proposed plan by participants is possible to gain public support. If the content of WS discussion is different from the media, it is suggested that there is a wide perception gap between participants and the general public. Participants' concerns in discussion are different from public concerns so that proposed plan by participants is possible not to gain public support. Planner needs to rephrase the content discussed by participants into easier understood by the general public at phase 3.

There are three main roles of discussion in participatory planning process. First, WS discussion should make participants' concerns clear. Participants have their own characteristics and different concerns from planners. WS discussion makes them clear which are participants' concerns and perception gaps between participants and planners. Secondly, it should mitigate perception gaps between planners and participants. And then thirdly, it should promote participants' understanding to enable to share their concerns. Then this study regards a discussion as a component of step-by–step planning process.



Fig. 1. Two-stage process of participatory planning process



Fig. 2. Perception gaps in local society

## Management of Workshop discussion

Management of WS discussion is discussed in this section. In management of WS discussion, planner needs to promote smooth communication between participants.

In WS discussion, participants' characteristics may hinder mutual understanding between them. Participants have equal opportunity to talk so that they can talk freely. They can say anything that comes into their mind. Additionally, they do not have enough skills to talk logically. In fact, the content of participants' stories is sometimes unclear in WS discussion. Participants do not necessarily have complete opinion on policy topics. They are expected to complement each other and to form common ideas. Facilitating WS discussion is difficult for planners because of these participants' characteristics.

The KJ method (Kawakita, 1986) is practiced to make participants' ideas clear and to coordinate them in many of WS discussion in Japan. The standard process of the KJ method is shown in Fig.3. It consists of four main steps: (i) generating ideas on the table and recoding them, (ii) sorting related ideas into a group and giving each group a title, (iii) finding a relationship of each group and making a diagram of it and (iv) summarizing ideas with repetition of (i)~(iii). The KJ method is convenient for planner to make participants' ideas and opinions clear. And it also promotes participants to understand each other. Through this method their ideas and opinions are visualized and deeper level of communication with each other is promoted. Therefore participants can easily understand each idea and opinion each other.



Fig. 3. Standard process of the KJ method

## Evaluation approach for Workshop discussion

In this chapter, two criteria for evaluation of workshop discussion are introduced. These are "Social acceptability" and "Context maintenance rate."

Based on WS discussion, participants' opinions and ideas are coordinated, and finally the plan is proposed. Legitimacy of the proposed plan is generated by the support of not only WS participants but also general public. In other words, proposed plan should be understood and accepted by both participants and the general public. First, the plan should be supported by participants of WS discussion. That is, the plan should be accepted by participants. Secondly, the proposed plan needs to be accepted by public, too. This is because the plan should be beneficial for whole society. In 3.1, we propose "social acceptability" criteria in order to evaluate the possibility that the proposed plan will obtains public support. Similarity of context is used as measure of social acceptability. In 3.2, we also propose "context maintenance rate", which shows whether contents of discussion function successfully in planning. Social acceptability is the measure how much acceptance the plan has been gained by public. Detail of each measure is to be described below.

## Social acceptability

Social acceptability is the criteria for evaluating the possibility that the proposed plan will obtain public support. Public support depends on whether people can understand value or significance of proposed plan. Planners who propose a plan should make its concept more easily understood and accepted by the general public. In other words, planners need to develop a common context with the general public to gain his/her understanding for proposed plan.

Context has two aspects, "verbal" context and "social" context (Leckie-Tarry, 1995). Verbal context is a meaning which is understood from the relationship between words, phrases or sentences. Social context is a societal and cultural background for these words, phrases and sentences to be written or spoken. When people live in the same culture, the way of words tends to be similar. This paper defines the way of words as how to choose words and how to combine words. The similarity of a context appears in the similarity of the way of words. That is, when the way of words (choosing and combining words) is alike in the community, there is a common social context in a community. In other words, if there are similar terms used simultaneously and frequently, there is a similar social context.

This paper analyzes the similarities and differences between the words used in the proposed plan and the words used in society. If the way of words in the proposed plan is similar with that in society, it is regarded that a common social context is found in both the proposed plan and society. When the proposed plan and society have the common contexts, the proposed plan is easily understood by the general public. In contrast, there is no common context between the proposed plan and society if there is a huge difference between the way of words in the proposed plan and that in society. Then the proposed plan is hard to be understood and accepted by the general public. It is important for planners/participants what kind of words they choose and how to combine them in order to share common social context with the general public.

In order to identify and to explain social context, in this paper, the way of words in newspaper articles is referred to as a sample of how to use the words in society. People read newspaper articles and understand them and then talk about the topics of the newspaper articles with family, friends, or coworkers. People share the written words of newspaper articles. We assume that there is a strong relationship between a context in newspaper articles and social context. Some similarity to the way of words in a newspaper article promotes public understanding toward the proposed plan. It is also expected that the plan understood by the general public tends to be accepted.

This paper distinguishes between verbal context and social context as follows. Verbal context of WS discussion is represented by the word group which is frequently used simultaneously in WS discussion. On the other hand, social context is presented by word group which is frequently used simultaneously in newspaper articles. When word groups used in WS discussion and newspaper articles are similar, it is interpreted that verbal context of discussion and social context have consistency. In this paper, the occurrence frequency between two word groups is analyzed. One is the group of words and phrases which constitute topics of WS discussion. The other is the group of words and phrases which constitute newspaper article. This analysis shows clearly whether these two groups are similar or not.

#### Context maintenance rate

Context maintenance rate shows how much participants' concerns in one WS discussion are maintained in the next WS discussion. Context among participants is generated through several times WS discussion. Large variety of ideas and opinions are created in the first WS discussion. Facilitator and participants coordinate these ideas in order to make their message clear. After several WS discussions, they finally adopt some ideas for plan. It suggests that final plan includes the concerns which are recognized as critical by participants. In other words, participants continue to discuss the ideas which are critical for participants. For successful discussion, facilitator first should identify participants' concerns and then adopt them for a plan.

Participants' concerns are expressed by participants' phrases in WS discussion. Context maintenance rate (C.M.R. in short) shows what kind of words and phrases are much more to be adopted for a planning process. It is calculated by noun phrases which are used in WS discussions. It is defined as (1) type.

C.M.R. = {the number of words which appeared in both n-th and (n+1) th discussion summary} / (the number of words which appeared in n-th discussion summary). (1)

A formula (1) shows how much the words have appeared in the (n+1) th discussion summary, which are included in the noun phrases in the n-th discussion summary. In other words, it represents percentage of the same words appeared in the discussion as well as the last discussion. It compares the words which appeared in the n-th discussion to the words which appeared in the (n+1) th discussion.

As a context maintenance rate is high, that means the noun phrase group appeared also in the next discussion. In other words, the facilitator and participants have chosen these noun phrases and combined

them to coordinate their ideas and opinions. It shows that these noun phrases have been understood and accepted by them. On the other hand, if the context maintenance rate of word group is low, that means these words do not appear in the next discussion. The facilitator and participants have not chosen these noun phrases and combined them in the next discussion.

Context maintenance rate can be used to explain the process which words a facilitator and participants choose and combine through WS discussion. In many cases, WS discussion is held more than once and they coordinate their ideas and opinions for each time. Facilitator sometimes needs to pick up the topic which seems to be valuable for continuous discussions. Facilitator needs also to rephrase participants' remarks into more appropriate words to adopt their opinion for a proposed plan. Context maintenance rate is helpful to see the word group in a hierarchical way. The word group of which context maintenance rate is high is regarded as well-formed opinion. In contrast, that of which context maintenance rate is low is not well-formed opinion. It suggests the word group is unnecessary for next discussion or needs to be rephrased and better summarized to adopt it then. Context maintenance rate of these words changes higher by rephrasing them in other words. Context maintenance rate promotes the facilitator to review what words he need to choose and how to combine them.

#### Relations between social acceptability and adoption rate

This paper has hypotheses that the groups of words with high social acceptability result in high context maintenance rate. A context maintenance rate of word group is expected to be higher if the word group has higher social acceptability. The facilitator is assumed to choose the words and phrases whose social acceptability is higher and combine them. These words are the words which are easily understood and accepted by public and are suitable for being adopted in a proposed plan.

If there exits positive correlation between social acceptability and context maintenance rate, facilitator should take effort to improve social acceptability of word groups. For improving social acceptability, facilitator can rephrase words remarked by participants as words which are more acceptable by the general public. Then, it is expected that context maintenance also becomes higher. Social acceptability and context maintenance rate are useful for a facilitator to rephrase the word group appropriately and effectively.

Fig.4 is a schematic view which shows context maintenance rate and social acceptability. Vertical axis represents context maintenance rate and horizontal axis represents social acceptability. Context maintenance rate and Social acceptability of the word group are calculated and they are plotted on fig.4. There are four areas where;

- 1. Both context maintenance rate and social acceptability are high
- 2. Social acceptability is high; however context maintenance rate is low
- 3. Both context maintenance rate and social acceptability are low
- 4. Context maintenance rate is high; however social acceptability is low

If the word group is plotted in area (1), these words have been summarized successfully and also they will be easily understood and accepted by both participants and public. It suggests that these words represent "high social context" or "shared social context" as shown in Fig.4.

If the word group is plotted in area (2), these words will not be adopted for next, while these words will be accepted by public.

If the word group is plotted in area (3), these words have not been summarized successfully and they will not be understood nor accepted by both participants and public. These words need to be rephrased as the words of which social acceptability is higher for gaining public support.

If the word group is plotted in area (4), these words may not be understood nor accepted by public. These words, however, have been accepted and reflected into the next discussion by participants. It suggests that these words represent "participants' high originality" as shown in Fig.4.

Thus, the word group can be arranged in a spatial dimension. By using this figure, the facilitator can understand the whole topics spatially. Facilitator can find the topic which needs to be changed into more

understandable terms and rephrase it. Then, this figure is useful for the measure what kinds of words are suitable to be adopted for a proposed plan.



Context maintenance rate (high)

Fig. 4 Adoption rate and Social acceptability

## Analysis of WS discussions

## Methodology

In this analysis, co-occurrence between words is measured as social acceptability first. Context maintenance rate between word groups of each discussion (3.2) is also calculated. Then social acceptability and context maintenance rate of word group are shown diagrammatically, which define a relationship between social acceptability and context maintenance rate. This analysis evaluates word group used in WS discussion quantitatively.

Two different kinds of data are analyzed; dialogue data and description data. Dialogue data is composed of the word group which was identified by the transcript of the WS discussion as the topic of it. In our previous study (Chosokabe, 2012), each of ten noun phrases was determined as each topic from the participants' remarks in WS discussion. Description data is composed of the word group which was summarized by a facilitator and participants through discussions as the result of WS discussion. In WS discussion, participants summarize their remarks and make a document each time.

Social acceptability is measured by means of co-occurrence between words, known as Jaccard coefficient (Ishikawa, 2011). Jaccard coefficient is calculated in order to measure a co-occurrence between the word groups used in WS discussion and the word groups used in the newspaper article. Co-occurrence means, in this paper, that *word* A and *word* B are frequently used together at the same time. Jaccard coefficient is defined as:

$$J(A, B) = |A \cap B| / |A \cup B|.$$
<sup>(2)</sup>

In this paper, co-occurrence between *word* A and *word* B is defined as:

C (*word A*, *word B*) = (the number of newspaper articles using both *word A* AND *word B*) / (the number of newspaper articles using *word A* OR *word B*). (2)'

Only noun phrases in dialogue/description data are used in the following analysis. Formula (2)' shows how often *word* A and *word* B have appeared in the same newspaper articles. The similarity and diversity of two words on newspaper articles can be compared with the words used in WS discussion. Average of Jaccard coefficient per one pair of word is measured to assess the correlation between social acceptability and context maintenance rate. Jaccard coefficient is calculated for each pair of words in dialogue data and description data. The total amount of Jaccard coefficient divides by the number of words. Then, an average of Jaccard coefficient per one pair of word is calculated.

In dialogue data, *word* A and *word* B are the words which were determined from the transcript of the WS discussion. These words are frequently used by participants in some close remarks. In description data, *word* A and *word* B are the words which were written in card and were sorted into the same group by participants, using the KJ method. These words are determined by participants that the each content of these words is similar to each other, which are sorted into the same group.

It is assumed that the verbal context of WS discussion is similar to the social context when two words which appear in WS discussion have a high co-occurrence in newspaper articles. When Jaccard coefficient of two words is high, the frequency of simultaneous appearance of these words is high. This means these words are often used in the same news paper articles. It is shown that the context of situation where these words appear is similar to the context of newspaper article. In this paper, it is assumed that the context of newspaper articles shows a social context. Therefore the words whose co-occurrence is high in newspaper article have high social acceptability. It is suggested that these words are easily understood and accepted by public.

Context maintenance rate is calculated from formula (1). Context maintenance rate shows what percentage of the same words appeared in the discussion as well as the last discussion. It compares the words which appeared in the *n*-th discussion with the words which appeared in the (n+1) th discussion. It is calculated by noun phrases which are written or spoken by participants in WS discussions. This study calculated context maintenance rates of both dialogue data and description data. In dialogue data, context maintenance rate shows what percentage of the same words spoken in the discussion as well as the last discussion. In description data, context maintenance rate shows what percentage of the same words spoken in the discussion as well as the last discussion.

Calculated average of Jaccard coefficient and calculated context maintenance rate were shown as prevarication figure. This figure shows a relationship between social acceptability and context maintenance rate.

## Results

Our analysis was conducted for the WS discussion on environmentally-sustainable transportation in Ube city, Japan, in 2010. This WS discussion was held once in two weeks during two month and the total number of discussions was five. The number of participants was approximately 50, and they are citizens selected from applicants, planning engineer and officials of the city government. Participants were assigned into five small groups according to subjects of discussion and each group has about ten participants. They discussed different subjects about environmentally-sustainable transportation; encouraging citizens to use eco-friendly transportation, to refrain from using automobile and to promote buses and trains and so on. This study analyzed three WS discussions which consist of these four steps, except 1st and 5th discussions.

The process of this WS discussion consists of four main steps: participants (i) generate ideas and write down them on card, (ii) sort ideas into groups, (iii) re-sort ideas by its importance and (iv) make a draft of action plan, as shown in Fig.5. In each step and each group, participants summarized their ideas and opinions as the result of the discussion. They wrote down their ideas and opinions on a sheet of paper. There were 15 documents and one action plan they produced through WS discussion. The description data is these documents. The dialogue data is the transcripts from recorded discussions.



Fig. 5 Process of the WS discussion

To calculate Jaccard coefficient we use internet search site "KIKUZO II VISUAL" provided by *Asahi simbun digital*, where we can search newspaper article with the keyword. The object of searching is the newspaper article which was published in the past decade from Jun 2001 to Jun 2011 and included the word "*traffit*".

This paper shows the results of group 2 and group 3. Table.1 and Table.3 show context maintenance rate (C.M.R.) and average of Jaccard coefficient (A.J.) of each topic in dialogue data on 2nd WS discussion and 3rd WS discussion. It is defined that ten noun phrases compose each topic in all topics by using the data from previous study. In previous study, we used factor analysis for analyzing the dialogue data, and identified topics discussed in the discussion. For example, there were 7 topics at 2nd WS discussion in group 2 as shown in Table.1.

Table.2 and Table.4 show context maintenance rate (C.M.R.) and average of Jaccard coefficient (A.J.) of each topic in description data on 2nd WS discussion and 3rd WS discussion. In each WS discussion, participants sorted their related ideas into the group which is called "theme" and also they named each group as "title". For example, participants sorted 25 kinds of noun phrases together and named them "*Bus service*" as shown theme 3 in Table.2.

Context maintenance rate from 2nd WS discussion to 3rd WS discussion and average of Jaccard coefficient of each topic or theme about group 2 are plotted on Fig.6: these of 3rd WS discussion are plotted on Fig.8. Also, context maintenance rate from 3rd WS discussion to 4th WS discussion and average of Jaccard coefficient of each topic or theme about group 2 are plotted on Fig.7: these of 3rd WS discussion are plotted on Fig.9.

Following are the results of this analysis.

- i. Theme 3 of description data at 2nd WS discussion in group 2 has high average of Jaccard coefficient and also has high context maintenance rate, as shown in Fig.6. The word group which is composed of 25 kinds of noun phrases has high average of Jaccard coefficient. It is suggested that these words are frequently used simultaneously in newspaper article which included the word "*traffit*". In this paper, it is represented these words have high social acceptability. We assumed these words as representing "high social context". Context maintenance rate of these words is 100%, in other words, all of these words were chosen by participants at next 3rd discussion. It is shown that participants in group 2 discussed about "*bus service*" at both 2nd and 3rd discussion.
- ii. Topic 5 of dialogue data at 3rd WS discussion in group 2 has high average of Jaccard coefficient and also has high context maintenance rate, as shown in Fig.7. The noun phrases which composed topic 5 are "*bus*", "*route*" and "*project*" and so on. The average of Jaccard coefficient of these words is high, so that these words are frequently used in newspaper article which included word "*traffu*", in other words, these words represent high social context.
- iii. Theme 1 of description data at 3rd WS discussion in group 2 has low average of Jaccard coefficient and also has low context maintenance rate, as shown in Fig.7. The word group which is composed of 14 kinds of noun phrases and named "*ICT*" has low average of Jaccard coefficient. It is suggested that these words are not frequently used simultaneously in newspaper articles which included word "*traffit*". In this paper, these words do not represent social context, which was assumed. Context maintenance rate of these words is 0.07, in other words, only one noun phrase is recorded by participants at 4th WS discussion. It is shown the theme about "*ICT*" was not adopted into the action plan of group 2. It is considered that this theme should have been rephrased by using other words.

- iv. Theme 4 of description data at 3rd WS discussion in group 2 has high average of Jaccard coefficient and also has relatively high context maintenance rate, as shown in Fig.7. The word group which is composed of 15 kinds of noun phrases and named "*the needs of buses*" has high average of Jaccard coefficient. It is suggested that these words are frequently used in newspaper article which included word "*traffit*". It is also shown the theme about "*the needs of buses*" was relatively adopted into the action plan of group 2.
- v. Topic 5 of dialogue data at 2nd WS discussion in group 2 has relatively low average of Jaccard coefficient but also has high context maintenance rate, as shown in Fig.6. The noun phrases which composed topic 5 are "*bus*", "*utilization*", "*eco-point*", "*commuter pass*" and "*project*" and so on. It is suggested that these words are not frequently used in newspaper article which included word "*traffit*". In this paper, these words have low social acceptability. However, context maintenance rate of these words is high; in other words, this topic was discussed by participants at next 3rd discussion. In this paper, the word group of which context maintenance rate is high but social acceptability is low is represented "participants' high originality".
- vi. The results (i)  $\sim$  (iv) suggest there exits positive correlation between average of Jaccard coefficient and context maintenance rate; that is also shown as in Table.1 and Table.2.
- vii. As seen in Fig.7, context maintenance rate of description data is totally low, however, that of dialogue data is totally high comparing with description data. Low context maintenance rate of description data suggests that most of theme is rephrased in other words when it is adopted into action plan. High context maintenance rate of dialogue data suggests that the topics discussed by participants remain unchanged so that participants' concerns are maintained.
- viii. As well as the data of group 3, there exits positive correlation between average of Jaccard coefficient and context maintenance rate, except the dialogue data at 2nd WS discussion, as shown in Table.3 and Table.4.

## Discussions

For successful WS discussion, facilitator needs to put participants' phrases into different terms which are easily understood by both participants and the general public. This paper proposes that he/she should choose the words of which social acceptability is higher and combine them to gain both participants' understanding and public support.

Facilitator has three opportunities to intervene the WS discussion for rephrasing terms; in the phase of dialogue, the phase of description and the phase of preparation for next discussion. First opportunity is when participants present their ideas and opinions. When a facilitator finds that the terms participants use is unclear, he/she can put their terms into more appropriate ones. Second opportunity is when participants describe their ideas and summarize them. Actually it seems to be difficult for participants to clarify what is on their mind and also to describe it in clearly understandable terms. When a facilitator finds the unsuitable terms which are not summarized clearly, the facilitator can support participants to describe them suitably. Final opportunity is when next discussion is prepared. As using this figure which shows context maintenance rate and average of Jaccard coefficient, facilitator can find the topic or theme which needs to change into more understandable terms and rephrase it. They put it into terms which have higher social acceptability and can facilitate next WS discussion. This figure is useful for the measure what kinds of words are suitable to be adopted for a proposed plan.

## Conclusion

In this paper, we proposed the methodology for conducting evaluation of WS discussion.

In section 2, we discussed about the management of planning process and the management of WS discussion itself. From the view point of step-by-step planning process, WS discussion is regarded as one component of participatory planning process.

In section 3, two criteria for evaluation of WS discussion were introduced; social acceptability and context maintenance rate. By using newspaper articles, similarity/difference between the contents of WS discussion

and social context was analyzed. Context maintenance rate showed whether contents of discussion function successfully in planning.

In section 4, these criteria were practically applied to dialogue data and description data of WS discussion in Japam. These results showed that there exits positive correlation between social acceptability and context maintenance rate. For improving social acceptability, facilitator can rephrase words remarked by participants. Then, it is expected that context maintenance rate also becomes higher.

In the management of WS discussion, facilitator has some opportunities to intervene the WS discussion for rephrasing terms. In the management of planning process, planner understands some perception gaps and facilitates WS discussion effectively to propose good plan and to gain public support.

Group 2	topic	noun phrases which made the topic	words	A.R.	A.J.
	TOPIC1	utilization, information, bus, citizen, train, etc.	10	0.70	0.112
	TOPIC2	project, bus, route, train, coordination, etc.	10	0.60	0.069
	TOPIC3	bus, service, ticket, commuter pass, Eco, etc.	10	0.60	0.034
2nd WS	TOPIC4	bus, route, train, bus stop, bicycle, etc.	10	0.70	0.071
	TOPIC5	bus, utilization, commuter pass, eco-point, yen, etc.	10	0.80	0.053
	TOPIC6	bus, route, bus stop, idea, number, etc.	10	0.60	0.044
	TOPIC7	utilization, bus, school, bicycle, connection, etc.	10	0.70	0.075
		correlatio	n coeff	icie nt	0.318
	TOPIC1	schedule, bus, automobile, line, car-sharing, etc.	10	0.40	0.063
	TOPIC2	utilization, bus, topic, route, IC card, priority, etc.	10	0.50	0.089
	TOPIC3	yen, bus, minute, hour, discount, Eco etc.	10	0.40	0.056
	TOPIC4	bus, Japan Railways (JR), priority, train, importance, etc	10	0.30	0.098
2rd WS	TOPIC5	this, topic, bus, route, project, etc.	10	0.80	0.176
510 W 5	TOPIC6	bus, yen, opinion, demand, utilization, importance, etc.	10	0.40	0.073
	TOPIC7	school, bus, high school, child, opinion, etc.	10	0.40	0.071
	TOPIC8	school, high school, private tutoring school etc.	10	0.60	0.055
	TOPIC9	school, JR, priority, needs, understanding, etc.	10	0.50	0.033
	TOPIC10	city, shared-taxi, function, IC card, bus, etc.	10	0.20	0.043
		correlatio	n coeff	icie nt	0.624
4th WS		Action plan	43	-	-

Table 1. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of DIALOGUE data (group 2)

Table 2. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of DESCRIPTION data (group 2)

Group 2	theme	title	words	A.R.	A.J.
2nd WS	THEME 1	Improvement and good point on buses and trains	34	0.69	0.032
	THEME 2	Bus connection	10	0.82	0.030
	THEME 3	Bus service	25	1.00	0.039
	THEME 4	Bus line and connections (problem)	50	0.71	0.042
	THEME 5	Bus users (problem)	30	0.75	0.034
		correlatio	on coeff	icie nt	0.188
3rd WS	THEME 1	Information-communication technology (ICT)	14	0.07	0.018
	THEME 2	Benefit	15	0.07	0.060
	THEME 3	Other	31	0.12	0.031
	THEME 4	The needs of buses	15	0.33	0.080
	THEME 5	Pleasantness	25	0.14	0.020
	THEME 6	Convenience	19	0.21	0.020
		correlatio	on coeff	icie nt	0.508
4th WS		Action plan	62	-	-



Fig. 6. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of 2nd WS (group 2)



Fig. 7. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of 3rd WS (group 2)

Table 3. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of DIALOGUE data (group 3)

Group 3	topic	noun phrases which made the topic	words	A.R.	A.J.
	TOPIC1	person, topic, bus, this, next, bus etc.	10	0.50	0.09
	TOPIC2	appeal, bus, first, needs, understanding, etc.	10	0.70	0.03
	TOPIC3	topic, bus, person, needs, group, etc.	10	0.70	0.08
2nd WS	TOPIC4	station, uniformity, pare, operation, environmental, etc.	10	0.60	0.09
2110 10 5	TOPIC5	yen, cost, person, utilization, project, etc.	10	0.40	0.12
	TOPIC6	station, bus, Japan Railways (JR), train, appeal, etc.	10	0.50	0.06
	TOPIC7	bus, minute, hour, taxi, bus stop, etc.	10	0.30	0.04
	TOPIC8	bus, fare, taxi, objectivization, needs, etc.	10	0.50	0.05
	correlation coefficient				-0.107
	TOPIC1	bus, theme, ride, poster, GPS, etc.	10	0.40	0.063
	TOPIC2	last, this, person, next, number, etc.	10	0.50	0.12 0.06 0.04 0.05 -0.107 0.063 0.159 0.077 0.030 0.046 0.083 0.038
	TOPIC3	bus, opinion, priority, first, promotion, etc.	10	0.40	0.077
	TOPIC4	bus, GPS, bus stop, needs, QR code, etc.	10	0.60	0.030
and WS	TOPIC5	opinion, priority, bus, new, rider, target, etc.	10	0.40	0.046
510 W 5	TOPIC6	station, bus, train, opinion, poster, image, etc.	10	0.50	0.083
	TOPIC7 bus, stati	bus, station, image, bus stop, QR code, etc.	10	0.30	0.038
	TOPIC8	importance, priority, cost, simplicity, location, etc.	10	0.40	0.049
	TOPIC9	bus, fare, Shinkansen, bus stop, uniformity, etc.	10	0.30	0.046
	TOPIC10	opinion, number, priority, new, rider, etc.	10	0.30	0.078
	correlation coefficient				
4th WS		Action plan	62	-	-

Group 3	theme	title	words A.R.	A.J.
2nd WS	THEME 1	The needs of buses (problem)	9 0.44	0.059
	THEME 2	Increasing awareness	27 0.21	0.036
	THEME 3	Time constraints	32 0.52	0.030
	THEME 4	Bus line (problem)	55 0.51	0.035
	THEME 5	Appealing buses	19 0.63	0.095
			correlation coefficient	0.551
	THEME 1	no title (unsorted words )	39 0.08	0.035
3rd WS	THEME 2	no title (sorted only)	11 0.45	0.076
	THEME 3	no title (sorted only)	13 0.00	0.036
	THEME 4	Information	14 0.14	0.033
			correlation coefficient	t 0.975
441 11/0		A ation mlan	01	

Table 4. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of DESCRIPTION data (group 3)

Fig. 8. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of 2nd WS (group 3)



Fig. 9. Context maintenance rate (C.M.R.) and Average of Jaccard coefficient (A.J.) of 3rd WS (group 3)

Acknowledgment. This work was supported by Grant-in-Aid for Scientific Research (C) (23560625) of JSPS KAKENHI.

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# Impartial Standards of Japan's Development Community

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**Abstract**: The following paper outlines ongoing research to analyze and explore the contextual understandings and definitions of third-party impartiality within organizational decision-making in Japan – specifically, organizations in Japan's development community. In-depth interviews, focus groups, and task-oriented conversations are being coded and analyzed in an attempt to reveal cultural patterns of the logical connections between impartial mechanisms with organizational decision procedures, and the fairness principles they are intended to represent.

Keywords: Impartiality, third-party conflict management, Japanese organizations.

## Introduction

Third-party intervention and alternative dispute resolution are well-established fields of practice and research (Pruitt and Carnevale, 1993). Third-parties are often defined within the literature by their "neutral" and "impartial" stance in a social conflict. The limitations of neutrality in the context of conflict resolution and ADR have been extensively argued (Mayer, 2004; Goetschel, 1999; Gibson et al., 1996; Forester and Stitzel, 1989), while the concept of impartiality is much less controversial in terms of its central role for conflict resolution practitioners. At a somewhat more abstract level, however, there remains a vigorous debate surrounding the role of impartiality in (moral) decision-making (Barry, 1995; Touchie, 2001; Gert 1995; Jollimore, 2011). One of the goals of this research is to directly link the concepts found within the philosophical discussions of impartiality, with the descriptive analyses of practical examples of conflict resolution. While there has been a significant amount of modeling and descriptive work focusing on the procedural role of mediators and arbitrators in various contexts (Lewicki et al., 1992), there is much less work focusing on exploring the reasoning behind cultural and contextual variations between these procedures, and their inherent or assumed impartiality (given that, their larger goals and roles as third-parties are the same).

## **Objectives**

The purpose of this research is to explore the perception of third-party impartiality within organizations of the Japanese development community (i.e., aid agencies, development consultants, and management consultants working in developing regions, among others), and to generate theories that will contribute to a deeper cultural understanding of organizational decision-making processes. Qualitative analyses will be used to contribute to an understanding of how impartiality is perceived within the current ideology, language, rituals, and symbols that legitimize such institutional processes (Hofstede et al., 1990; Pettigrew, 1979). The findings of such a study should provide valuable insight to mediators, arbitrators, and managers who may find themselves in the position of having to act as a legitimate third-party in what has been described as a culture of conflict resolution emphasizing the avoidance approach (Pruitt and Rubin, 1986) and compromise (Gelfand et al., 2001).

## Analytical Framework and Methodology

Data is currently being gathered among subjects in Japan. Subjects are professionals between the ages of 27 and 40 who are working in the development field of Japan. Transcripts will be coded and analyzed to reveal the perceived importance of impartiality within organizations, as well as the organizational behaviors and procedures that represent impartial standards. This research defines a third-party decision-making process as the process of incorporating (1) an additional party's input to influence a decision between stakeholders, or (2) an additional party's contribution towards a decision-making process between existing actors. Potential differences in the perception of impartiality across decision-making contexts are considered by exploring the role of impartiality within the following third-party decision processes that can be found in organizations:

- Top-down managerial decisions
- Peer intervention to a conflict
- Delegating decisions to external bodies
- Requesting evaluations from third-parties

The purpose of a discussion of these third-party processes is to identify and better understand the criteria and objective standards that become important throughout each process. For example, in the case of competing proposals for a specific development project, should an impartial manager evaluate your proposals (top-down) based on the feasibility of implementation? Or should she simply evaluate the bottom line and the total direct monetary or economic benefit that would result from each project? Specifically defining the criteria of evaluation in this manner will lead to an explanation of the fairness principles that subjects are trying to invoke through these objective standards (e.g., consequentialism vs. justice as utilitarianism). The qualitative analysis will be based off of a detailed examination of the logical templates that subjects use to explain the relationship between the type of conflict, the decision process, the appropriate standards, and the fairness principles.

In terms of the coding elements of the transcribed data, a review of the philosophical debate surrounding impartiality in moral judgment reveals that impartiality is associated with both the substance of a moral judgment (decision outcome), and the process for coming to these outcomes (decision procedures) (Barry, 1995; Touchie, 2001). Gert (1995), on the other hand, discusses impartiality from an agent-based perspective, and defines a moral agent's impartiality with respect to its relationship with the group it is potentially affecting with its input. Thus, interviews and focus groups will be transcribed and coded to identify when subjects refer to any of these three themes: impartiality through (1) substance, (2) procedure, and (3) agent characteristics. Some of the philosophical principles of fairness that can be gleaned from such themes, for example, are whether the substance of an agreement should be made using a utilitarian, consequential, or equitable/meritocratic approach; whether and how such principles should be reflected to ensure procedural justice; and the virtuous characteristics of a desirably fair and impartial third-party. The role of this analysis will be to identify patterns (if any) between the series of logical templates that are used to link the assumed fairness principles, with the invoked objective criteria appropriate, to the decision procedure being discussed. These patterns will become the base for cultural explanations and grounded theories used to describe the invocation of the various objective standards across common decision procedures of some of the main actors in the Japanese development community.

## **Implications and Future Work**

The major implication of this ongoing research is the ability to highlight the situational dependence of the Japanese development community's perception of impartiality. Providing a comprehensive discussion and framework for understanding impartiality, and its role in specific decision-making procedures will be a valuable perspective for global-international negotiators and mediators who find themselves maneuvering in local contexts. The preliminary findings and theories generated from this study will also be grounds for further empirical testing of cultural conflict models. Findings that are arguably culturally unique can be tested against other cultures, organizations, or subjects.

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# A Framework for Negotiating Information Technology Outsourcing Agreements

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**Abstract**: Industry practices in negotiating IT outsourcing agreements are sub-optimal. What is required is a proven method to negotiate these agreements more effectively. This research study has developed and showed the efficacy of a structured Framework for Negotiating IT Outsourcing Agreements. Six industry experts evaluated this framework for efficacy and completeness. The research outcome was assessed against seven success criteria. These success criteria were developed using information gleaned from the case studies on how industry experts measure success of an IT outsourcing negotiation.

Keywords: Information Technology Outsourcing, Principled Negotiation, Frameworks for Negotiating Agreements, Evaluation of Negotiated Agreements

# Introduction

It is becoming increasingly difficult for organisations to achieve strategic advantage through Information Technology (IT) outsourcing. Expectations of benefits and the significance or "business value" placed on them remain very high. However, research conducted by Gartner shows that as much as 50% of Information Technology Outsourcing agreements fail to achieve a satisfactory outcome (Cohen and Young 2006).

Carefully negotiated IT outsourcing agreements can deliver substantial benefits to the organisation as a whole. However, current industry practices in negotiating IT outsourcing agreements are based on ideology, fashion and personal expectations rather than structured techniques. Subsequently, a large proportion of IT outsourcing agreements either fail to deliver expected results or terminate abruptly, with severe consequences to the organisation (Lacity et al. (2009) and Lacity et al. (2010)).

An Outsourced IT environment is complex. It is also exposed to many internal and external pressures. The long-term nature of an IT outsourcing agreement also poses additional challenges, as the contract that is put in place needs to withstand numerous changes. These include changes not only affecting the outsourced IT department directly, but changes to the client's or supplier's business priorities, and economic or global influences.

# Negotiating IT outsourcing agreements

Negotiation of an IT outsourcing agreement is not an intuitive, ad-hoc process. Nor is it a procurement process, where negotiation can occur predominantly on price. Understanding the complex organisational, strategic and operational changes that need to take place in an outsourcing endeavour is imperative to the negotiation process. An organisation is most likely to benefit from outsourcing if it understands exactly how the outsourcing vendor will provide value and can use that knowledge to effectively negotiate an agreement. (Chandar and Zeleznikow (2007), Chandar and Zeleznikow (2009) and Chandar and Zeleznikow (2010)).

The research project described develops a structured framework for negotiating information technology outsourcing agreements and then evaluates the effectiveness of the framework. The framework is based on principled negotiation techniques (Fisher et al. 1994) and industry best practices.

#### Industry case studies

This research involves an in-depth qualitative analysis of 10 industry-based, test cases, used to understand the challenges and glean industry best practices in negotiating IT outsourcing agreements. The case studies included the review of contractual documents and in-depth interviews with several key decision makers and negotiators involved in each IT outsourcing agreement.

The discussions focussed on lessons learnt through the participants experience in negotiating IT outsourcing agreements. Also explored were proven methods or practices that would produce an effective IT outsourcing agreement, and any specific pitfalls to be aware of and avoid. Each interview lasted several

hours and in most cases, a follow up discussion was also necessary to finalise details that were not available at the time of the interview, or to clarify missing information or further explore subjects/questions that were overlooked during the initial discussion.

Participants stressed that the way IT outsourcing negotiation were approached have significantly changed since the 80s and early 90s compared with the present 2010/2011. Ad-hoc, unstructured negotiation may have been the norm in the 80s and early 90s, where client and supplier would discuss an opportunity and craft an IT outsourcing agreement together and rely heavily on the strength of the pre-existing relationship to navigate through issues and challenges of the IT outsourcing endeavour. However, the business landscape and the economic climate have changed significantly. Although there still existed a propensity for initial discussions to be dominated by price, the negotiation of IT outsourcing agreements appears to be a lot more structured in 2010/2011.

The need for structure as well as a consistent, carefully planned strategy for negotiation was well understood. It was noted that the negotiation of an IT outsourcing agreement had far reaching effects throughout the life-cycle of the IT outsourcing agreement and also the organisation as a whole. The participants involved in the research study understood that success in IT outsourcing was underpinned by an effectively negotiated agreement. However, participants commented on the lack of a proven, widely accepted, methodology or framework for negotiating IT outsourcing agreements.

Participants were aware of several publications available on the subject of IT outsourcing. However, few concentrated specifically on the negotiation process, and a number of publications were not based on academic research but rather on anecdotal observation and the author's personal experiences.

During the examination of industry-based test cases for this research study, it became obvious that each negotiation required specific expertise in the area of IT services being outsourced. I.e., there were quite specific issues that needed to be discussed or considered during an IT outsourcing negotiation, depending on the IT services being targeted for outsourcing. When outsourcing an IT help-desk, the considerations were different to outsourcing services relating to IT software development and these considerations were different again when outsourcing IT infrastructure services. However, there were common issues and topics that were explored during all IT outsourcing negotiations examined during this research study.

#### Unsuccessful and Successful strategies for the negotiation of IT outsourcing agreements

The information gleaned was then analysed and used to build a body of knowledge that has been represented under two categories:

Category 1: Where industry practices have been consistently shown to produce successful results in IT outsourcing, these practices have been represented as "successful industry best-practices".

Category 2: Where factors, techniques, practices or indeed the lack of attention to a specific area have produced negative results, these have been listed under "pitfalls to avoid".

A series of simulated IT outsourcing negotiation sessions were used to augment the information gathered and test any assumptions made.

The resulting body of knowledge was then used to develop a set of guidelines for use in preparing for, and conducting, structured, principled negotiations of IT outsourcing agreements. These set of guidelines include instructions on how to approach IT outsourcing in a structured manner.

We then developed recommendations on how to prepare for the negotiation and the styles and techniques to use during the negotiation. These recommendations contain a substantial list of considerations that need to be made when negotiating IT outsourcing agreements and various strategies to minimise the significant risks of IT outsourcing.

Successful strategies adopted by participants in this research when negotiating IT outsourcing agreements included:

- 1. Involve the correct people in the negotiation;
- 2. Relationships are important;
- 3. Discuss and agree on how the relationship will work;
- 4. Protect intellectual property;
- 5. Craft a memorandum of understanding;
- 6. Insist on transparency of subcontracting;
- 7. Schedule regular reviews, and specify how disputes will be handled;
- 8. People issues need to be handled very carefully during outsourcing

However there are also many pitfalls to avoid. These include:

- a) The absence of SLAs (Service Level Agreements) during negotiation or inadequate measures of success;
- b) Avoid too much emphasis on SLAs;
- c) Avoid assessing the outcomes of the outsourcing engagement using unquantifiable properties or events based on personal judgement;
- d) Minimise the effect of one party's authority or dominance from influencing discussions;
- e) Avoid conditions that severely disadvantage one party;
- f) Beware of rapid changes in technology that could make a rigid IT outsourcing arrangement unviable longer term;
- g) In the mandate to reduce costs, do not lose focus on innovation;
- h) Avoid vendor lock-in;
- i) Avoid overlapping areas of responsibilities or unclear boundaries of separation between multiple outsourced vendors;
- j) Cost of establishing, transferring and governing the contract should not be under-estimated;
- k) If the IT services being delivered in-house are of a poor standard, do not expect to fix this by outsourcing;
- l) Be aware of the potential for hidden costs.

# **Evaluation of results**

Hall et al. (2003) state that "For the evaluation to proceed, appropriate criteria must to be chosen with suitable metrics and minimal acceptable levels of attainment, which should be agreed upon in advance of measurement. This choice of criteria is guided by an understanding of the contexts of system use and of the evaluation, particularly its goals and objectives." The evaluation criteria was developed using published literature on IT outsourcing best practices and using the information gleaned from the test case review on how industry experts measure the success of an IT outsourcing negotiation.

A significant effort was made to evaluate the framework in terms of contribution to theory and practice. We now discuss the evaluation of the research process, analysis of the sample size and discussion on the success criteria used for the evaluation of the framework.

Six industry experts evaluated this framework for efficacy and completeness. Industry experts invited to evaluate the research outcome, had specifically negotiated IT outsourcing agreements and had seen the

repercussions of negotiation practices adopted, on the outsourcing agreement in question, and on the rest of the organisation. Only those industry practitioners that had repeatedly conducted and reflected upon IT outsourcing negotiations over a number of years were requested to evaluate the research study, so that they may be cognisant of trends and best practices, and have the appropriate in-depth knowledge to assess the framework's efficacy. CEO's and Managing Directors of several companies (both clients and suppliers) participated in the evaluation, as well as managers and leaders of outsourced divisions.

The research outcome was assessed against seven success criteria. These success criteria were developed using information gleaned from the case studies on how industry experts measure success of an IT outsourcing negotiation. These criteria were:

- Was there a significant level of improvement to the IT outsourcing negotiation process as a result of using this framework?
- Did the framework facilitate the transparency of factors that need to be considered prior to conducting an IT outsourcing negotiation?
- Does the framework provide guidelines about the best negotiation styles and techniques to use when negotiating IT outsourcing agreements?
- Does the use of the framework aid preparation for negotiating IT outsourcing agreements? Does the framework provide topics or factors to be considered for discussion during the negotiation? Does the use of the framework provide structure to the process of negotiation?
- Does the contract established as a result of using the framework, contain defined success criteria and mechanisms to measure these criteria objectively?
- Is the resultant contract contains flexible? I.e., does it allow for the planned re-negotiation of certain terms and conditions? Does the contract allow for early termination under certain circumstances?
- Does the resultant contract effectively cope with changes to the organisations' priorities, strategic direction and structure?

The success criteria was used to determine whether the framework was useful in negotiating IT outsourcing agreements, whether it promoted effective practices in ensuring success of the overall IT outsourcing endeavour, and assessed whether the information and guidance it provided was comprehensive. The overall result of the evaluation was that the framework met all the success criteria specified to measure the efficacy and completeness of the framework. It was also positively viewed and considered very useful by the industry experts.

# Conclusion

Our research study has revealed that industry practices in negotiating IT outsourcing agreements were suboptimal and what is really needed is a proven method to negotiate these agreements more effectively. The study then developed and showed the efficacy of a structured Framework for Negotiating IT Outsourcing Agreements.

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# Information Sharing in Interorganizational Systems – A Story about Falsehood, Greed, and Privacy

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**Abstract**: As agents, be it software or human agents, are dedicated to the goals of their respective organization, the coordination of autonomous agents suffers from several obstacles. In this paper, we outline that – under certain circumstances – agents are liars, greedy, and uncommunicative and smart mechanisms are needed. Furthermore, we discuss coordination approaches and theirs means to counteract those issues.

Keywords: Interorganizational Negotiations, Game Theory, Agent Modeling

# Introduction

Multi-agent systems offer big opportunities for the collaboration of different organizations. The organizations can assign their decision making and the communication to autonomous software agents which are integrated within the organizations' planning systems. The agents negotiate contracts with each other which governs the actions of the different parties. For example, automated negotiation by software agents can achieve agreements regarding the usage or scheduling of a common resource (Kraus 1997).

Frequently, information sharing is assumed to be limited, but existing. However, there are barriers suggesting that information sharing is either infeasible, revealed information is unreliable, or information should stay private in interorganizational systems (IOS).

This work adapts behavioral properties of autonomous agents to the case of information sharing in IOS. As a result of this, we discuss three barriers for information exchange in such domains and outline it by means of game-theoretical illustrations. Referring to these barriers, we deduce requirements regarding the treatment of information for the design of such systems and discuss how common coordination mechanisms fulfill the requirements. The findings state different suitabilities of coordination approaches for collaborative interorganizational decision making. Finally, we aim for a better understanding of agents' willingness to cooperate than it is often assumed in the research community recently.

# **Barriers of Information Sharing**

In this section, we present three barriers of information sharing in interorganizational systems.

#### Agents are Liars

Many group decision mechanisms draw on communication. However, communication can be biased due to untruthful information. Agents may have an incentive to lie about their preferences.

Let us suppose, a central authority asks two agents if they strongly or weakly agree or disagree to a proposal. A strong acceptance wins over a weak rejection, but not over a strong rejection. Figure 1 shows this game.

		Agent 2		
		Strong	Weak	
Agent 1	Strong	1;0	1;0	
Agent 1	Weak	0;1	1;0	

Fig. 1. A response game: Agent 1 rejects and Agent 2 accepts.

Evidently, the strong response is a weakly dominant strategy, i.e., it is at least as good as every other strategy and, hence, it is superior to those. This result can be generalized to more stages like  $\{1\%,2\%,...,100\%\}$ . The optimal strategy is to answer with the strongest response throughout. Thus, revealed information might be false and unreliable. Ergo, the information becomes a fruit of a poisonous tree. Concluding, agents can

obtain an advantage by revealing false information; this phenomenon is commonly referred to as incentive incompatibility, i.e., revealing information truthfully is not a dominant strategy (Shoham & Leyton-Brown, Ch. 10, 2009).

#### Agents are Greedy

In MAS, agents can benefit from cooperation. This argument is often invoked to support, at least limited, information sharing (Kraus, 1997). However, even beneficial cooperation is far from being guaranteed.

Let us suppose two agents that can voluntarily choose to share relevant information or to keep relevant information secret, share less, or false information (see game in figure 2).

		Agent 2				
		Non-Cooperative	Cooperative			
A cont 1	Non-Cooperative	C; C	A; D			
Agent 1	Cooperative	D; A	B; B			
$A \succ B \succ C \succ D$						

Fig. 2. An information sharing game.

The social welfare optimum lies in the strategy set {"cooperative"; "cooperative"}. Compared to mutual non-cooperation, both agents can benefit from information sharing as  $B \ge C$ . Nevertheless, rational agents act greedily and try to achieve a unilateral better payoff by deviating: the unique Nash equilibrium is the strategy set {"Non-Cooperative"} with an outcome of C for both.

The situation is an instance of the famous Prisoner's dilemma. There are mechanism trying to solve the dilemma; most famously, tit-for-tat punishes deviant behavior (Axelrod & Hamilton, 1981). However, commonly complete information about preferences is supposed. Since information is asymmetric, the preferences are unknown to the counterpart and it cannot be prevented that an agent reveals false or unimportant information. Consequently, deviant behavior cannot be detected and, thus, not punished.

#### Agents are Uncommunicative

Up to now, we have argued that agents spread false information or do not share information. However, there are mechanisms (e.g., the Vickrey auction (sealed second-price auction) (Vickrey, 1961)) that incentivizes rational agents to reveal information truthfully. Nevertheless, agents might be disadvantaged due to this procedure. Rival companies or subcontractors can deduct information from actions such as auction bids which might reveal production cost or technology (Sandholm, 1999). Sensitive information should stay private, but public bidding is needed for allocation transparency reasons (Rothkopf, Teisberg, & Kahn, 1990).

Let us suppose, there is a call for bids for two different projects  $\{P_1, P_2\}$ . A, an enterprise, bids for these projects and can be either strong or weak (e.g., advanced production technology or not). B is a subcontractor which charges a high, medium, or low fee. B does not know the type of A (strong or weak), but observes the bid. If B charges more than the net gain, A quits and both achieve a utility of -1.



Fig. 3. A signaling game with separating equilibira.

As shown in the figure 3, bidding for  $P_1$  is the dominant strategy for a strong A, while bidding for  $P_2$  is the dominant strategy for a weak A. Consequently, B can deduce the agent type from bidding behavior and

adjust the charging. This kind of game is called signaling game with separating equilibria. Concluding, agents might have a reasoned interest in the privacy of sensitive information.

# **Discussion of Coordination Approaches**

Based on the findings of the previous section, we propose three requirements for coordination mechanisms:

- R1: A coordination mechanism has to be incentive compatible.
- R2: A coordination mechanism must not be manipulable by individual strategic behavior.
- R3: A coordination mechanism shall reveal as little information as possible.

An overview over how common approaches fulfill those requirements is shown in table 1.

		Hierarchy	Voting	Communication
R1	(Falsehood)	No	No	Yes/No
R2	(Greed)	No	No	No
R3	(Privacy)	No	Yes/No	Yes/No
		Auction	Vickrey Auction	Mediated Neg.
R1	(Falsehood)	No	Yes	Yes
R2	(Greed)	Yes/No	Yes	Yes
R3	(Privacy)	No	No	Yes/No

Table 1. Overview over coordination approaches.

**Hierarchies** are an easily implementable method for the coordination of multiple agents, yet based on information sharing. As we have argued, this is vulnerable to lying and free riding without any sophisticated mechanism governance. Furthermore, it does not meet the privacy requirement as the agents have to exchange potentially sensitive data. Hierarchies are extensively discussed by the agency theory.

A widespread approach for the coordination of interests is **voting**. In an election, multiple agents vote over a set of alternatives according to a voting procedure. A voting procedure is not per se incentive compatible, as every non-dictatorial procedure for three and more real alternatives is manipulable under certain conditions (Gibbard-Satterthwaite theorem) (Gibbard, 1973; Satterthwaite, 1975). For instance in a majority voting, agents could vote for an alternative that is likely to win instead of their most preferred alternative which might be chanceless. This counteracts the requirement of truthfulness, but does not represent a manipulative intervention, as the agent tries to avoid that his or her vote becomes useless. However, in an instant runoff voting, an agent could vote for a not preferred alternative, because it appears to be a weaker opponent in later voting rounds. Privacy can mostly be protected like in a simple majority voting, which just reveals the most preferred alternative. However, there are also procedures revealing cardinal information (Shoham & Leyton-Brown, Ch. 8, 2009).

**Communication** can as well facilitate the coordination of agents. From a game theoretical perspective, there are two reasonable ways of communication: cheap talk and signaling. Cheap talk is a noncommittal information exchange without any cost. This way of communication can be truthful (e.g., if there are so-called focal points that are the best choice for all parties), but mostly cheap talk announcement are incredible and false (Shoham & Leyton-Brown, Ch. 8, 2009). Signaling is communication by doing (e.g., see figure 1). Signaling is more likely to be truthful, as signaling false information is costly. However, this cost can be less than the benefit gained from lying. Thus, falsehood is still possible, but limited by the cost of signaling. Generally, communication is subject to individual strategic behavior, as an agent can spread wrong information or withhold relevant information. Regarding privacy, in cheap talk scenarios, agents can freely choose to share sensitive information or not, but, in signaling scenarios, agents cannot prevent to reveal sensitive information, as he or she cannot hide their actions.

IOS designers frequently draw on **auction** mechanisms which draw on prices ("put money where your mouth is"). The advantage is that the agents have to pay a price for their actions; the price is flexible and determined by a desirability of an action. Nevertheless, common auction procedures like the sealed first-price auction are not incentive compatible. Agents could bid strategically and try to achieve a smaller bidding price than their true willingness to pay. If a speculating agent fails in his or her speculation, this does not

generally violate the second requirement, since another agent wins and gains a benefit. However, if there is a group bidding scenario, i.e., agents jointly bid for something, a single agent can lower his or her bid and try to free ride at the others' expense. As bidding prices have to be public to provide transparency, auctions do not preserve privacy.

There are also other auction procedures like the **Vickrey auction** which ensures incentive compatibility (Vickrey, 1961). In a Vickrey auction, there is no benefit from bidding less than the reservation price, so the bids are truthful. Moreover, the truthfulness prevents strategic behavior and, thus, individual manipulation. However, all kinds of auctions reveal information which might be sensitive. As argued before, an auction can be a signal or reveal cardinal values that can be used to the disfavor of an agent (Rothkopf et al., 1990; Sandholm, 1999).

Finally, there is the approach of **mediated negotiations** in which a mediator proposes contracts drafts iteratively and the agents accept or reject them (see, e.g., Klein et al. 2003). Since the agents cannot obtain an advantage by lying (rejecting a better contract proposal is not beneficial), the approach is incentive compatible. As argued above, if there is an opportunity to give a differentiated response, the responses would just be to fully accept or reject. The negotiation does not include any asymmetries such that there is no opportunity for individual manipulation. In mediated negotiations, privacy is mostly given – the agents just reveal preference of one contract over another, so there is not much revelation of sensitive information. Nevertheless, other agents and the mediator could learn from the response and deduce information from it. In software negotiation, the proposing is automated and can be done by random mutation of contract issues without knowledge about preferences, as it can last millions of rounds which is not feasible in human negotiation (Fink, 2006). Therefore, in human negotiations, the mediator needs additional information about the preferences of the agents. If the agents proposed the contract (non-mediated negotiation), there would be opportunities to act strategically and untruthfully. For instance, an agent could propose a contract that is not his or her first choice, but expected to be accepted by all collaborators most likely.

## **Conclusion and Future Work**

The paper has outlined three central issues of information sharing in interorganizational multi-agent systems which is a crucial part of collaborative system design. We have elaborated that agents, be it software agents or human agents, can state the untruth and manipulate the collective outcome by individual interests. Furthermore, they might be forced to reveal information that is sensitive.

Concerning the design of interorganizational multi-agent systems, developers must get a detailed understanding of the underlying problem and adjust coordination mechanisms to meet the challenges. The proposed requirements and findings of the study shall support this process and represent a rationale for a more explicit distinction between aligned and conflicting interests. Although IOS developers may be tempted to presuppose information sharing mechanisms referring to the advantages of cooperation, a fair and resilient system does not embed such practices.

Future work will be concerned with the generalization of the issues by formal modeling and the discussion of coordination mechanisms is going to be deepened and more formalized. Furthermore, we are going to analyze IOS in more detail by means of case studies in different application domains and, in doing so, demonstrate the theoretical findings practically. Finally, we will discuss the requirements of inter- and intraorganizational systems and their severity.

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# Toward the Development of Grounded Theory to Guide the Transition of Inter-Organizational Social Networks into Self-Sustaining Communities

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**Abstract**: This extended abstract reports on-going research into the design of virtual communities of practice. Major research challenges and questions are discussed. An overview of major cases and a framework for analysis are presented. Our purpose for this line of research is to build a grounded socio-technical design theory for cross-cultural virtual communities of practice based on our extensive design experience. This will provide a basis then for developing the design patterns for virtual communities of practice.

**Keywords**: Virtual Communities of practice, Design patterns, intra organizational knowledge management systems, inter-organizational knowledge management, cross-cultural contexts, enterprise social networks, barriers to adoption.

# Introduction

Development of intra-organizational knowledge management systems is well established and researched. However, the development of inter-organizational knowledge management systems is less well understood especially in global cross-organizational, cross-discipline, and cross-cultural contexts where multi-cultural boundaries and barriers potentially inhibit knowledge creation and sharing. Enterprise social networks (ESN) emerged as a legitimate organizational knowledge sharing tool in 2008 and 2009, and are moving toward institutionalization. (Mann et al., 2012) predicts that fifty percent of all large organizations will have an ESN by 2016, almost a third of which will be considered as essential as email. These networks, far beyond the personal social networks such as FaceBook and MySpace (Parameswaran, 2007), seem to be finding a legitimate role in both private industry and governmental institutions as a platform for intra-organizational knowledge sharing.

Web 2.0 virtual teaming environments are following a similar adoption pattern. Dozens of virtual teaming products exist, and over 100 open source groupware packages are available for implementation (Mittleman et al., 2008). Social software is software that aims to simplify the realization and preservation of networks among people, and has become a part of organizational life. However, most knowledge workers have limited idea of what colleagues are working on or what they know about and only have limited time for knowledge exchange. This is caused by geographical distance, structural boundaries (Ardichvilli et al., 2003), and a knowledge hoarding culture. Less research has been performed on the uses of such platforms to share knowledge in the form of lessons learned in diverse global settings.

# Background

Communities of practice (CoP) have been well researched and promoted as models of both intra and interorganizational knowledge sharing and creation (Wenger, 1998). CoPs are promoted as a valuable approach for organizational learning in multiple environments and organizational settings. With the rise of online learning and the necessity of building community as a valuable part of the learning process virtual communities of practice has increasingly become a focus of research. While much descriptive research on communities of practice has been done (Schwen and Hara, 2004), the transition from the rich research and constructs developed for understanding CoP's does not translate well in the design of virtual communities of practice which seems a logical step. Schwen and Hara (2004) identify through a case study analysis five challenges for the design of online communities of practice and propose a design approach that suggests analysis of an existing community of practice, a prototyping approach using iterative development followed by evaluation and revision of the system. Our own experience supports this view both in the types of problems experience and the difficulty of design and acceptance especially in situations where communities of practice are emergent in an online only environment. This complicates the analysis and design work because the design of the environment is that constitutes the virtual location of the community, but the community itself in some cases must be recruited, and established.

In this paper we report multiple efforts to elicit requirements for a Web2.0 online community platform optimized to support the unique collection of virtual collaboration requirements inherent in interorganization, cross-cultural, and cross-discipline team environments that comprise a variety of virtual communities. The key challenge in these projects is neither the analysis nor construction of the online community platform (though neither is in itself a trivial task), but rather the question of how to encourage adoption of the platform, and transition into a self-sustaining community of practice. This is a complex socio-technical problem difficult enough within a single organization, and even more complex as an interorganization, cross-cultural, and cross-discipline community of collaborators.

# Research purpose and questions

Our purpose for this line of research is to build a grounded socio-technical design theory for cross-cultural virtual communities of practice based on our extensive design experience. This will provide a basis then for developing the design patterns for virtual communities of practice.

Meta-questions for this stream of research:

- 1. How to put together a virtual conference (alone or combined with a physical conference)?
- 2. How to put together an ongoing online virtual community of practice?
- 3. Which design approach is better: planned or emergent?
- 4. Does emergent work if certain architecture is decided ahead of time? Can policy
- 5. How should an online community of practice be managed? What human roles are required?
- 6. Organizational change issues: These communities imply a change of organizational culture (roles, power structures, reward structures, relationships).
- 7. Problem of using descriptive theory for design (normative theory).

# Case studies employed for our analysis

The following case studies comprise multiple intersecting professional, organizational and national cultures (Schneider and Barsoux Jean-Louis, 1997; Straub et al., 2002). They all involve complex socio-technical problems difficult enough within a single organization and even more complex as an inter-organization, cross-discipline, and cross culture community of collaborators. These case studies were collaboratively developed and researched by the two authors and represent 7 years of practical field research. The cases represent extensive design experience in multiple settings: International educational collaborations, online learning communities, and international non-profit initiatives.

- **ACTIVE** Atlantis Collaborative Team Interaction Virtual Environment. This completed project developed a virtual environment for international consortiums of university partners.
- Accelerate77, This unique project utilized a social media system for communities of practice focused on sustainability projects in the 77 neighborhoods of the City of Chicago.
- 8th Global conference on Human Development, A virtual conference platform was developed for an international human development conference in Kathmandu, Nepal. Pre-conference, Conference and post-conference communities of practice were part of the design requirements.
- iTeach Community of practice on pedagogy practices.

- **Online course design projects** designing multiple online learning communities in a university environment using blackboard and desire2learn platforms.
- EDRA Environmental Design Research Associates knowledge networks and social media sites.
- ICAVE Institute of Cultural Affairs Virtual Environment an ongoing design project for a global non-profit enterprise virtual platform and social media strategy IBM partner grant
- **ToP Trainers** Technology of Participation trainers community of practice focused on facilitation practices.

## **Research challenges**

The development of sustainable cross-team, cross-cultural online communities of practice involves several major research challenges. Schwen and Hara (2004) identify five key challenges that are confirmed in our own work:

#### Prescriptive vs. description distinction

The foundational social theory is not a warrant for designing or nurturing a CoP. This challenge is central to our own published work where we have used the Value Frequency Model (VFM) (Briggs, 2006) as a guide to design. VFM is a foundational descriptive social theory and the translation to prescriptive theory as a guide to design is not straight forward. (Kolfschoten et al., 2011).

#### Ready-made vs. communities in the making

Situated learning theory has more to offer the "formed" community. Little is known about the early life cycle of CoPs. The best opportunity for online design is with formed CoPs. We report on both of these situations, though the contribution of our research is primarily in design for communities in the making.

#### Knowledge of possession vs. knowing in practice

CoPs are rarely centered around declarative knowledge acquisition. Rather, CoPs support knowledge in action. Our experience here is in tackling both of these situations, online classroom communities are focused more on knowledge possession while our cases experience with professional collaborations in the educational non-profit sector are focused on knowing in practice.

#### Mid-level social theory vs. micro learning theory

Situated learning theory is a "middle-level" social theory; mixing learning theory and related pedagogy are either inappropriate or untested mixing of levels of theory and methodology.

#### Motivated members vs. unwilling subjects

The intentions of the community members are often subverted in "designs of" CoP. We have explored this problem extensively in a designed community of practice with international university consortiums (Kolfschoten et al., 2011).

In addition we note an additional critical challenge from our own work:

#### Identifying and bridging cultural communication gaps

Cross-Cultural challenges are not only a result of communication differences among multiple national cultures participating in a CoP, but also include differences emanating from participation among multiple organizational and professional cultures. Significant communication gaps can occur that inhibit knowledge sharing and collaboration and must be identified and accommodated in both the design and evaluation of a project. If such gaps are not addressed the project will not sustain long term usage and adoption. Researchers have been trying to identify how deep culture influences IT adoption by people (Leidner, 2006; Livari, 2002; Walsh, 2009). We assume that the there is a possibility to further understand the cultural influence in the behavioral intentions as proposed in the Briggs et al. value frequency model (2006).

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# Prediction of Game Behavior Based on Culture Factors

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**Abstract**: This paper investigates the cultural differences in values and decision making in on-line surveys and games, comparing subjects from the United States and India. The empirical data validates the existence of cultural differences seen previously for in-person game performance; there are also significant differences in answers to Hofstede's Values Survey Models questions, the derived Hofeste dimensions, and our own values questions. We also use this data to make predictions of game play, country of origin, and values, based on other features. Results include. We are also able to predict the national culture of the participants by considering their behavior in the game. The results are that our values model is significantly better than other factors at predicting game play, but Hofstede questions are best at predicting country of origin.

Keywords: Cultural Differences, Decision Making and Negotiation, Low Stakes Ultimatum Game, Multi Attribute Decision Making, Culture, Cross Cultural Ultimatum Game, Mechanical Turk

#### Introduction

Previous research has shown that decision-making behavior does not simply maximize economic selfinterest and varies systematically across cultural background (Camerer, 2003; Henrich et al., 2005). While the body of work on quantitative measurement of the effect of cultural background on people's decision making process is ever increasing, it is still very limited. In this paper we intend to add to this knowledge, looking specifically at several different models of culture, two simple negotiation games, and populations of on-line players from two different national culture groups: The United States and India. We present what we believe to be the first cross-cultural study of online low-stakes game play for the Ultimatum game and Dictator game.

Our goal is to create models of decision-making behavior that is sensitive to the role of cultural background and individual values, as well as the specific context. In particular, we are focusing on decision-making behavior in the context of simple negotiation games. In previous work (Nouri and Traum 2011, Nouri et al., to appear 2013), we have posited that multi-attribute decision-making techniques (Fishburn, 1968) can be applied to social-decision making, by allowing different weights to be assigned to different valuations of a situation. Valuations include self-gain (as in the traditional economic models), but also factors like total gain, other gain, relative gain, and fairness. Individual differences in decision-making can be attributed to different weights on the valuation, and different trends across cultural groups can be attributed to different distributions of weights across individuals in the different groups. In (Nouri and Traum, 2011), we used weights based on Hofstede's Cultural dimensions (Hofstede, 2001), and tested the model by having agents play the ultimatum game. This model did show results that were broadly consistent with the reported results of human players in multiple cultures, in terms of average offer and rejection rate, however the specific choice of weights were somewhat ad hoc and the model was limited to considering only high and low values for each dimension, rather than actual values. In (Nouri et al., 2012), we learned weights from distributions of culture-specific player data, using inverse reinforcement learning techniques. This resulted in models that could generate distributions of play that were closer to the culture that they were designed for than other cultures, however, a set of training data from the culture is required to learn the weights, and it was not discernible whether these models represented the players actual values.

In this paper, we present new work aimed at eliciting the actual values that players report, as well as examining correlations between these values and game play as well as correlations to the Hofestede dimensions and the raw questions that were used to form the Hofstede dimension values. Our hope is that using this data can lead to better, more accurate models, as well as an ability to generalize to other cultures, where we have some notion of cultural values, but no performance data.

The rest of the paper is structured as follows. In section 2, we review background work related to observed cultural differences in negotiation game play and models of culture. In Section 3, we present our

experimental design, in which we elicited game play behavior, Hofstede's Values Survey Module (Hofstede et al., 2008), and our own values survey, for two different games (dictator game and ultimatum game) and two different broad national cultures: US and India. In Section 4, we present the results, looking at cultural and game-specific differences among each of these elements. In Section 5, we apply machine-learning techniques to try to predict game play based on cultural factors (country of origin, Hofstede dimension values, VSM question answers, and our value questionnaire), as well as trying to predict country of origin, based on game play, Hofstede dimension values, VSM question answers, or our value questionnaire.

# Background and Related Work

#### Cultural Differences & On-line games

Country-level differences are observed in different levels of social, cultural, financial and economical behavior. A high level economic example is the difference in behavior towards the security of property as public good (Campos et al., 2012). Behavioral game theorists try to measure these phenomena by looking into games that appear to reflect the common interactional patterns of everyday life. A very good example of such work on demonstrating country level differences in behavior is (Roth, et al 1991) in which four countries of Israel, Japan, US and Yugoslavia are studied in terms of bargaining and market behavior. (Heinrich et al., 2005) studies the influence of culture on decision making process in economic domains by running the ultimatum, public goods, and dictator games among 15 small-scale societies. This study not only reveals substantially more behavioral variability across social cultural groups than has been found in previous research but also suggests that group-level differences in economic organization and the structure of social interactions explain a substantial portion of the behavioral variation across societies. This study also provides evidence that the available individual-level economic and demographic variables do not consistently explain game behavior, either within or across groups.

In most prior work people participate in face to face laboratory conditions. A few recent studies have begun to look into what happens when these games are played online. These studies have reestablished the classical findings in behavioral studies such as the effect of framing and priming on Mechanical Turk participants (e.g., Buhrmester et al 2011; Rand, 2011). (Amir et al., 2011) has also shown that running economic games experiments on Mechanical Turk are comparable to those run in laboratory setting even when using very low stakes for payment. These experiments alleviate concerns about the validity of economic games experiments run online versus ones in the laboratory. There have also been studies t (e.g., Suri and Watts, 2011; Horton et al., 2010) that have shown that self-reported demographics on Amazon Turk in these tasks are reliable.

#### Hofstede's Dimensional Model of Culture

Hofstede's model of culture (Hofstede, 2001; Hofstede and Hofstede, 2005; Hofstede et al., 2008) posits that cultures vary systematically along several dimensions, such as ways of coping with inequality, uncertainty, relations with groups, and gender. Based on statistical analyses of the trends of answers to questions about values and attitudes, four different dimensions were identified (with three additional dimensions added later). These dimensions are PDI: Power Distance (large vs. small), IDV: Individualism vs. Collectivism, MAS: Masculinity vs. Femininity, UAI: Uncertainty Avoidance (strong vs. weak), LTO: Long- vs. Short-Term Orientation, IVR: Indulgence vs. Restraint, and MON: Monumentalism vs. Self-Effacement.

The values of a culture for the dimensions can be estimated using instruments like the Values Survey Module 2008 (Hofstede et al., 2008). This is a 28-item questionnaire, with a set of questions that relate to each dimension. The questions are shown in Table 1, with answers ranging from 1 to 5.

Question Number	Question	Related Dimension
Q1	have sufficient time for your personal or home life	IDV
Q2	have a boss (direct superior) you can respect	PDI
Q3	get recognition for good performance	MAS
Q4	have security of employment	IDV
Q5	have pleasant people to work with	MAS
Q6	do work that is interesting	IDV
Q7	be consulted by your boss in decisions involving your work	PDI
Q8	live in a desirable area	MAS
Q9	have a job respected by your family and friends	IDV
Q10	have chances for promotion	MAS
Q11	keeping time free for fun	IVR
Q12	moderation: having few desires	IVR
Q13	being generous to other people	MON
Q14	modesty: looking small, not big	MON
Q15	If there is something expensive you really want to buy but you do not have enough money, what do you do?	o LTO
Q16	How often do you feel nervous or tense?	UAI
Q17	Are you a happy person?	IVR
Q18	Are you the same person at work (or at school if you're a student and at home?	) LTO
Q19	Do other people or circumstances ever prevent you from doing what you really want to	g IVR
Q20	how would you describe your state of health these days?	UAI
Q21	How important is religion in your life?	MON
Q22	How proud are you to be a citizen of your country?	MON
Q23	How often, in your experience, are subordinates afraid to contradic their boss (or students their teacher?)	t PDI
Q24	One can be a good manager without having a precise answer to every question that a subordinate may raise about his or her work	o UAI
Q25	Persistent efforts are the surest way to results	LTO
Q26	An organization structure in which certain subordinates have two bosses should be avoided at all cost	o PDI
Q27	A company's or organization's rules should not be broken - no even when the employee thinks breaking the rule would be in the organization's best interest	t UAI e
Q28	To what extent We should honor our heroes from the past	LTO

Table 1.	Hofstede	Questions	from	VSM	2008
		2 · · ·	/		

The value for each dimension is calculated as a linear combination of the answers to four questions, as shown in Table 2. The constant for each dimension is used to normalize scores. In section 4, we use constants chosen so that our values for the US match the values from the literature.

#### Table 2. Hofstede Dimension Value Formulae

Power Distance Index (PDI) =	35(m07 - m02) + 25(m23 - m26) + C(pd)
Individualism Index (IDV) =	35(m04 - m01) + 35(m09 - m06) + C(ic)
Masculinity Index (MAS) =	35(m05 - m03) + 35(m08 - m10) + C(mf)
Uncertainty Avoidance Index (UAI) =	40(m20 - m16) + 25(m24 - m27) + C(ua)
Long Term Orientation Index (LTO) $=$	40(m18 - m15) + 25(m28 - m25) + C(ls)
Indulgence versus Restraint Index (IVR) =	35(m12 - m11) + 40(m19 - m17) + C(ir)
Monumentalism Index (MON) =	35(m14 - m13) + 25(m22 - m21) + C(mo)

We find the Hofstede model of culture attractive because it includes the following features:

- Explicit dimensions of cultural norms that can be tied to valuation
- Multiple ways in which cultures can be similar or differ
- Data on dimension values for a large range of (national) cultures

On the other hand, it is not trivial to relate the general values to evaluation of a specific situation. Therefore we also examine another valuation scheme that can be more directly tied to the outcomes of simple games. This is described in Section 3.

#### Support Vector Machines

In section 5, we create classifiers that attempt to predict offers or country of origin from other available information about an individual. To do this we use support vector machines (SVM) with the radial basis function kernel. Some recent applications and extensions of support vector machines in pattern recognition are handwritten digit recognition (Cortes and Vapnik, 1995), object recognition (Blanz et al., 1996), and face detection and identification in images (Osuna, Freund and Girosi, 1997). In most of these cases, SVM generalization performance (i.e. error rates on test sets) either matches or is significantly better than that of competing methods.

# **Data Collection Design**

#### **Participants**

The tasks were set up as "hits" on Amazon Mechanical Turk, open to participants from the US and India. Roughly two hundred participants were recruited for each culture, and assigned randomly to one of two game conditions described below (107 for each culture for the dictator game, and 101 for each culture for the ultimatum game). Each participant was told they would receive a \$0.5 fee for participating in the task and they had an opportunity to earn up to another \$0.5 based on their performance in the game. They were told they would receive \$0.05 for each 10 points that they accumulated in the game.

#### Games

The Ultimatum Game. is a simple bargaining game for two players in which the first player, often called the "proposer," is provisionally allotted a divisible "pie" (usually money). The proposer then offers a portion of the pie to a second person, often called the "responder." The responder, knowing both the offer and the total amount of the pie, then has the opportunity to either accept or reject the proposer's offer. If the responder accepts, he or she receives the amount offered and the proposer receives the remainder (the pie minus the offer). If the responder rejects the offer, then neither player receives anything. In either case, the

game ends and the two subjects receive their winnings accordingly. This stylized negotiation was first studied in (Guth et al., 1982).

The Dictator Game. The Dictator Game is played exactly like the standard Ultimatum Game, except that the responder is not given an opportunity to accept or reject the offer. The proposer merely dictates the division. In the Dictator Game positive offers cannot result from a fear of rejection. Thus, when used in conjunction with the Ultimatum Game, this experimental tool allows researchers to determine whether proposers make positive offers out of a 'sense of fairness' or from a 'fear of rejection' (Henrich et al., 2005).

Just like in the case of standard Ultimatum game, in this game, the canonical assumption would predict that the proposers would offer the minimum possible offer to the other person but numerous studies have shown that people deviate from this prediction and make considerable amounts of the pie offers to the other person. (Camerer, 2003).

#### **Decision-making Values Survey**

In order to directly calculate weights for the model from (Nouri and Traum, 2011), we created a survey of desiderata for making game decisions, shown in Table 3. Participants were asked to indicate how important each factor was in their decision making process, on a scale from -5 (very important to avoid) to 0 (not important) to 5 (very important to have).

	<u> </u>
Abbreviation	Value Description
$V_{self}$	Getting a lot of points
Vother	The other player getting a lot of points
Vcompete	Getting more points than the other player
V <sub>fairness</sub>	having the same number of points as the other player
V <sub>joint</sub>	Making sure that if we add our points together we got as many points as possible
V <sub>rawls</sub>	The player with fewest points (whoever that is) gets as many as possible
$V_{lower \ bound}$	Making sure to get some points (even if not as many as possible)
V <sub>chance</sub>	The chance to get a lot of points (even if there's also a chance not to get any points)

Table 3. Decision-making Values

#### 3.4 Method

Participants who accepted the "hit" from Amazon mechanical turk went through the following sequence:

- 1. Fill out the VS08 Hofestede Survey (Table 1), as well as demographic information about their country of origin and native language.
- 2. Receive instructions about the game (Dictator Game or Ultimatum Game). They were told that they would be playing with another participant from their country.
- 3. Make an offer as the proposer in Dictator Game or Ultimatum game, proposing a partition of 100 points between themselves and their partner in the game.
- 4. Fill out the Decision-making values survey (Table 3)
- 5. Receive their partner's move (in the case of the ultimatum game) and their final reward. In reality, there was no partner and the ultimatum game responses were chosen according to a fixed protocol.

# Results

We investigate differences between behavior of the US and Indian player groups. We examine differences in game play (size of offers), Hofstede Values, as cacluated using the formulae in Figure 2, Hofstede questions, as shown in Table 1, and our Decision-making values, shown in Table 4.

#### Offers in the Ultimatum Game and the Dictator Game

Table 4 shows a summary of mean offers and Standard Deviations for US and Indian players in the Dictator and Ultimatum games. Following the trend of reported results of different previous studies we also observe that in our experiments the majority of the participants from both US and India offer a significant amount of the money to the other person.

Condition (mean,std)	Dictator Game	Ultimatum Game
US	39.81, 21.23	48.51, 16.08
India	37.75, 27.96	45.14, 20.52
Both	38.78, 24.78	46.83, 18.47

Table 4. Summary of Offers across Game and Culture

#### Ultimatum Game

As reported in Table 4, the average offer for US participants was \$48.51 in comparison to the average offer of \$45.14 for the Indian participants. More detailed distributions are shown in in Figure 1. 63% of the US participants offered half of the money to the other person in the game in comparison to the 40% of the Indian participants. The result of one way ANOVA test on offers in Ultimatum Game grouped by the country of the proposers does not show a significant difference in offers (p=0.20). The Kruskal-Wallis test trends toward significance (p=0.058)

The KL-divergence value between to distributions is 0.2048.



Figure 1. Offer Distribution in Ultimatum Game

#### **Dictator Game**

As shown in Table 4, the average offer for US participants was \$39.8 in comparison to the average offer of \$37.7 for the Indian participants. More detailed distributions are shown in in Figure 2. 48% of the US participants offered half of the money to the other person in the game in comparison to the 30% of the Indian participants. We were not able to detect a significant difference in game performance between US and Indian participants in either the one-way ANOVA (p=0.5453) or the Kruskal-Wallis test (p=0.4368). The KL-divergence value between the two distributions is 0.2914.



Figure 2. Offer Frequency in the Dictator Game

The comparison of all individual offers in both games shows significant game effect on the amount of the offers in the game, offers made in ultimatum game being higher than offers in the dictator game. We believe this is mainly due to fear of rejection in Ultimatum game. (Camerer, 2003)

The KL-divergence value between Ultimatum Game distribution and Dictator Game distribution of the US participants is 0.35, and for Indian participants the KL-divergence value is 0.42.

#### Hofstede's dimensional values

Given that the procedure was exactly the same for both games up to this stage and that we recruited subjects from the same pool with the same method, we report the culture profiles calculated for the two countries here with both games aggregated. We analyzed the cultural scores of the participants based on the answers that they provided to the Hofstede questionnaire VS08 and calculated the values for the Hofstede's dimensional culture model for participants of the two countries, according to the formulae in Table 2. The initial results are shown in Table 5.

Dimensions	PDI	IDV	MAS	UAI	LTO	IVR	MON
US scores reported by Hofstede	40	91	62	46	29	68	0
India scores reported by Hofstede	77	48	56	40	61	26	0
Initial calculated US	15.21	11.10	-2.18	-56.37	9.18	30.31	-2.93
Initial calculated India	17.95	0.67	5.38	-53.17	4.83	56.00	70.98
Constants using US baseline	24.78	79.89	64.18	102.37	19.81	37.68	2.93
ANOVA p-values	0.60	0.05*	0.13	0.62	0.47	0.00**	0.00**

Table	5.	Ho	fstede	values	Calculation
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As mentioned in (Hofstede and Hofstede, 2005), the difference observed between the reported values and the new calculated ones can be attributed to many factors such as the differences between the demographics of the people who take the survey and culture change throughout time (the Hofstede scores are based on the IBM survey in 1970). Given that set of matched samples from different countries should include at least one sample matched with the others in our study for one country covered before with Hofstede score; we chose US to be the base country. The base value score for MON dimension is set to 0 since this dimension was not present in the earlier version of Hofstede's cultural model. The final scores are shown in Figure 3. We notice significant differences between Indian and US norms for three of the seven dimensions, as shown



in the last line of Table 5. No linear correlation was observed between the Hofstede Scores and the offers made.

Figure 3. Derived Hofstede Dimension Scores

#### Hofstede's Survey Questions

We also analyze differences in the distribution of the individual VSM 2008 survey questions, shown in Table 1. These provide a more fine-grained, though less theoretically motivated view of the cultural differences. Table 6 shows the questions that have significant differences in distribution across the countries at the \* (p < 0.05), \*\* (P < 0.01), and \*\* (P, 0.001) levels.

Question Number	ANOVA p-value	Question	Related Dimension
Q3	0.01**	get recognition for good performance	MAS
Q4	0.02*	have security of employment	IDV
Q5	0.03*	have pleasant people to work with	MAS
Q6	0.02*	do work that is interesting	IDV
Q9	0.00***	have a job respected by your family and friends	IDV
Q10	0.01**	have chances for promotion	MAS
Q13	0.01**	being generous to other people	MON
Q14	0.00**	modesty: looking small, not big	MON
Q16	0.02*	How often do you feel nervous or tense?	UAI
Q17	0.00***	Are you a happy person?	IVR
Q20	0.01**	how would you describe your state of health these days?	UAI
Q21	0.00***	How important is religion in your life?	MON
Q22	0.00***	How proud are you to be a citizen of your country?	MON
Q24	0.00***	One can be a good manager without having a precise answer to every question that a subordinate may raise about his or her work	UAI

Table 6. Cultural Differences for VSM 2008 Questions

Q26	0.00***	An organization structure in which certain subordinates PDI have two bosses should be avoided at all cost	
Q27	0.00**	A company's or organization's rules should not be broken UAI - not even when the employee thinks breaking the rule would be in the organization's best interest	
Q28	0.01**	To what extent We should honor our heroes from the past LTO	

No correlation was found between each answer to the questions and the offers made.

#### **Decision-Making Values**

Figures 4-6 show differences between participants from the US and India on the Decision-making Values Survey in Table 3. Figure 4 shows median values in the Dictator Game, Figure 5 shows median values in the Ultimatum Game, and Figure 6 shows median values across both games.



Figure 4. Decision Making Values in Dictator Game



Figure 5. Decision-making Values in Ultimatum Game



Figure 6. Decision-making Values across both Games

Since participants are asked to report their values after making the offer in the Ultimatum game and the Dictator game, the difference between the values on some dimensions can be attributed to the effect of the game on participants. However, there were significant differences in values for the two games only for US participants on dimensions Vcompete (p=0.01), Vequal (p=0.04) and Vchance (p=0.001). No such difference is observed among Indian participants. Table 7 shows the results of ANOVA analysis comparing the differences in decision-making values. We can see the following significant differences between players from US and India: Indians are more competitive and care more about own gain and the chance to get points (dictator game only).

P values	Vself	Vother	Vcompete	Vfairness	Vjoint	Vrawls	Vlower bound	Vchance
Ultimatum Game	0.11	0.43	0.00***	0.89	0.75	0.41	0.41	0.37
Dictator Game	0.06	0.75	0.00***	0.31	0.77	0.49	0.64	0.00***

Table 7. ANOVA analysis of Country effect on Decision-making Values

Table 8 shows the result of the correlation test between the reported values with the amount of offers. All of the correlation values had (p-value<0.00\*\*) and were statistically significant. The dimensions corresponding to Vself and Vcompetence and Vlower bond and Vchance are negatively correlated with the amount of offers made by the participants and is compatible with the intuition behind the definition of the dimensions. As expected, Vother and Vfairness and Vjoint and Vrawls are positively correlated with the amount of offers made by the participants implying that the more players care about these dimensions the higher offers they made in the games.

Table 8. Correlation analysis between Decision-making Values and Offer Values in the games

Correlation	Vself	Vother	Vcompete	Vfairness	Vjoint	Vrawls	Vlower	Vchance
							bound	
Dictator Game	-0.35	0.36	-0.33	0.36	0.24	0.20	-0.03	-0.28
Ultimatum Game	-0.14	0.23	-0.26	0.27	0.20	0.05	-0.05	-0.09

No such linear correlation was observed between each individual dimension of the Hofstede scores and the offer values in the games.

# Prediction of the culture and behavior

In this section, we use machine learning in order to make a model of our data that can predict the value of the offer an individual would make in the dictator game or in the ultimatum game based on different features of their cultural background. We perform two experiments: trying to predict the offer, and trying to predict the country of origin. For each experiment we try all other sets of features.

#### Prediction of offers

We used support vector machine (SVM) classifiers to predict the offers made, using each of the following sets of features:

- a) Country of the origin
- b) Hofstede's calculated scores (section 4.2)
- c) Answers to the Hofstede Survey Questions (section 4.3)
- d) Decision-making values (Section 4.4)

Given that the number of sample points we had were limited to the data we collected in our experiment (101 distinct data points for each country in the Ultimatum Game and 107 data points from each country in the Dictator game that made up a total of 416 individual data points), we used a 10-fold cross-validation training/test paradigm. We performed a support vector machine (SVM) classification with parameters C and  $\gamma$  optimized through grid search. For the prediction model, (SVM) classifier with the radial basis function kernel was trained and tested.

Percent correct	Dictator Game (214 total)	Ultimatum Game (202 total)
Country (US or India)	39.55%	51.61%
Hofstede Scores (7 dimensions)	39.56%	50.05%
Hofstede Questions (28 questions)	39.24%	53.52%
Decision-making Values (8 values)	52.86%	54.90%
Random baseline: frequency of offers in the data	21%	32%
Most common offer baseline (50%)	38%	51%

Table 9. Prediction of Offers from Cultural Features

The final reported accuracy in Table 9 is the average of the all the predictions made in each round of the 10-fold cross-validation. For each game, the best classifier is based on our Decision-making values. In the dictator game Welch's two sample t-test shows that this is significantly better than all other classifiers (p < 0.01). For the Ultimatum game, the decision-making value classifier performs significantly better than the classifier using Hofstede's scores (p < 0.05), however it is not significantly better than the other classifiers.

#### Prediction of country based on offers in the Game

We also use the same method as in section 5.1 to try to predict country of origin from game play, the Hofstede values, the Hofstede Questions, and the Decision-Making values. Table 10 shows the results (all of the differences are significant). We can see that the Decision-making values again out-performs the Hofestede scores, but in this case, the model trained on the individual Hofstede questions is better able to distinguish the country of the participant.

percent correct	Dictator Game	Ultimatum Game
	(214 total)	(202 total)
Offers (11 values)	53.40%	54.11%
Hofstede Scores (7 dimensions)	64.42%	69.85%
Hofstede Questions (28 questions)	76.39%	77.79%
Decision-making Values (8 values)	60.09%	65.70%
Random Baseline	50%	50%

Table 10. Prediction of Country of Origin

# **Discussion and Conclusion**

In terms of the general behavior in the two games most people tend to offer about 50% to the other side of the interaction and the offers are higher in the Ultimatum game in comparison to the Dictator game. The offers in both games follow a normal distribution. Considering the simplicity of these one shot games we were not able to detect meaningful cultural differences between the US and Indian offers in the context of the ultimatum Game and dictator Game. Significant cultural differences are observed in the answers to the Hofstede survey questions and the score values. It is worth mentioning that the reported values by participants demonstrate that they have more than one valuation criteria when they were making their decisions. We are able to make SVM based models that can predict the behavior in the games based on the national culture or self reported value of the players. We are also able to determine what culture the participants belong to with higher than chance probability based on the offers that they make in the games.

In future we will investigate more complex negotiation scenarios and whether we can make computational agents that use the self reported values for their policies in the negotiation.

Acknowledgments. This work was funded by a MURI award through ARO grant number W911NF-08-1-0301.

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# Multinational Inter-institutional Negotiation and Decision-Making in PEPFAR: Organizational Interaction in the Delivery of AIDS Treatment in Africa

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Over thirty years since it first came to light, HIV/AIDS remains a major global public health threat. Many health researchers believe that it is the defining health crisis of this generation. Globally, about 34 million individuals are infected. Approximately 2.7 million new infections occurred in 2010 alone. Significant regional epidemics exist in North and South America, the Caribbean, Eastern Europe, Russia and the former Soviet States, China, India, and South East Asia; however, two-thirds of those living with the disease and three-quarters of all AIDS deaths are found in Africa, south of the Sahara. Currently, AIDS and tuberculosis are the leading causes of death in Africa. The rapid global spread of this pandemic over recent decades can be attributed to modern patterns of tourism, commerce, and war. In industrialized societies, HIV/AIDS first moved quickly through the white male homosexual community then expanded to poor minority homosexuals and heterosexuals who inject drugs. In the developing world, especially Africa, the social context of the disease is different. Gender inequalities in education and wealth, widespread poverty, stigma, polygamy, and constant internal and international migration support the propagation of the disease. As Paul Farmer (2001) and others have observed, poverty, male dominance, and traditional cultural practices and beliefs have facilitated the development of generalized HIV/AIDS epidemics in many nations located in Central and Southern Africa.

Despite decades of medical research in the United States and Europe, thousands of clinical trials in industrialized and developing countries, and the investment of billions of dollars, no effective vaccine has been found to eradicate HIV. Without an effective "silver bullet" to eliminate the virus universally, donor nations have developed new strategies of prevention, treatment, and care to limit its spread and ameliorate its effects. Since the early 1990s, several milestones in the war against HIV/AIDS have been treatments blocking mother-to-child transmission of HIV, development of effective anti-retroviral drug regimes, implementation of the President's Emergency Plan for AIDS Relief (PEPFAR) programs, and application of evidence-based prevention programs.

In the early 1990s, it was reported that treating pregnant women with Nevirapine significantly reduced the probability that they would give birth to an HIV positive child. This breakthrough in HIV prevention soon became a protocol, Prevention of Mother-To-Child Transmission (PMTCT), which was implemented throughout the industrialized and developing world. Currently, HIV transmission from mothers to their newborn infants is rare in the United States and Western Europe. Substantial progress has also been made in PMTCT in less developed countries. Recently the WHO reported that 15 low- and middle-income countries had already reached the 80 percent target for coverage with antiretroviral prophylaxis to prevent mother-to-child transmission of HIV.

In the mid 1990s researchers in the United States and Europe found that treatment of persons with HIV who did not yet have severely compromised immune systems with combinations of anti-retroviral drugs successfully blocked disease progression to "full blown" AIDS. Patients who remained on combination drug therapy became relatively asymptomatic, less infectious, and maintained functionality. HIV infection, once a certain death sentence, became another treatable chronic illness. Despite the high cost of medications, anti-retroviral treatment soon became widely available in the United States and Western Europe resulting in a significant drop in AIDS mortality in those countries, but most persons with HIV in developing areas

could not afford the new treatments. This impasse was soon overcome when Brazil, India, and China broke the patents on anti-retroviral drugs and began to manufacture and distribute effective low-cost generics to governments in Africa and Asia.

Despite the availability of relatively inexpensive HIV medications, most of the developing countries with the highest infection rates lacked the health infrastructure to deliver drug treatments to their infected populations. Recognizing this need, the United States and other Joint United Nations Programme on HIV/AIDS (UNAIDS) participants launched PEPFAR in 15 focus countries in Africa, Asia, and the Caribbean. PEPFAR dedicated \$5 billion primarily for HIV/AIDS treatment and prevention and by 2008 reported that over 2 million persons were receiving life-saving anti-retroviral therapy. The program was reauthorized in 2009. PEPFAR II seeks to treat an additional 3 million people in the focus countries, prevent 12 million new infections, care for 12 million individuals including 5 million orphans and vulnerable children, expand PMTCT services to 80 percent of the target population, and train approximately 140,000 new healthcare workers.

In the early years of the HIV/AIDS epidemic, attempts to change risk behavior that transmitted the virus were limited to mass media and public information campaigns directed at general populations. Behavior change HIV prevention programs based in social science and evidence-based community trials were first attempted in North America and Western Europe. They were soon implemented with varying levels of success in developing countries. A common criticism was that they were individually focused and culturally insensitive. Nevertheless, systematic behavior change programs instituted in Uganda in the late 1980s and early 1990s with donor support, technical assistance, and local cooperation were convincingly shown to reduce HIV infection. Currently, evidence-based risk behavior change programs, when integrated with HIV counseling and testing and more widely available anti-retroviral treatments, are more likely to reduce infection rates in industrialized and developing areas than past stand-alone efforts.

Since 2006, there has been a worldwide consensus led by the WHO that there should be universal access to HIV/AIDS prevention, treatment and care. Even without an effective vaccine, it was believed by health researchers and policy makers that increasing access to these services in industrialized and developing areas would begin to curb the pandemic. However, the economic recession of the past several years has limited the funds invested in these programs. The gap between HIV/AIDS funding needs and available monies grows every year. Further, donor fatigue has caused private donors and governments to refocus their resources on malaria, maternal and child health, and tuberculosis (TB). Despite recent breakthroughs in anti-retroviral prophylaxis as applied to microbicides and potential sexual behavior risk of males, the global prognosis on HIV/AIDS remains uncertain.

The proposed presentation will focus on cross-cultural and international group decisions and negotiations in PEPFAR. PEPFAR is the Presidents Emergency Plan for AIDS Relief. It is, financially, the largest international health intervention in history involving governments, public health ministries, and medical schools. Currently, it is funded at about \$11 billion per year. Among industrialized nations, the United States has the leadership role, but it enters into cooperative agreements with European nations and Japan. The program is primarily implemented in selected countries with relatively high HIV infection rates in Africa (6 nations), the Caribbean (Haiti), South America (Guyana), and Asia (Cambodia). Case evidence of cross-cultural and international group decisions and negotiations in PEPFAR will be provided from several programs in Southern Africa.

As a recent Institute of Medicine report (IOM, 2013) shows, PEPFAR has maintained and bettered the lives of millions of people through its HIV prevention, treatment and care services, and support of programs addressing the needs of vulnerable children impacted by the disease. This has been accomplished through massive bilateral aid and successful engagement with partner country governments and other local stakeholders. This could not have been achieved without a process of health diplomacy involving many complex cross-cultural and international group decisions and negotiations. Yet in an era of fiscal austerity, PEPFAR faces daunting challenges, i.e., maintaining great numbers of currently enrolled patients; enrolling many new patients in treatment who are now eligible; and possibly enrolling many more who will be come eligible under new World Health Organization (WHO) guidelines.

Currently, PEPFAR is transitioning from an emergency public health intervention to a sustainable response to the HIV epidemic in the partner countries. While this will still involve substantial amounts of bilateral

financial and healthcare assistance, the focus of the overall program will shift to enhancing local healthcare leadership, organization, and capacity to provide effective long-term HIV/AIDS treatment, prevention, and care. This programmatic change will involve new cross-cultural and international discussion and negotiation. Representatives of donor nations will have to work with local leaders from multiple sectors of partner countries as well as other in-country stakeholders. Successful programmatic outcomes will depend upon resolving social and behavioral issues arising from group decisions and negotiations.

Keywords: PEPFAR, AIDS, Africa

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# Digital Volunteers and the Law: A Decision Support System to Address Potential Liabilities

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**Abstract**: Crisis mapping is a new field that has emerged as a set of online collaborative practices to source, process, and visualize information and data on events that derive from natural disasters (earthquakes, floods, cyclones, bushfires), civil uprisings and conflicts. This extended abstract presents preliminary research towards the development of a decision support system to help digital volunteer organizations to address the legal issues they face when assisting in crisis situations.

Keywords: crisis mapping, emergency management, crowdsourcing, digital volunteers, legal responsibilities, decision support systems

# Introduction

Hurricane Sandy devastated the shores of New Jersey in a short few hours, but it also ignited an unprecedented bottom-up response. Volunteer communities quickly swarmed to map communication network outages and recoveries, petrol stations, wireless spots available, etc. The #OccupySandy movement, relying on the experience gathered in the days of Occupy Wall Street (OWS), established distribution hubs, transportation, first aid and medical supplies. They also partnered with other organizations and platforms such as Sahana (managing requests and dispatch of items, meals, volunteers, etc.) and Recovers (a site allowing people to offer/request assistance).

Likewise, the Federal Emergency Management Agency (FEMA) and the Civil Air Patrol partnered with digital volunteers and requested the crowds to tag thousands of post-disaster aerial images to have an initial assessment of the extent of the damages in buildings.



Fig. 1: Crowdsourcing the assessment of Sandy damage (http://sandy.hotosm.org).

Major emergencies and crisis can overwhelm local resources. Over the past couple of years, self-organized digital volunteers have made use of the power of social media and "crowd mapping" for collaborative crisis responses. Instead of mobilizing a physical response, these digital volunteer groups have responded virtually by creating software applications, monitoring social networks, gathering, processing and verifying data and creating "crowdsourced" maps to assist the formal response community in their effort to aid affected populations (Robson, 2012; Poblet and Casanovas, 2012).

Nevertheless, there are a number of potential liabilities that digital volunteers and associations may face when engaging in crisis mapping activities and it is essential for those who commit to assisting in crisis mapping understand the need to strategize also for their risk exposure. Such liability touches issues such as land trespass, negligence, intellectual property infringement, invasion of privacy and/or disclosure of confidential information, security concerns and possible jurisdictional crimes. The main objective of this research, therefore, is to prepare an on-line decision hierarchy and support criteria model for the legal issues facing digital volunteer organizations assisting with natural disasters.

# Digital Volunteers at Risk

Digital volunteers are at risk if they fail to take reasonable care when making their responses. Problems may arise from disseminating false information, developing software in a loose fashion, failing to act in a manner that is not within industry standards, or failing to properly vet and supervise volunteers.

Digital volunteers may also be subject to liability if they fail to act when they have a duty to do so. Such a "duty to rescue" could arise if a digital volunteer creates a hazardous condition, and then begins to provide assistance, or forms a special relationship with survivors. Some nations now have laws which mandate a response and even allow for statutory protection and immunities to certain digital volunteers particularly if they have established appropriate organizational structures. As many digital volunteers make inter-national responses, there is much uncertainty and the choice-of-law doctrine is applied unpredictably and in this sense, state immunity laws may be limited. Digital volunteers may suddenly find themselves liable in other countries simply by sitting at a home/office computer and actively assisting others in strife.

# **Research and Objectives**

This research will canvas digital volunteers who are groups of like-minded people connected on-line to assist with crowd-sourcing information due to a natural disaster. The project will strive to create a model which not only states the legal issues which face such 'digital volunteers' but also will assist them to categorize these legal risks in the context of what is facing these organizations. In a hierarchical manner, the model will assist as an on-line decision support tool to objectively help to measure the gravity of the legal risk and if the organization should proceed with a particular activity. The tool will be an artificial intelligence assistant instrument not an absolute decision maker, as are humans.

The main outcome of this research, therefore, will be an on-line decision support model which will assist digital volunteer organizations to contextualize the legal issues which face them whilst they are engaged in crisis mapping initiatives.

A project outline will include the following tasks:

- **Task 1:** To meet with industry partners (government department and not for profits) to secure partnerships for the project.
- **Task 2:** To state more clearly the legal issues which face digital volunteer organizations. As part of this task, 20 international digital volunteer organizations will be surveyed via an on-line survey. Findings from this survey will be discussed in a conference/journal article.
- **Task 3:** To obtain funding to complete the on-line decision support criteria model. Industry partners will input into the model.

Upon completion of the decision support model, information and knowledge of the model will be disseminated to the digital volunteer community.

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# Trust development in cross-cultural and uniculture collaboration teams

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Keywords: Trust, Cross-cultural teams, Uniculture teams, Collaboration

# Introduction

With the rapid development of collaboration technologies and practice, there are various kinds of collaboration teams, such as global teams, cross-cultural teams. Trust development is very important in cross-cultural and also uniculture team collaboration. In East-Asia, the countries such as China, Korea, and Mongolia, are near to each other and also have many similarities in culture by historical reasons. Currently, those countries all have used information technology to facilitate their team collaboration in various fields. Due to the economic region, they have also frequently connections with each other. Therefore, a collaboration team founded with different participants from different nationalities and cultures is also required by many companies and organizations.

There are a lot of trust researches conducted for the collaboration teams (Wilson et al. 2006, Nolan et al. 2007, Piccoli and Ives 2003, Powell et al. 2006, Cheng et al. 2009, Cheng et al. 2013). There are also some research for cross-cultural trust research (Costigan et al. 2011). However, current research doesn't compare the difference for the trust development within cross-cultural collaboration with uniculture collaboration teams. It would be interest to see how individual trust develops in cross-cultural teams and uniculture teams by conducting experiments and case studies. Therefore, we have decided to conduct a cross-cultural and uniculture collaboration case study.

# Case study and experiment

We have conducted a case study in a China university. The case study was lasted for one semester. There were two classes doing collaboration project over the semester. There were several groups in each class. Each group is composed of five or six participants. One class is composed of participants from China only which is a uniculture background. The other class is composed of participants from China, Mongolia and Korea (ROK). The students were required to do the team collaboration project by using thinkLets which could help the collaboration (Briggs et al. 2003). There are brainstorming, popcorn-sort, bucketwalk, strawpoll used for their collaboration sessions over semester. They used the tools like QQ group, meetingsphere, Kanbox, and powermeeting to be the platform for their group project. At the same time, they had offline communication and group meetings with the group members when they thought to be necessary. The collaboration experiment cases in the two classes have the same settings.

# Data collection

We have used a previous designed individual trust survey protocol (Cheng et al. 2009) to collect data from three points, which is the beginning of the semester, mid of semester, and final stage of the semester which was also their project deadline. We have also conducted interviews in the three points as well. All students were highly motivated to take part in the surveys and interviews.

# Results

The survey data were then analyzed initially after the data collection. Interview data has not been coded at this stage. We also take the ideal individual trust value from previous research (Cheng et al. 2009) for a comparison basis. Finally, we have successfully obtained three findings. Firstly, all groups could not reach the ideal value for trust development. Second, the trust level in uniculture groups is increasing but in cross-cultural groups is decreasing over time. Third, the trust level in uniculture groups is more stable than cross-cultural groups which are showing more fluctuation. In general, the trust development in the uniculture

groups is better than cross-cultural groups. Furthermore, we could easy find that in our research context, although all are East-Asian teams, however, they are not following the same trust development status.

## Conclusion and future work

Trust development is a complicated topic. In order to analyze the individual trust development over time, this study takes a cross-cultural collaboration context. This study is a first step to analyze the individual trust development in cross-cultural teams using thinkLets for sustained collaboration over time. By the initial results, we have found that uniculture teams have better individual trust development than cross-cultural teams. In future, we are going to validate and evaluate the survey findings by using the analysis from the interviews and maybe there is some more findings coming out. We will also include more cases inside and thus validate the findings in a better level. We also aim to find out the reasons for changing in future work.

Acknowledgement. This research thanks the funding provider NSFC (71101029).

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# Negotiation by Veto

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# Introduction

Positional bargaining - i.e. picking one out of the set of possible solution and defending this position by threats and arguments – is a commonly observed approach in negotiations. This approach, however, can cause inefficiently long and conflicting negotiation processes or even in the worst case impede reaching an agreement at all due to the inflexibility of negotiators and the feeling of losing face when giving up a position (Fisher & Ury, 1981). Therefore, professionals suggest, building on case-based and experience-based knowledge, alternative approaches like 'Principled Negotiation' (Fisher & Ury, 1981) or the 'Single Negotiation Text' (SNT) (Fisher, 1978).

However, practice and experiments suggest, that the majority of negotiators engage in a negotiation dance that starts with a high opening offer, which is followed by a concession procedure of offers and counteroffers proceeding incrementally and cautiously to an agreement in the hope not to be taken advantage of (Mumpower, 1991). Therefore the exchange of offers is argued to be the most important type of communication in negotiations (Tutzauer, 1992) and negotiations are often formally modeled as offer exchange processes.

In this paper we introduce an alternative to negotiation by the exchange of offers, namely negotiation by veto. Instead of stating what the negotiators want by formulating and exchanging offers, they state what they do not want by vetoing possible solutions. By means of an empirical study we investigate the effects of negotiation by veto on objective and subjective measures of the negotiation process and outcome for varying complexity of the negotiation problem.

# Negotiation by Veto

Negotiation by veto was derived from the concept of voting by veto (Müller, 1978), i.e. by the transfer of an approach from group decision making (public choice) to negotiation. The approach of voting by veto requires, that each of n voters makes a proposal so that together with the status-quo (or some other reference alternative) in sum n+1 alternatives are available. Then an order of the voters is determined randomly and each voter can veto one alternative, i.e. reduce the set of possible alternatives by this chosen alternative. After all voters placed their veto one alternative is not deleted from the set of possible alternatives and is declared as the winner.

In negotiations the number of possible solutions typically exceeds the number of negotiators plus one (e.g. three possible solutions in bilateral negotiations), therefore, a modification is necessary. the procedure of negotiation by veto starts with randomly determining which negotiator begins the veto process. Thereafter, negotiators alternate in vetoing possible solutions until only one solution is left. Finally, the negotiators can decide whether or not they agree on this remaining solution. Negotiation by veto implies two important aspects: (i) the negotiators problem must be fully specified and constant and (ii) during the negotiation process the negotiators must systematically consider all possible solutions.

A fully specified and constant negotiation problem implies that all issues of the negotiation and all possible options for settling these issues and therefore all possible solutions of the negotiation problem are known by the negotiators. Furthermore, the negotiators have to have constant preferences over for these possible solutions and these preferences have to remain constant during the whole period of the negotiation.

As all possible solutions are either vetoed by the negotiators or the single remaining solution is accepted by the negotiators at the very end of the negotiation process the negotiators have to go through all possible solutions. This could be quite time consuming depending on the number of issues and settlement options, i.e. the combinatorial complexity of the negotiation problem. It can be assumed that a negotiator will always
veto the worst of the possible solutions that remain in the set of possible solutions. Thereby, the utility of a possible settlement monotonically increases during the negotiation process.

In negotiations that use the exchange of offers the negotiation problem needs not be fully specified. Therefore, the creativity of the negotiators and information asymmetry leave room for win-win constellations (Kersten, 2001). However, if the negotiation problem is fully specified and the preferences are constant negotiation by offer exchange could follow systematic offer processes similar to the systematic procedure of vetoing. Kelley (1966) for example proposed, what he called a 'systematic concession making model', a procedure according to which the negotiators start with their optimal offers and then systematically propose offers of the next lower utility level only in case all offers of the current utility level where already proposed. However, it is questionable, especially in complex negotiation problems, if the negotiators would follow this systematic offer exchange if they are not forced to.

# **Empirical Study**

To answer our research questions, concerning the impact of negotiation by veto, we conducted a series of face-to-face laboratory experiments over two years with student participants at the Vienna University of Technology and University of Vienna. Students received course credits for their participation independent of the respective outcome of their negotiation. The negotiations case represented bilateral second hand laptop negotiation with two issues. The complexity of the negotiation problem was considered by implementing two treatments using negotiation problems with different numbers of possible solutions. The simple treatment included 25 and the complex treatment 100 possible solutions. The negotiation problem structure was designed to have integrative potential by assigning different weights to the issues for the two parties and concave partial utility curves, see Figure 1.



Fig. 1. Illustration of the negotiation problem structures in the simple and complex treatments

The two negotiation procedures (offer and veto) and the two negotiation problems structures (simple and complex) combine to a 2 x 2 experimental design (see Table 1 - differences in the treatment sizes result from different course sizes). In all treatments the negotiation procedure prescribed to randomly determine which negotiator starts the negotiation. In the negotiation by veto treatment, the negotiators alternated in vetoing possible solutions until only one possible solution remained. Then the negotiators decided whether or not they are mutually willing to settle the negotiation for this solution. In the negotiators of the negotiators alternated in making offers (with no restrictions on the form of offers – i.e. no enforced concession procedure, package offering etc.) and the negotiation ended if one negotiator accepts the offer of the opponent.

	-	-
(dyads)	simple	complex
offer	26	42
veto	40	30

Table 10. Experimental design

As negotiators using the negotiation by veto are forced to follow a systematic negotiation processes, we expect them to reach objectively better outcomes. However, we expect this effect only in a complex setting, while we do not expect the negotiation procedure to influence the quality of agreements in the low complex treatments. We therefore formulate hypothesis H1 as follows:

H1a: In simple negotiation problems negotiation by veto leads to similar outcomes in terms of number and quality of agreements as negotiation by offer.

**H1b:** In complex negotiation problems negotiation by veto leads to superior outcomes in terms of number and quality of agreements than negotiation by offer.

Furthermore we suggest that eliminating inferior solutions might be easier for negotiators than giving up preferred possible solutions. The process of vetoing unwanted alternatives is expected to reduce the level of conflict and increase negotiators' satisfaction with the process and outcomes. However, the negotiation by veto procedure is also novel and unfamiliar to negotiators. Handling an unfamiliar procedure is typically more problematic for decision makers, which we expect to be even more true for negotiation problems of higher complexity. We therefore formulate hypothesis H2 as follows:

**H2a:** In simple negotiation problems negotiation by veto leads to higher satisfaction of the negotiators, in terms of satisfaction with the negotiation process and the outcome, than negotiation by offer.

**H2b:** In complex negotiation problems negotiation by veto leads to similar satisfaction of the negotiators, in terms of satisfaction with the negotiation process and the outcome, as negotiation by offer.

For the purpose of the ongoing analyses we collected data regarding the sequence of offers or veto respectively, and the utility of the final outcome. Additionally, we used post-negotiation questionnaires to collect information about the participants' decision making style and demographics.

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# Actual and Perceived Individual Influence on Group Decisions: The Impact of Personality, Expertise and Discussion Content

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**Abstract**: We examine how actual and perceived individual influence on a ranking decision can be explained by individual differences in personality, expertise and discussion content. Results reveal that actual influence can be better explained by personality and expertise, while perceived influence can be better explained by discussion content.

Keywords: Individual Influence, Actual Influence, Perceived Influence, Group Decision, Ranking, Personality, Expertise, Face-to-Face Group Discussion, Content Analysis.

### Introduction

While several different aspects of group decision making have been examined in the literature, e.g. group think (Janis, 1982), the field of individual influence on group decisions has been addressed quite infrequently. Apart from some exceptions, e.g. Deuling et al. (2011), the questions which and how individual differences in characteristics and behaviors can make certain group members more and others less influential, has not been covered extensively in the literature on group decision making (Bonner et al., 2002). This holds especially for rankings set up by groups. Many real world decision problems, e.g. choosing job candidates (Goddard, 1983), are solved by ranking a number of alternatives (Cook, 2006). The higher the number of alternatives to be ranked, the more probable it becomes that the final ranking after the group discussion differs from some members' individual rankings (Milch et al., 2009), thus reflecting differences in individual influence. We follow the recommendation to distinguish actual influence and influence as perceived by the other group members (Bottger, 1984).

# A Group Discussion Focus on Individual Influence

A lot of studies, e.g. Brauer et al. (1995), have shown the predictive power of discussion content in explaining the output of decision making groups (Milch et al., 2009). In addition, empirical and theoretical research, e.g. Isenberg (1986), has shown that information and persuasive arguments are often the basis of influence in decision making groups (Littlepage et al., 1995). Nevertheless, many authors studying individual influence only take an input-output perspective, e.g. Ohtsubo and Masuchi (2004), thus neglecting the group discussion. As far as we know, only Littlepage et al. (1995) and Littlepage and Mueller (1997) study not only personality, but also the group discussion in an input-process-output framework (Jarboe, 1988). However they use peer reports, which has been disadvised for studying interactions in problem solving groups (Baumeister et al., 2001). Therefore we use content analysis to examine individual discussion content in a fuller and more objective way (Barr et al., 1992). Besides discussion content, we investigate both the effect of personality (Barrick and Mount, 1991), especially dominance (Anderson and Kilduff 2009) and neuroticism, i.e. a person's inability to effectively control negative emotions (Kanfer and Heggestad, 1997) as well as expertise (Bonner et al., 2002) on individual influence.

Therefore we formulate our central research question as follows:

"How are individual differences in personality, expertise and discussion content related to actual and perceived influence members have on the group ranking?"

# Study Design and Methodology

We conducted a laboratory study with a sample of 100 business students. After filling a questionnaire on personality, participants individually worked on the "Desert Survival Situation" (Lafferty and Pond, 1974) in which 15 given objects (e.g. knife, mirror) have to be ranked according to importance for survival of a group of individuals in the desert. This classical ranking task has an objectively correct solution, which is

difficult to verify (McGrath, 1984), a situation common in business and personal life (Littlepage et al., 1995). A spearman rank correlation between each individual ranking and the expert ranking (taken from the task manual) served as measure for expertise. After that, participants were randomly assigned to face-to-face groups of five. Groups had to rank the 15 given objects again in a group discussion using unanimity. In a postdiscussion-questionnaire participants rated each other for perceived influence on the group ranking. Actual influence on the group ranking was determined by a rank correlation coefficient between individual ranking and group ranking.

Following the stages of content analysis by Srnka and Koeszegi (2007), video-taped group discussions were transcribed according to speaking turns (Giebels et al., 1998) and divided into thought-units (Weldon et al., 1991). We developed a coding scheme adapted from the Rank Problem Category System (Stech, 1970) and the Conversational Argument Coding Scheme (Meyers and Brashers, 2010). Exemplary categories are preference statements and arguments. Two independent coders coded all 20 group discussions (Weingart et al., 2004). Coding has been performed very reliably, as evidenced by the final Cohen's Kappa of .85 (Cohen, 1960).

### Results

We found a sufficient and quite similar amount of preference diversity between individual rankings in each group (Bonner, 2000) which ensures comparability of groups. Additionally, task familiarity and member familiarity are both very low and therefore our groups can be considered as zero-history groups, so that we can exclude distorted effects due to prior acquaintance (Jehn and Shah, 1997). Given that the intraclass-correlation coefficients of our discussion content variables are all very close to zero, we can conclude that groups do not have a substantial effect on individuals and therefore individuals can be used in statistical analysis (Kenny et al, 2002).

To test our hypotheses, derived from the research question, we ran a couple of multiple regressions. Results show that input variables (personality and expertise) better predict actual influence than process variables (i.e. discussion content categories). Conversely, process variables better predict perceived influence than input variables. The highest variance explanation of actual influence (about 51%) and perceived influence (about 59%) is achieved by including both input and process variables in the same model. While the input variables, neuroticism and expertise, are significant in all models of actual and perceived influence, the input variable dominance does additionally significantly explain perceived influence. According to the hypotheses, neuroticism does negatively and expertise does positively impact actual and perceived influence. Dominance does positively impact perceived influence. The process variable "preference statements" is significant in all models of actual and perceived influence. The more preference statements are made, the higher is the individual influence. The remaining significant process variables either predict actual or perceived influence. Talking about the task and the general situation does positively impact actual influence, while suggesting how the group discussion should proceed has a negative effect on actual influence. Those that express expertise in (desert-) survival have more actual influence than those who do not express expertise. In addition to the positive effect of preference statements, arguments do positively and significantly impact perceived influence.

These results confirm our belief, that simple input-output models are insufficient to explain actual and perceived individual influence on the group ranking.

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# A Market for Votes: Can Bribing be Beneficial?

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**Abstract**: This study examines the idea of structured bribing and its welfare effect. At this, we design a market for votes, whose price mechanism adapts the structure of a stock exchange, and conduct computational experiments. As a theoretical rationale, the study analyzes the consequence of an increasing group size on the outcome of group decision mechanisms such as negotiations, auctions, or elections, as well as the impact of information on manipulation.

Keywords: Vote Buying, Mechanism Design, Manipulation

### Introduction

In contrast to decision theory, group decision theory is also characterized by the interaction of individuals. The group has to find a consensus that is preferably fair and beneficial and subject to not only the preferences but also the strategies of the group members. In a non-cooperative environment, single individuals have incentives for applying strategies which are beneficial for them, but at the group's expense. Consequently, group decision research especially has to focus on interactions and strategies of the agents, as agents may try to trick and use malicious strategies for their own good.

The classical example of a group in group decision theory is a committee (Black 1948). A committee is characterized by a small and manageable number of participants. However nowadays, there are a variety of applications in which the number of group members is not small anymore – especially in the field of computerized applications (see Bichler et al. 2003; Conitzer 2010; Sycara 1998). The finding of a consensus becomes increasingly harder the larger the group is. A further issue is the availability and processing of information. The more individuals are included in the process the more complex it becomes to process and track information. It is often assumed that agents have perfect information which is not feasible in real-world applications though (Harsanyi 1962; Rubinstein 1991).

This study deals with the scalability and manipulation of multi-issue group decision mechanisms and the impact of information availability. Besides theoretical analysis, we consider the question whether bribing can be beneficial, i.e., if manipulation is bad per se or if institutional rules can use such mechanisms for social purposes. Considering this, we designed a market for votes in which votes are traded like in a stock exchange and conducted simulation experiments. The experiments intend to show that it is feasible to improve the social welfare by utilizing "bribing". In contrast to manipulative bribing, the market for votes has clear rules, transparency, and verifiability. Social choice pioneer Kenneth Arrow stated in his seminal paper of 1950 that there are "two methods by which social choices can be made: voting, typically used to make 'political' decisions, and the market mechanism, typically used to make 'economic' decisions" (Arrow 1950, p. 328). In this study, we intend to bring together both.

The remainder of this paper is structured as follows: At first, we discuss the scalability of different group decision approaches and analyze manipulation of elections as well as the role of information. Afterwards, we introduce the experiment's design as well as its results and discuss the experiment's validity. Finally, we conclude the paper and present future work.

### Scalability of Negotiations, Auctions, and Social Choice

As mentioned beforehand, finding a group consensus becomes harder the larger the group is. Regarding this matter, we analyze the scalability of iterative negotiations, auctions of decision rights, and social choice mechanisms like elections.

### Negotiations

One mechanism to find a consensus that is agreeable to all negotiation parties is negotiation. A lot of research covers those aspects from the view of game theory. Most famously, there is the axiomatic work of

Nash, Kalai and Smorodinsky, as well as Rubinstein's strategic approach (Nash 1950; Kalai & Smorodinsky 1975; Kalai 1977; Rubinstein 1982). However, the assumptions of game theory are commonly not fully satisfied and researchers have to consider perception, restricted rationality, and human reasoning (Harsanyi 1962; Rubinstein 1991). This leads to heuristic approaches like iterative negotiations (Jennings et al. 2001). In iterative negotiations, the negotiators successively work out a contract. There are a lot of mechanism design approaches which draw on such iterative exploration of possibilities (e.g., Klein et al. 2003; Fink 2006). When analyzing the scalability of negotiations, on the one hand, we have to consider if a contract proposal is beneficial for an individual, but, on the other hand, the proposal has to be unanimously accepted by the group as a whole. Proposition 1 analyzes the scalability of iterative negotiations with unanimity.

**Proposition 1:** Given a sufficiently large group size and independent preferences, iterative negotiations with unanimity result in dissent.

The probability that a proposal is favorable for j is  $p_j^A$  and the probability that the remainder of the group – represented by a representative counter agent  $\varphi \neq j$  – accepts it as well is  $p_{\varphi}^A$ . A contract proposal has to be accepted by unanimity and we assume that the acceptance likelihoods are stochastically independent between the parties. Then, the probability  $P_i^I$  that j achieves an improvement with N negotiation parties is

$$P_j^I = p_j^A * \left( p_{\varphi}^A \right)^{N-1}$$

Consequently, the alteration rate, subject to the number of parties, is

$$P_j^I = p_j^A * \left( p_{\varphi}^A \right)^{N-1}$$

As  $\ln(p_{\varphi}^{A}) \leq 0 \forall 0 \leq p_{\varphi}^{A} \leq 1$ , we can conclude that the probability of achieving an improvement in the negotiation becomes increasingly unlikely proving the proposition:

$$\ln(p_{\varphi}^{A}) \le 0 \forall 0 \le p_{\varphi}^{A} \le 1$$

### Auctions

Besides iterative negotiations, there are also negotiation protocols that are based on auctions (e.g., Hattori et al. 2007; Lang & Fink 2012). Those protocols auction decision rights for contract issues off. The advantage of auctions is that they reveal additional information which is truthful and are not subject to strategic manipulation – given adequate mechanisms are in place (Pekec & Rothkopf 2003). Complex auctions such as combinatorial auctions forms suffer from lacking scalability due to computational issues. Furthermore, the scalability from welfare perspective is also questionable given there is a single winner (see proposition 2).

**Proposition 2:** Given a sufficient large group size and independent preferences, the bids in an auction which sells the decision rights of contract items to a single winner do not have an impact on social welfare.

We suppose that individual j wins a set of decision rights  $\mathcal{R}$  with the highest bid in an auction. We analyze the scalability by means of the social welfare SW for the set  $\mathcal{R}$  which is defined as

$$SW(\mathcal{R}) \equiv U_j(\mathcal{R}) + \sum_{j=1; j \neq j}^N U_j(\mathcal{R})$$

Without loss of generality, we can replace the different counter agents  $j \in \mathcal{J} \setminus j$  with a single representative counter agent  $\varphi$ , i.e., all parties except for j have the same utility. Using this, we can replace the sum with a product.

$$SW(\mathcal{R}) = U_j(\mathcal{R}) + (N-1)U_{\varphi}(\mathcal{R})$$

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As j decides about the issues in his or her set of decision rights  $\mathcal{R}$ , we specify his or her contribution to the social welfare as following:

$$w_j(\mathcal{R}) = \frac{U_j(\mathcal{R})}{SW(\mathcal{R})} = \frac{U_j(\mathcal{R})}{U_j(\mathcal{R}) + (N-1)U_{\varphi}(\mathcal{R})}$$

Deriving this, we obtain the alteration rate of the contribution for  $\mathcal{R}$  which is less than or equal to zero given that  $U_{\phi}$  is greater or equal to zero. The latter can be derived from the individual rationality constraint, i.e., generally, a mechanism has to yield a non-negative outcome or the participants would opt out of it.

$$\frac{\partial w_j(\mathcal{R})}{\partial N} = \frac{-U_j(\mathcal{R}) * U_{\varphi}(\mathcal{R})}{SW(\mathcal{R})^2} \le 0 \quad \forall \ U_{\varphi} \ge 0$$

As shown below, the limit of j's contribution to the social welfare converges to zero. In other words, the more parties participate the less relevant the decision of individual j is. This shows that if decision rights are auctioned to a single individual, the social result is more or less independent of the decision of the auction winner with large group sizes given independent preferences of parties.

$$\lim_{N\to\infty}w_j(\mathcal{R})=0$$

### Social Choice

Social choice is mainly concerned with group decision making by means of voting (Sen 2003). There is a huge spectrum of voting protocols like, e.g., majority voting, eliminating voting (runoff voting), cumulative voting, or ordinal voting (Shoham & Leyton-Brown 2009). In this paper, we take a closer look at pairwise simple majority voting. At this, there are two alternatives, and the alternative gathering the most votes is elected. Proposition 3 analyzes the scalability of such an election.

# **Proposition 3:** Given a sufficient large group size and independent preferences, the impact of a single vote in a paired election becomes infinitesimal; however, the result converges to the ordinally average preference.

The voter which has the ordinally average preference is called the median voter (MV) as he or she halves the population. For instance, if a group wants to estimate its budget, one half wants to have more budget and one half wants to have less budget than the MV. According to the median voter theorem, the MV's vote represents the winning alternative (Hotelling 1929). The probability  $P_j^I$  that agent *j*'s preferred choice wins the voting is subject to (1) the probability  $p_{MV}^j(N)$  that an agent *j* becomes MV and (2) the likelihood  $p_{\varphi}^I$  that *j* is not MV, but the MV's vote is beneficial for *j*.

We define  $P_i^I$  as

$$P_{j}^{I} = p_{MV}^{j}(N) + p_{\varphi}^{I} * (1 - p_{MV}^{j}(N))$$

We assume that the probability of being MV has the following property: the more agents participate the less likely he or she is MV  $\left(\frac{p_{MV}^{j}}{\partial N} \leq 0\right)$ . Differentiating leads to:

$$\frac{\partial P_j^I}{\partial N} = \frac{p_{MV}^j}{\partial N} - p_{\varphi}^I * \frac{p_{MV}^j}{\partial N} \le 0$$

Since  $p_{\varphi}^{I} \in [0,1]$  and  $\frac{p_{MV}^{i}}{\partial N}$  is negative (hence,  $\frac{p_{MV}^{i}}{\partial N} \ge p_{\varphi}^{I} * \frac{p_{MV}^{i}}{\partial N}$ ), the derivation is also negative, i.e., the probability that the preferred choice of j is elected decreases with rising group size. Nevertheless, the voter still has some chance to win the voting as the limit converges to  $p_{\varphi}^{I}$ .

$$\lim_{N\to\infty} P_j^I = p_{\varphi}^I$$

Consequently, we conclude that in voting mechanisms the impact of a single individual becomes infinitesimal, but the outcome converges towards the social preference average. The impact of a single agent is limited, but the group decision making does not become stuck.

# Manipulation and Information

In the last section, we have argued that elections are eligible for group decisions involving a large number of participants. However, in contrast to other group decision mechanisms, elections can be manipulated, i.e., some agents can be better off by tricking. In the following, we discuss different manipulation forms and the impact of imperfect information.

### **Manipulation Forms**

Unfortunately, elections suffer from manipulative behavior. Manipulation means that voters can benefit from not acting according to their real preference (Gibbard 1973). In this context, the seminal Gibbard-Satterthwaite impossibility theorem states that any non-dictatorial voting scheme with three or more alternatives is subject to manipulation (Gibbard 1973; Satterthwaite 1975).

One group of manipulation forms is individual manipulation. Strategic voting is such a manipulation form (Cranor 1995). For instance, in pairwise elections, in which alternatives are successively eliminated by pairwise comparison, it might beneficial for a voter, if he or she votes for a worse alternative to have better chances for his or her most preferred alternative (or, in other words, to obtain a weaker opponent in subsequent elections). Besides individual manipulation, collective manipulation is an issue in social choice research. Relevant forms of collective manipulations are logrolling, vote buying, and collusion. Logrolling is vote trading, i.e., a voter trades his or her vote in an election in exchange for a vote in another election (Wilson 1969). This is especially relevant if there are several decisions. Similarly, vote buying (or bribing) means that voters trade votes for money (Schaffer & Schedler 2007). Those two manipulation kinds are bilateral. Opposed to that, collusion is multilateral. Collusion is when a set of voters constitute a coalition and vote according to the preference of this coalition (Laffont & Martimort 1997). In majority voting with N voters, a coalition of N/2+1 voters can dictate the result in any case.

### The Role of Information

All of the manipulation forms presented above require certain information about preferences or voting behavior. As mentioned beforehand, models often draw on game theory which most often suppose complete information; however, information is often not completely available and, thus, imperfect (Rubinstein 1991). If a voter tries to manipulate a voting, he or she has to know at least some of the preferences or intended votes of the other participants. So, he or she has to know, e.g., who to bribe or which alternative is strategically beneficial.

However, a participant of a group decision process has very little incentives to reveal relevant information. If one individual discloses preferences and another does not, there is an asymmetry which can be exploited. Therefore, the agents would act uncommunicative and keep their preferences dark (Sandholm 1999).

Another issue is the accessible information about voting results and votes. Given the voting is a secret ballot voting, a sufficient number of votes are not predictable, and preferences are hidden, assignment of votes to voters becomes infeasible, i.e., a voter's choice stays hidden from the other voters.

**Proposition 4:** Given that votes are not assignable to certain voters, bilateral manipulation such as logrolling or bribing is not feasible.

A manipulator could get a bribe for voting in a certain manner, but the fulfillment of the agreement is not verifiable. Consequently, there is no incentive to vote according to the agreement. Let us assume that agent *j* has a utility function satisfying  $U_j(A) > U_j(B)$  for alternatives *A* and *B*. Another agent offers him or her a bribe amounting to  $\beta$  for voting for alternative *B*. If his or her actions are hidden, *j* would vote for *A* as his or her payoff of  $p_{MV}^j * U_j(A) + \beta$  is larger than sticking to the bribing agreement  $p_{MV}^j * U_j(B) + \beta$  (with  $p_{MV}^j$  as probability of being the median voter). The same holds true for logrolling. Let us say there are

two elections with  $U_j(A) > U_j(B)$  as well as  $U_j(C) > U_j(D)$  and the logrolling agreement is that j votes for B in exchange for an additional vote for C. Again, the payoff is larger if j does not fulfill the agreement  $(p_{MV}^j * (U_j(A) + U_j(C)) > p_{MV}^j * (U_j(B) + U_j(C)).$ 

Concluding, the manipulation can be manipulated itself.

We have seen that secrecy of votes can prevent bilateral manipulation. In the case of multilateral manipulation, secrecy might prevent collusion as well (see proposition 5); nevertheless, the supposition of secret votes is hard to stand by (see proposition 6).

**Proposition 5:** Given that votes are not assignable to certain voters, coalitions are instable.

We consider two alternatives A and B and a representative voter j is part of a coalition which can dictate the result. We assume that j prefers A, such that  $U_j(A) > U_j(B)$ , and the coalition prefers B. Hence, if jvotes according to the coalition's preference, it would lead to a utility of  $U_j(B)$ , as the coalition can dictate the result. Voting against the coalition's will results in an expected utility of  $p_{MV}^j * U_j(A) + (1 - p_{MV}^j) *$  $U_j(B)$  which is larger than  $U_j(B)$ . Voter j can become the median voter if sufficient coalition members deviate or the coalition consists of exactly the N/2 + 1 voters. After all, given secrecy of actions, being a traitor in the coalition might be the individual best choice.

Nevertheless, in coalitions the number of voters is smaller and, since there is a primary election within the coalition, the knowledge about preferences is larger. Considering that, a traitor is more likely to be uncovered. The next proposition analyzes the situation in which a traitor could be uncovered and has to act in consideration of this uncertainty.

**Proposition 6:** Given that votes are assignable to certain voters in some cases, coalitions can be stable due to potential reprisals.

Based on proposition 5, we suppose a probability of being discovered of  $\omega$  and a consequence of being discovered with a utility of  $C_j < 0$  now. Consequently, the expected utility of betraying is  $p_{MV}^j * U_j(A) + (1 - p_{MV}^j) * U_j(B) + \omega * C_j$ . Thus, a coalition is instable if the expected benefit from the cheat is larger than the negative consequences:  $|p_{MV}^j * (U_j(A) - U_j(B))| \ge |\omega C_j|$ .

However, if this inequality is not fulfilled, the coalition is stable, and all participants vote according to the coalition's will.

The environment of the coalition is also known as the cartel game. Game theorists examined the stability of cartels and the incentive to betray the cartel by, e.g., not sticking to arranged production quotas (Osborne 1976).

### Structured Bribing: A Market for Votes

As a consequence of the last section, mechanism design could try to prevent information revelation such that manipulation of elections becomes more difficult. However, in this section, we analyze if introducing transparency and structure can turn bribing into a beneficial mechanism. Instead of trying to prevent manipulation between few voters, we propose to include all voters. Bribing can be seen as side payments which are paid as compensation payments for giving up one's vote. In the following subsection, we present a market design for selling votes and some experimental results gained by market simulation.

### **Related Work**

Buchanan and Tullock (1962, Chapter 10) as well as Coleman (1966) discuss the welfare effect of logrolling and argue that it can be beneficial. Coleman (1966) even regards the move from logrolling to market competition as a conclusive extension. Philpotts (1972) computationally simulates vote trading using vote exchanges ratios for subsequent elections which is a hybrid version of logrolling and vote buying. Casella et al. (2010) shows the existence of an ex ante market equilibrium with welfare losses and evaluate the theoretical findings by means of laboratory experiments. Similarly, Kultti and Salonen (2005) show the theoretical feasibility of market equilibria, whereas Weiss (1988) proposes that there is no market equilibrium. Stokes (2007) discusses vote buying from an ethical, normative point of view.

In contrast to social choice theory, the issue of vote buying is fairly covered in public choice theory, often alongside the issue of lobbyism. For instance, Philipson and Synder (1996) present a vote market for legislators where prices are elicited by means of market specialist and the legislators are clearly divided into majority and minority coalitions. Similarly, Koford (1982) present an approach in which legislators deal with party leaders, and Dal Bó (2007) analyzes bribing payments from a third party and discusses the principal-agent consequences for legislators.

# Experiment Design, Hypotheses, and Measures

We consider an environment in which a group of size J has to decide over I issues. An issue i has a binary decision variable  $d_i \in \{0,1\}$ , and, depending on  $d_i$ , an individual obtains a utility  $U_j(i) \in [-\alpha, +\alpha]$  which can be both, negative and positive. The utility function for a set of decision issues  $\mathcal{D}$  be  $f_j(\mathcal{D}) = \sum_{d_i \in \mathcal{D}} U_j(i)$ . The objective is to find a social welfare maximizing set of decisions:  $\max \sum_{i=1}^{J} f_i(\mathcal{D})$ .

As a starting point, we choose a simple majority voting for each issue and designed a market for votes, i.e., votes are tradable. For an odd number of agents, simple majority voting with two alternatives is fair, anonymous, and decisive (May's theorem: May 1952). Like in a stock market, demand and supply yield a quote for a vote. Table 1 shows an example, how prices are made. Bids for votes and asks votes are matched and the price maximizing the number of deals is chosen. After this, votes are traded subject to this price. As a consequence, some voters have more than one vote and some obtain compensation payment for not having a vote anymore.

According to our design, all participants submit one bid  $b_j(i)$  per issue which is concurrently ask and bid price, i.e., a voter has to be willing to do both, buying and selling, subject to an adequate price.

We supposed that all voters have to submit a bid and, furthermore, we assumed that they act truthfully according to our behavioral model. A detailed discussion about the assumptions can be found in the next section. The assumed behavioral model is that agents' bidding price is  $b_j(i) = p_{MV}^j * |U_j(i)|$ , whereby the probability of being median voter  $p_{MV}^j$  is given ex ante, and we approximated  $p_{MV}^j$  with 1/N for the simulations. In other words, they bid with their expected valuation of the vote which is calculated using the likelihood of being the decisive voter. The valuation or opportunity cost is equal to the absolute value, as voters try to prevent (if  $U_j(i) < 0$ ) or enforce (if  $U_j(i) > 0$ ) a decision  $d_i = 1$ .

These assumptions are very simplifying and may be incongruent with rational behavior as they disregard likely voting outcomes and majority relations, which, however, could be unknown to the agents. Nevertheless, this heuristic behavioral model helps us to approach the problem and show if the market for votes is hypothetically capable of delivering beneficial solutions.

Price	Demand	Supply	Deals
52	8	12	8
51	9	10	9
50	12	10	10
49	15	9	9
48	16	7	7

Table 1. Price formation example.

The vote exchange is nothing else than bribing. Nevertheless, in this setting, the bribing is structured and all voters participate. Furthermore, there is transparency and a supervisory authority (the votes' auctioneer) monitoring the process. Basically, this allocation mechanism is an auction; however, there is more than one winner (different to section "Scalability of Auctions"). We hypothesize that this mechanism is more beneficial than a simple majority voting (see hypotheses 1 & 2).

**Hypothesis 1:** A market in which votes are traded can lead to a larger social welfare of a group decision than a truthful simple majority voting subject to the assumptions of this study.

**Hypothesis 2:** A market in which votes are traded is superior for more individuals than it is inferior compared to a truthful simple majority voting subject to the assumptions of this study.

To evidence the hypotheses, we compared the welfare performance of the market approach with the simple majority voting. At this, we draw on two measures:

Firstly, the social welfare markup  $SW_{imp}$ , i.e., the improvement of the social welfare of the market approach  $SW_m$  in terms of the common voting  $SW_v$ .

$$SW_{imp} = \frac{SW_m}{SW_p} - 1$$

Consequently, if  $SW_{imp}$  is non-negative, the market approach performs better.

Secondly, we took a closer look at the voters who are better off and those who are worse off and computed the difference of the shares  $Ind_{diff}$ . The sets of people better or worse off are called  $\mathcal{B}$  and  $\mathcal{W}$ , respectively. To account for different group sizes, the figure  $Ind_{diff}$  measures the difference between those two subsets' shares of the total voter population (with  $|\mathcal{X}|$  as cardinality of set  $\mathcal{X}$ ):

$$Ind_{diff} = \frac{|\mathcal{B}|}{J} - \frac{|\mathcal{W}|}{J}$$

Again, a positive value indicates that more individuals are better off with vote trading than without.

In total, we have conducted 39,200 computational experiments. Table 2 shows the chosen parameters. We used different numbers of issues (from 25 to 200) and different group sizes (from 3 to 99 individuals; odd numbers only, see May's theorem). To avoid deadlock results, we only considered odd numbers of agents. The utility of an agent j for a decision  $d_i = 1$  is uniformly distributed in the interval  $\mathcal{U}(-100,100)$  (or 0, if  $d_i = 0$ ). For each number of issues/agents combination, the group decision was repeated 100 times using new random utility values.

Issues (I)	25 - 200	(step: 25)
Agents (J)	3 – 99	(step: 2)
Experiments per Issues/Agents Comb.	100	
Utility of an Issue	Uniformly D	istributed (-100,100)
Total Experiments	39,200	

Table 2. Parameterization of the experiments.

### Results

In this section, we present the findings of the computational experiments and their limitations.

#### **Computational Results**

Table 3 shows some descriptive statistics as well as significances of the 39,200 simulations.

	SW <sub>imp</sub>	Ind <sub>diff</sub>
Mean (µ)	14.49%	11.09%
Coefficient of Var. $\left(\frac{\sigma}{\mu}\right)$	2.05	1.87
5 <sup>th</sup> / 95 <sup>th</sup> percentile	-4.99% / 45.67%	-10.34% / 53.85%
Significance (p-value) Market > Voting	< 10 <sup>-15</sup>	< 10 <sup>-15</sup>

Table 3. Descriptive statistics and significances.

Firstly, the market approach yields a 14.49% larger social welfare in relation to a simple voting, which is the welfare performance mark-up. The coefficient of variation is relatively high with a factor of 2.05, i.e., the standard deviation amounts to 29.65%. If the values were normally distributed, around 68% of the results would be in the interval of -15.17% and 44.14% ( $\mu \pm \sigma$ ). We performed a Shapiro-Wilk test as well as a Kolmogorov-Smirnov test which show that the values are not normally distributed, although they have a bell-shaped histogram. Actually, there are not 68%, but more than 93% of the values in the mentioned interval. This and the 5<sup>th</sup>/95<sup>th</sup> percentile (-4.99% / 45.67%) show that there are a lot of outliers. Finally, we conducted a Wilcoxon-Mann-Whitney test (since a t-test is infeasible due to the requirement of a normal distribution) and tested whether  $SW_m$  is significantly greater than  $SW_p$ . This test can be verified with a very high significance. Consequently, we can confirm hypothesis 1 – the market based approach yields a larger social welfare subject to the given assumptions.

Secondly, we took a closer look at the shares of voters better and worse off. The results show that the share of voters being better off is 11.09% larger than the share of voters being worse off. Again, the coefficient of variation is relatively large with a factor of 1.87 (standard deviation ( $\sigma$ ): 20.78%). As the curve is also densely centered (and not normally distributed), there are around 84% of the data set in the interval  $\mu \pm \sigma$ . The 5<sup>th</sup>/ 95<sup>th</sup> percentile lies at -10.34% / 53.85%. The data indicates that there are less outliers than in the social welfare data, but still plenty. Analogously to above, we performed a Wilcoxon-Mann-Whitney test whether the share of voters better off  $|\mathcal{B}|/J$  is significantly greater than the share of voters worse off  $|\mathcal{W}|/J$ .

Likewise, the test reveals that the statement is true with a very high significance and, thus, we can confirm hypothesis 2 as well – more individuals are better off in a market for votes than worse off subject to the given assumptions.

Figure 1 shows the boxplots without outliers of the two approaches. Here, the welfare is normalized with respect to group size and issue count. The market-based approach has a wider spread, which is beneficial in

this case, as both lower whiskers are at zero. Furthermore, the lower quartile, the median, as well as the upper quartile are larger than in the common voting scenario. Finally, the upper whisker is also larger which indicates better results as well.





Fig. 1. Boxplots of the welfare results normalized with group size and number of issues (outliers omitted).

In figure 2a and 2b, we plotted how an increasing number of voters and an increasing number of decision issues affect the measures. Obviously, the superiority of the market declines with a rising number of voters (the figure shows a group size of 3–99). The comparative advantage seems to converge to approx. 7.5%  $(SW_{imp})$  or 3.0%  $(Ind_{diff})$ , respectively.

The analysis of the number of decisions yields different results. Here, the advantage of more social welfare declines with a rising number of issues and converges as well. However, the share of voters better off increases with a rising issue count. This means, the more issues are involved in the group decision, the more people benefit from the market-based approach.



Fig. 2a / 2b. Average SW<sub>imp</sub> (black diamonds) and Ind<sub>diff</sub> (gray circles) depending on group size (2a, left) and number of issues (2b, right).

### Limitations

The computational experiments show that the market-based approach is hypothetically capable – subject to the given assumptions – to yield high quality solutions which considerably improve the outcome of a simple majority voting. Nevertheless, the findings are substantially based on the behavioral assumptions, we have made. We assumed that voters act truthfully at the vote market, i.e., they ask or bid using their true valuation and the probability of being median voter. Proposition 7 analyzes if the market price can be manipulated.

**Proposition 7:** The voters except for one cannot manipulate the market price, and this price-determining voter submits the second best price.

For both, asking and bidding, a voter has to state a reservation price  $r_j(i)$  for an issue *i*. This price is concurrently the ask and bid price  $b_i$ . A bidder could bid strategically if the alteration of his or her bid  $b_i$ 

leads to a lower price  $p^*$ . Thus, if  $\hat{b}_j = b_j - \varepsilon$  led to a better outcome, the voter would manipulate the pricing. However, if  $b_j \neq p^*$ , a marginal change of  $b_j$  does not lead to a change of the market price – the voter is price taker. Consequently, just one bidder whose bid is  $b_j = p^*$  can influence the market price (or another bidder by lowering his or her bid to  $p^*$ ). This specific bidder can lower his or her bid until it is equal to the next closest smaller bid. Since all prices that are less than the bid lead to a request and all prices that are larger than the bid lead to an offer, the bid can be lowered until the bidder drops out of the allocation. This is the case if the bid becomes smaller than the next closest bid, i.e., the price-determining bidder bids the second best price. Consequently, the mechanism is equivalent to a second price auction.

From proposition 7, we have learned that the price mechanism cannot be manipulated. It just converges to the second best price. Proposition 8 deals with the truthfulness of bids.

**Proposition 8:** The voters act truthfully in the market according to the assumed behavioral model only if he or she can influence the decision.

As stated before, we assumed that the bidding price of an agent j is  $b_j(i) = p_{MV}^j * |U_j(i)|$  and the probability of being median voter  $p_{MV}^j$  is given ex ante.

Firstly, we look at the situation that a voter can influence the decision which is when a voter can turn the scale  $(p_{MV}^j = 1)$ . Then, the voter bids his or her opportunity cost that is his or her valuation which is  $p_{MV}^j * |U_j(i)|$ . Supposing  $U_j(i) > 0$ , the gain for buying a decision influencing vote, i.e., the vote changes  $d_i = 0$  to  $d_i = 1$  (or vice versa, if  $U_j(i) < 0$ ), is equal to  $|U_j(i)|$ . As shown in proposition 7, the bidder pays at most the closest smaller price, which is the second best price. This is equivalent to a second price auction. Consequently, the voters are truthful, if they can influence the decision.

Secondly, if the majorities are clear and the resulting decision is obvious, a voter could set the bid to almost zero, and give up his or her vote for almost free. Following the logic of  $p_{MV}^j * |U_j(i)|$ ,  $\hat{b}_j$  would converge to zero, if  $p_{MV}^j$  converged to zero. Nevertheless, the "free" votes of the majority could be obtained by the minority which then can become the majority. Consequently, the members of the majority have to submit bids which are just enough such that the minority cannot buy a sufficient number of votes. The probability of being median voter is not constant as assumed, but rather dynamic, i.e., besides an ex ante probability  $p_{MV}^{j_{EA}}$ , there is also an ex post probability  $p_{MV}^{j_{EP}}$ . The bid price is higher than the ex ante valuation ( $p_{MV}^{j_{EA}} * |U_j(i)| < \hat{b}_j(i)$ ). Thus, the precise bid amount is subject to the majority / minority relation and dynamics.

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As a consequence of proposition 8, we have to decline that truthfulness in terms of our ex ante model is given (in addition to the vague approximation). Voters would take the dynamics of the majority / minority relation into account and adjust their bids accordingly. The determination of the expost probability is a task for our future work. After having modeled the equilibrium strategies, we should be able to show if truthfulness is given or not in general. Nevertheless, the strategic equilibrium is subject to the information sets of the individuals which we also are going to analyze further.

Concluding, we have shown that the strategic behavior of this market mechanism is a non-trivial problem that needs further research (see next section).

### **Conclusion and Future Work**

In this study, we introduce an approach of using a manipulation form to improve group decision making. Concerning this, we discuss the scalability of different group decision mechanisms such as negotiations, auctions, or elections. The analysis reveals that negotiations with unanimity get stuck with large group sizes and the impact of an auction winner becomes marginal. However, elections can provide large-scaled group decision making as the process does not get stuck and the outcome converges to the social preference average. Social choice is an important and well-researched field. Nevertheless, elections are known to be manipulable. The paper shows that the role of information is very important while analyzing manipulations. On the one hand, more revealed information facilitates manipulations such as coalition formation or logrolling, but, on the other hand, we showed that manipulation is not bad in general. We constructed a market for votes in which the voters "bribe" each other. The market is designed like a stock exchange. By introducing structure and transparency as well as clear rules, the outcome of the election can be significantly improved. In other words, by selling votes on a structured market, some individuals obtain a compensation payment while others can buy the decision power. When few care much and many care little, payments can improve both, the social welfare as well as number of individual improvements. Like the famous proverb "put money where your mouth is", group members have to pay for their actions instead of noncommittal announcements in the group decision process.

As we have discussed, we used a heuristic and simplifying behavioral model which does not correspond to rational behavior. Nevertheless, besides those limitations, the model helps us to approach the problem and show its potential for future research.

Future work will be to improve the voters' behavioral model and deduce optimal responses to one's environment's events. At this, we are going to discuss in more detail which information might be public and which information might be hidden during the market phase and how the valuation based on the median voter probability's dynamics is established. Furthermore, we will improve the market mechanism and are going to enhance the experiments by incorporating more complex group decision problems which, e.g., consider interdependencies of issues or problem spaces beyond binary decision variables.

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# Using Anonymity and Cognitive Factions to De-Fuse Power Relationships in an Academic Strategic Planning Setting: A Case Study

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**Abstract**: Strategic plans reflect the beliefs and values of their architects. Uncovering these diverse beliefs using anonymity and cognitive factions is proposed to facilitate the development of a more democratic strategic plan. We suggest that making diverse beliefs explicit may ameliorate power effects associated with organizational decision-making. In this specific case, through the use of anonymity and cognitive factions, we found that the sources of power typically found and used to drive decisions in an academic setting did not drive the content of the strategic plan.

Keywords: Anonymity, Cognitive Factions, Organizational Power, Strategic Planning

# Introduction

Traditionally, strategic plans are presumed to be the product of a "top down" approach that often is plagued by political forces such as power differences (Finklestein, 1992). Unfortunately, powerful actors in the group can block, alter, or sway choices to the detriment of the organization or organizational unit. Even when these actions are avoided, the "top down" approach often introduces changes that generate inevitable resistance and, at best, lessen employee commitment to the plan (Ansoff, 1987). Given these potential outcomes and their effect on strategy implementation, many scholars have called for a "bottom up" or more democratic process to strategy formation and strategic planning (Andersen, 2004).

Research has shown that a bottom-up process can promote cognitive diversity that can increase the fit between the strategic plan and the organization's performance by: (1) promoting a broader set of opportunities to evaluate (Burgelman, 1991), (2) encouraging critical evaluation (Jehn and Mannix, 2001) and (3) reducing the likelihood that groupthink will occur (Janis, 1982). It can also increase decision acceptance (Jehn, 1997) and consensus (Markoczy, 2001). But, the results linking bottom-up planning, group process, and performance have been mixed. Simons et al. (1999) found that the group must actively debate the issues in order to benefit from diversity. So, to optimally benefit from a bottom-up approach, strategic planning processes need to be structured in order to generate diverse beliefs and include constructive debate.

While the exchange and discussion of diverse beliefs have been linked to strategic planning effectiveness (Hambrick, 1994, 2007; Jackson, 1992), the question of which beliefs emerge in the strategic plan warrants more investigation. Studies have shown that the most powerful team members often shape the content of the plan (Eisenhardt et al., 1997). Since the influence of power on the plan itself can result in decisions that promote the most powerful constituents, ways of controlling the impact of power should be further explored. We investigate whether only the most powerful constituents influence the content of an actual strategic plan or whether the lower level, less powerful constituents also influence it. In doing so, we hope to shed light on how to practically implement a bottom-up strategy formation process which can control the deleterious effects of power on strategic planning.

Recognizing the importance of using bottom-up planning, Ansoff and McDonnell (1990) recommend an interactive process that facilitates the inclusion of information and beliefs from all parts of the organization. To explore the recommended bottom-up approach to strategic planning, we use a Group Support System (GSS) that provides a mechanism for supporting anonymity during two vital stages in the strategic planning process: identification (uncovering of diverse beliefs) as well as reconciliation (e.g., debate and agreement) of the diverse beliefs (Eden and Ackermann, 1998). In addition, using the GSS reveals cognitive diversity (underlying thoughts, beliefs and values) that has been shown to be central to effective decision-making and strategic planning (Hambrick and Mason, 1984; Millikin and Martins, 1996).

In sum, this study uses a GSS to investigate whether the content of an actual strategic plan is driven by: (1) the most powerful constituents' set of beliefs or (2) a broad range of beliefs from all constituents that are anonymously uncovered. Our contributions are two-fold:

- 1. We show that anonymity in brainstorming and cognitive factions can diffuse power.
- 2. We extend the cognitive diversity literature by linking a diverse set of beliefs to the content of an actual strategic plan.

Our paper is organized as follows. In the Background and Propositions section, we develop a set of propositions that are rooted in the strategic decision-making and planning, group support systems, and organizational power literatures. In the Research Design section, we describe the steps in a strategic planning process that was conducted in a multi-disciplinary academic department at a major university in the eastern United States. The Analysis section illustrates the process used to link the individual beliefs that were elicited during the strategic planning process to the actual content of the strategic plan and uses these results to evaluate the propositions. Finally, the Discussion section reviews the results, their implications, and the limitations of this study.

# **Background and Propositions**

### Individual Beliefs and Strategic Planning

Research has consistently shown a strong link between the beliefs of each strategic planning member and his or her strategic thinking and choice (Box et al., 1991; Hambrick, 1994, 2007; Jackson, 1992; Schwartz, 1992). These beliefs can result in very idiosyncratic individual differences among strategic planning members (Ackermann and Eden, 2011; Johnson et al., 1998). For example, decision makers in different functions, specialization, and work groups can hold different beliefs that drive their individual decision-making (Daniels et al., 1994; de Chernatony et al., 1993; Johnson 1987, 1988; Laughlin 1991; Prahalad and Bettis, 1986). At the same time, functionally specific frames of reference can be fractured by personal belief systems (Dearborn and Simon, 1958; Handy 1985). Throughout this research, there is little doubt that when making decisions, each strategic decision maker will draw upon a variety of frames of reference (Hodgkinson and Johnson, 1994) including those related to career backgrounds, tenure and education (e.g., Gunz, 1989; Gunz and Whitley, 1985; Hambrick and Mason, 1984; Whitley 1987).

### Beliefs of Cognitive Factions and Strategic Planning Content

Ideally, the strategic planning process should include as many stakeholders as possible that are affected by the results of the plan (Bryson et al., 2004). In this study, we use a process that systematically uncovers cognitive factions (cognitive diversity), i.e., subgroups comprised of individuals that have similar beliefs about a problem domain that differ from other subgroups (Tegarden et al., 2009). A critical precursor to uncovering cognitive factions is each decision maker's willingness to express his/her beliefs. Research has shown that under conditions of anonymity, individuals are more willing to express opinions that are incongruent with the group (Baltes et al., 2002; Valacich et al., 1992). And, anonymity "should reduce the impact of implicit reference group norms and of group members' social approval of one another..." (Siegel et al., 1986, 162).

In field studies using GSS, group members have reported that anonymity encouraged open and honest discussions and reduced organizational politics including the fear of embarrassment, disapproval, or sanction of a poorly-received remark (Diehl and Stroebe, 1987; Jablin et al., 1977). Anonymity also promotes idea generation and objective evaluation of inputs (Hiltz et al., 1989; Nunamaker et al., 1987). Furthermore, supporting anonymity through the use of GSS technology upholds a more democratic decision process (Siegel et al., 1986; Watson et al., 1988). This is especially true, with regard to formal or informal power relationships, when the group of participants is made up of individuals that participate in actual or perceived superior/subordinate roles (Wilson et al., 2010). Therefore, anonymity supported by GSS technology offers a low-threat communicative environment (Diehl and Stroebe, 1987; Jablin et al., 1977) that promotes a broader range of beliefs to be considered in the generation of a strategic plan.

In summary, utilizing uncovered anonymous cognitive factions increases the breadth of beliefs used in a strategic planning process. We propose that when cognitive factions are used in a strategic planning process,

the elements of the strategic plan will reflect the diversity of beliefs across the cognitive factions. In other words, the strategic plan content will be related to cognitive factions. Stated more formally:

**Proposition 1:** It is expected that the beliefs of the cognitive factions will be reflected in the content of the strategic plan.

### Beliefs of Powerful Participants and Strategic Planning Content

A reality of most organization life is the impact of power. Since strategic decision making groups are composed of group members with different beliefs, the pursuit and use of power is inevitable (Pfeffer, 1981, 1992). Two levels of power (i.e., individual and group) and their impact on the strategic planning process are briefly discussed below.

Individual Level. The individual perspective defines power as the individual's ability, or perceived ability, to influence another (French and Raven, 1959), including the ability to influence strategic choices (Finklestein, 1992). Structural power, the most commonly studied type of individual power (Finkelstein, 1992; Pfeffer, 1981), is based on formal organizational structure and hierarchical authority (Brass, 1984; Hambrick, 1981; Tushman and Romanelli, 1983). Individuals are said to have structural power when they have (1) a legitimate right to exert influence over others (Weber, 1947); (2) perceived control over valuable resources (Pfeffer and Salancik, 1978), or (3) the ability to administer rewards and punishments (Dornbusch and Scott, 1975). This form of power is similar to authority, i.e., power that is derived from institutionalized roles or social arrangements (Weber, 1947). Traditionally, in academic departments, structural power comes from two sources: the position of chair and rank (i.e., promotion and tenure status). Chairs typically are boundary spanners who are responsible for scheduling, assigning faculty to committees, and allocating the department's budget. Through these and other actions, department chairs can directly and indirectly shape the content of a strategic plan. At the same time, tenured faculty, especially senior faculty, are seen as powerful forces that have the power to block or implement "slow death" initiatives that conflict with their beliefs (Chu, 2010). In this case, structural power is operationalized by the rank of and the number of years of service (tenure) of each faculty member. Essentially, the higher the rank and the greater the tenure of a faculty member, the greater the amount of individual power the faculty member possesses. Decision making at this level would be consistent with traditional centralized (top management) strategy formation, that those who have structural power will have more influence on the strategic plan outcome.

Group Level. In the context of group decision-making, research has shown that power inhibits the direct expression of ideas (Gruenfeld, 1995; Gruenfeld and Preston, 2000; Holtgraves and Lasky, 1999; Hosman, 1989) as well as social reasoning (Kipnis, 1972; Nemeth, 1986; Woike, 1994;). Studies also suggest that the mere presence of the more powerful agents evoke deference even when there are no overt attempts to persuade (Copeland, 1994; Petty and Cacioppo, 1986). Furthermore, strategic decision makers will often form coalitions with other like-minded individuals in order to control decisions (Cyert and March, 1963; March, 1962). Given the career backgrounds and education differences within a strategic decision making unit, it is inevitable that multiple coalitions are formed that will vie for dominance through the acquisition of power (Pfeffer and Salancik, 1978), especially when preferences conflict as is the case when resources are limited and where conditions create a zero-sum game situation (e.g., Gunz, 1989; Gunz and Whitley, 1985; Pfeffer, 1981). In this study, the group level dimension of power is operationalized by the discipline in which the faculty resides. The discipline to which a faculty member was assigned is based on the faculty member's career backgrounds, education, and teaching and research interests.

The basic premise is that power is expected to affect the content of a strategic plan and we propose that the more powerful members will influence the strategic plan to a greater degree than those with less power. Specifically, given the two identified dimensions of power, we propose that:

**Proposition 2a:** It is expected that the beliefs of more powerful individuals (rank and years with the organization) will be reflected in the content of a strategic plan to a greater degree than those with less power.

**Proposition 2b:** It is expected that the beliefs of more powerful group (discipline) will be reflected in the content of a strategic plan to a greater degree than those with less power in the other groups.

# **Research Design**

It is widely accepted that public universities are decentralized, political structures in which there is widespread strategic discretion and considerable jockeying for power (Hackman, 1985; Pfeffer and Salancik, 1974). University faculty and administrators use strategic planning as a tool to craft and achieve short and long term objectives (Edge, 2004) as well as design institutional and academic change (Clagett, 2004). Our study focuses on a single academic department's strategic planning process. The department was comprised of 23 tenure-track faculty, where 17 participated in this process. The department offered three undergraduate majors, three masters degrees with multiple options, and a PhD program with multiple options, supports a regional professional conference, and has a large donor base and endowment fund. Since we are seeking to discover whose beliefs were extracted and reflected in the resulting strategic plan, a brief description of the strategic planning process is summarized below.

# Step 1 - Capture the Diverse Beliefs of the Members of the Department

At the time of the study, the department was facing a reduction in resources, while at the same time having to deal with increasing demands. Given the need to address so many changes, the department head adopted a GSS process that would capture the diverse beliefs of the department members (see Tegarden and Sheetz, 2003 for a detailed description of the process). The specific procedures to elicit the individual beliefs using this process are given in Table 1. The framing statement given in Figure 1 drove the brainstorming process that was used to elicit the concepts.

Activity	Description
1. Elicit Brainstorming Concepts	Elicit characteristics, concepts, and/or issues that contribute to addressing the department's strategic issues contained in the framing statement. Comments are shared among all participants in an anonymous manner as they are entered.
2. Identify Strategic Factors	Participants verbally suggest names and definitions of strategic factors that group concepts by similarity. Participants discuss and debate factors until consensus is reached.
3. Classify Brainstorming Concepts into Strategic Factors	Each participant anonymously classifies the concepts into the strategic factors.
4. Rate Strategic Factors	Each participant anonymously rates each strategic factor on a 9-point scale, from important to extremely important.
5. Define Causal Relationships Between Strategic Factors (Create Individual Cause Maps)	Each participant anonymously identifies causal relationship among the strategic factors. Each causal relationship is assigned a direction (positive + or inverse -) and a strength from 1 to 3 for a scale of -3 to +3, from strong negative influence to strong positive influence of one category on another category.
6 Derive Cognitive Factions and Essential Theme Maps	Researchers cluster individual cause maps to identify cognitive factions. Based on the cognitive factions identified, researchers create a cognitive faction and an essential theme map for each faction (Tegarden, Tegarden, and Sheetz 2009).

Table 1	: Cause	Mapping	Procedure	to	Elicit	Diverse	Beliefs
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- 1) What does it mean to be a world class (Top 20) XXX<sup>a</sup> department?
- 2) What are the factors that influence the success and/or failure of a world class department?
- 3) As a department, what are our strengths and weaknesses?
- 4) What present and future constraints do we face that could keep us from being a world class department?
- 5) What should we do to become a world class department in the next five years?

<sup>a</sup>XXX was substituted for the name of the specific department to protect anonymity.

#### Figure 1: Framing Statement Used to Elicit Brainstorming Concepts

Strategic Factor Name	Definition	Brainstorming Concept Count
1. Curriculum/Programmatic Emphasis	PhD, Master's, Integration of disciplines, Degree options <sup>a</sup>	29
2. Faculty Development/Support	Flexible Assignments, Conferences, Mentoring, Training, Continuing Education	9
3. Outside Research Funding	Sponsored Research, Grants, Consulting, Corporate and Agency Funding	7
4. Quality of Students	Recruitment of Quality Students, All Students	12
5. Research Emphasis	Faculty Collaboration, Quality and Quantity of Research, Continuous Focus	26
6. Resources	Cash/Funding/Non-Financial Resources, State and Outside Development Funding	11
7. Reward Structure	Recruiting Faculty, Retention, Salary and Non-financial Rewards, Promotion and Tenure	10
8. Service	Contributions to Dept, College, University, Profession, and Society	4
9. Strengths of Dept	Diversity of Interests, Accounting and Information Systems, Low Pressure Environment	10
10. Teaching	Importance of Teaching, Course Delivery, Course Development, Integration with Research	10
11. Technology Support	Equipment/Computers, Labs, Projection Systems, Software, Databases for Teaching, Research, and Service, Technical Support for Technology	3
12. Visibility	Profession, Academy, Students, Employers, State and University Administration	12

#### Table 2: Participant Identified Strategic Factors and Concept Count by Strategic Factor

<sup>a</sup> specific degree name specifics were generalized to protect anonymity.

The faculty members anonymously generated a set of concepts. Based on the brainstormed concepts, faculty members then collectively defined twelve strategic factors (see Table 2). To validate that these twelve strategic factors reflected the concepts generated, the faculty members then classified the concepts into the twelve strategic factors. The researchers performed a content analysis of the 143 concepts that were categorized by a majority of the faculty members and found that the concepts placed by the majority in the strategic factors were in agreement with the strategic factor definitions. Next, the faculty members rated the importance of the strategic factors toward addressing the issues contained in the framing statement. The

faculty members reached a moderate level of agreement (Kendall's W = .432, X2 = 80.812, p = .000). These two steps (classifying the concepts and rating the importance of the strategic factors) provided some face validity that the faculty members had developed a common understanding of the strategic factors. Based on this common understanding, all 17 faculty members were able to create cause maps by linking the twelve strategic factors. Finally, based on similar beliefs about the relationships between the factors, the beliefs were aggregated into three cognitive factions using Ward's agglomeration clustering method and the squared Euclidean distance measure (Aldenderfer and Blashfield, 1984; Tegarden et al., 2009).

### Step 2 – Report the Planning Process Results to the Department

A department meeting was held to report the results. The 12 strategic factors and definitions, the 143 brainstormed concepts placed into the strategic factors, the anonymous individual and cognitive faction maps were discussed by the members of the department. During this discussion, anonymity was enforced so that department members did not know the source of the brainstormed concepts, the individual maps, or faculty membership associated with the three cognitive factions.

### Step 3 - Use the Anonymous Results to Create the Strategic Plan

A departmental strategic planning committee was formed. The committee was comprised of four senior faculty members and the department head. Three faculty members wrote the plan, while the fourth faculty member served as moderator and critique of the plan. The department head only intervened when necessary to ensure that the plan was comprehensive. The committee was charged to use the results from the GSS process. The strategic plan encompassed seven sections covering academic programs (undergraduate, masters, and PhD), research, outreach/service, alumni/employer relations, and donors/endowment funding.

### Step 4 - Report the Plan To and Gain Final Approval From the Members of the Department

Finally, the strategic plan itself was presented, debated, and approved by members of the department. The plan was disseminated prior to the faculty meeting. During the meeting, the committee explained and clarified the elements of the strategic plan. After discussion, the department members voted and unanimously endorsed the plan.

# Analysis

### Linking Individual Beliefs to the Strategic Plan Content

Each proposition is tested by evaluating the magnitude of influence each subgroup has on the content of the strategic plan by linking the individual beliefs (brainstorming concepts) to the elements of the strategic plan content via the strategic factors. We describe our methodology below.

Link of Subgroup Individual Beliefs (Brainstorming Concepts) to Strategic Factors. To determine the level of influence each subgroup (cognitive faction, rank/tenure, and discipline) had on the actual strategic plan, we counted the individual brainstorming concepts that were generated by members of each subgroup that were placed by a majority of the participants into a strategic factor. The greater the percentage of concepts generated by members of a subgroup, the greater the influence the subgroup had on the strategic factor.

*Cognitive Faction Beliefs.* Three cognitive factions were uncovered by clustering individual faculty maps by similarity of map relationships. As shown in the dendogram in Figure 2, there were nine faculty members associated with CF1, five with CF2, and three with CF3. Table 3 reports the number of concepts generated by participants associated with each cognitive faction. This number reflects the level of influence the subgroup had on each strategic factor. For example, the first factor, Curriculum/Programmatic Emphasis, contained concepts generated from individuals in each cognitive faction: Cognitive Faction 1 (CF1) generated 41% of the concepts, compared to CF2 that generated 45% and CF3 that generated 14%. Based on these percentages, we assume that CF1 and CF2 had a greater influence in the generation of this factor compared to CF3. In contrast, since participants in CF1 generated 86% of the concepts with the Outside Research Funding factor, CF1 had the most influence.



Figure 2: Dendogram Identifying Cognitive Factions

Table 3: Brainstorming Concept Generation by Cognitive Faction Subgroups

Strategic Factor where majority placed the Brainstorming Concepts during the cause	CF1	CF2	CF3
mapping process			
1. Curriculum/Programmatic Emphasis	12	13	4
	41%	45%	14%
2. Faculty Development/Support	4	4	1
	44%	44%	12%
3. Outside Research Funding	6	0	1
C	86%	0%	14%
4. Quality of Student	8	3	1
	67%	25%	8%
5. Research Emphasis	13	9	4
1	50%	35%	15%
6. Resources	3	6	2
	27%	55%	18%
7. Reward Structure	6	3	1
	60%	30%	10%
8. Service	1	2	1
	25%	50%	25%
9. Strengths of Dept	5	3	2
	50%	30%	20%
10. Teaching	6	4	0
	60%	40%	0%
11. Technology Support	2	1	0
	67%	33%	0%
12. Visibility	5	5	2
	42%	42%	16%

Cell:
Brainstorming Concept Count
Percent of Total Brainstorming Concepts by Sub-Group Category

*Individual-Level Power (Rank/Tenure) Beliefs.* The faculty members were classified into three rank/tenure subgroups: Chaired, Senior, and Junior. The Chaired group was comprised of the most powerful members of the faculty and included the chaired professors and the department head. The Senior classification included the Full professors and Senior Associate professors. Finally, the Junior classification included newly tenured Associate professors and untenured Assistant professors. In this study, there were three faculty members in the Chaired classification, five in the Senior classification, and nine in the Junior classification.

Table 4 reports the number of concepts generated by participants within each Rank/Tenure sub-group. The Chaired-High Power subgroup generated most of the concepts for the Resources (#6) factor. Consequently, they had the greatest influence on this factor since participants in this subgroup generated 46% of the brainstorming concepts. The Senior-Moderate Power subgroup had the most influence on the Outside Research Funding (#3) factor with 57% of the concepts generated from members of this subgroup. The Junior-Low Power subgroup had the greatest influence with many of the factors as noted by the relatively higher percentages compared to the other subgroups.

### Table 4: Brainstorming Concept Generation by Rank/Tenure

Strategic Factor where majority placed the	Chaired	Senior	Junior
Brainstorming Concepts during the cause	High Power	Moderate	Low
mapping process		Power	Power
1. Curriculum/Programmatic Emphasis	3	6	20
	10%	21%	69%
2. Faculty Development/Support	1	3	5
	11%	33%	56%
3. Outside Research Funding	0	4	3
_	0%	57%	43%
4. Quality of Student	2	2	8
	17%	17%	66%
5. Research Emphasis	2	6	18
	8%	23%	69%
6. Resources	5	2	4
	46%	18%	36%
7. Reward Structure	2	2	6
	20%	20%	60%
8. Service	0	2	2
	0%	50%	50%
9. Strengths of Dept	3	4	3
	30%	40%	30%
10. Teaching	0	2	8
	0%	20%	80%
11. Technology Support	0	1	2
	0%	33%	67%
12. Visibility	3	3	6
	25%	25%	50%

Cell: Brainstorming Concept Count Percent of Total Brainstorming Concepts by Sub-Group Category

*Group-Level Power (Discipline) Beliefs.* Each subgroup's (discipline's) power is derived from a complex variety of sources, e.g., research excellence, income generation (grants), reputation, and student's starting salary, etc. (Jarzabkowski and Wilson, 2002; Salancik and Pfeffer, 1974). Also, based on Strategic Contingency Theory (Hickson et al., 1971), the less substitutable and more access a discipline contributes to the department's critical resources, the more power it should have over the other disciplines within the department. In this study, faculty members were classified into one of three discipline-based subgroups. For anonymity purposes, we refer to them as Discipline-1, Discipline-2, and Discipline-3. Given the nature of the disciplines in this department, it was determined that the Discipline-1 subgroup was more powerful than the Discipline-3 subgroup. This ranking was based on the relative impact of classes taught and research topics investigated with regard to the academic and professional disciplines within the department. The discipline-based ranking

was discussed with and validated by the department head. There were five faculty members in Discipline-1, seven in Discipline-2, and five in Discipline-3. Table 5 reports the number of concepts by subgroup.

### Table 5: Brainstorming Concept Generation by Discipline

Strategic Factor where majority placed the	Discipline-1	Discipline-2	Discipline-3
Brainstorming Concepts during the cause	Ĥigh	Moderate	Low
mapping process	Power	Power	Power
1. Curriculum/Programmatic Emphasis	8	11	10
	28%	38%	34%
2. Faculty Development/Support	3	3	3
	33%	33%	33%
3. Outside Research Funding	1	2	4
_	14%	29%	57%
4. Quality of Student	1	3	8
	8%	25%	67%
5. Research Emphasis	7	8	11
-	27%	31%	42%
6. Resources	6	2	3
	55%	18%	27%
7. Reward Structure	2	4	4
	20%	40%	40%
8. Service	1	1	2
	25%	25%	50%
9. Strengths of Dept	4	6	0
	40%	60%	0%
10. Teaching	1	5	4
	10%	50%	40%
11. Technology Support	0	0	3
	0%	0%	100%
12. Visibility	5	2	5
	42%	16%	42%

Cell: Brainstorming Concept Sub-Category Count Percent of Total Brainstorming Concepts by Sub-Category

### Table 6: Strategic Plan Section Descriptions

Strategic Plan Section	Strategic Plan Section Description	Number of Section
_		Elements
Alumni and Employer Relations	Foster relations with alumni, employers, and friends.	19
External Funding	Increase financial support from alumni, friends,	17
	firms, and corporations in the form of annual	
	unrestricted giving and endowment necessary to	
	support strategic objectives of the department.	
Master's Program	We seek to prepare students for professional careers	66
	with specializations in assurance and financial	
	services, taxation, and information systems.	
PhD Program	We seek to prepare students for academic careers in	48
	research and teaching.	
Research	We seek to improve the disciplines of accounting and	53
	information systems by conducting quality research	
	and disseminating the results.	
Service Program	We seek to deliver outreach services to accounting	21
	and information systems professionals and	
	educators.	
Undergraduate Programs	We seek to prepare students to enter accounting and	86
	information systems professions with the practical	
	skills and conceptual knowledge of business,	
	information systems, and accounting.	

Link of Strategic Plan Elements to Strategic Factors. The strategic plan consists of seven sections. Each section contained a set of distinct elements that included description, objectives, measures, goals, and action

plans.<sup>7</sup> The description of each plan section and the number of elements for each section are reported in Table 6. The number of elements associated with the different sections of the strategic plan varied considerably. For example, there were 17 elements in the External Funding section compared to 86 elements in the Undergraduate Program section.

A content analysis of the strategic plan was conducted to link the elements of the plan to the previously generated strategic factors. Two researchers (coders) independently linked a strategic factor to each strategic plan element. They were given three documents: the strategic factors and their definitions (see Table 2), the individual brainstorming concepts that were categorized by a majority of the participants into the strategic factors (not reported in this paper), and a coding form that contained the elements of the strategic plan.

Table 7: Strategic Factor Influence on Strategic Plan Section Elements. 310 Strategic Plan Elements

Contract England	1	Percent of Se	ection Element	s by Strategic	Factor		
Strategic Factor			Stra	itegic Plan Se	ections	<u> </u>	<b>.</b>
From Cause Mapping process	Alumni and Employer	External Funding	Master's Program	PhD Program	Kesearch	Service Program	Under- graduate Program
	Relations						0
1.			20	5			40
Curriculum/Programmat			30.30%	10.42%			46.51%
2. Faculty			2		3	2	2
Development/Support			3.03%		5.66%		2.33%
3. Outside Research					10		
Funding					18.87%		
4. Quality of Students			34	12			14
			51.52%	25.00%			16.28%
5. Research Emphasis				21	24	2	
				43.75%	45.28%	9.52%	
6. Resources	1	15	2	2	5		2
<b>-</b> D 10	5.26%	88.24%	3.03%	4.17%	9.43%		2.33%
7. Reward Structure					1 1.89%		
8. Service			1		2	10	1
			1.52%		3.77	47.62%	1.16%
9. Strengths of the							1
Department							1.16%
10. Teaching				6	4		8
_				12.50%	7.55%		9.30%
11. Technology Support			1		1		
			1.52%		1.89%		
12. Visibility	18	2		2	3	7	1
	94.74%	11.76		4.17%	5.66%	33.33%	1.16%
Not Classified			6				17
			9.09%				19.77%
Total Strategic	19	17	66	48	53	21	86
Plan Elements							

Cell:
Strategic Plan Section Element Count
Percent of Section Elements by Strategic Fa

The coders separately mapped each of the elements to one of the twelve factors. They were also given a "not applicable option" (i.e., the element was not associated with any of the factors). The two coders submitted their mappings to a facilitator who examined their level of agreement. Next, the facilitator returned the updated coding form to each coder. The updated forms indicated where the coders agreed and disagreed. The coders were then asked to remap the disagreements. By the end of the fourth round, the coders had agreed to the mapping of 266 of the 310 elements (85.81% agreement, Krippendorf's alpha =

<sup>&</sup>lt;sup>7</sup> The strategic planning committee, not the researchers, identified the 310 elements of the plan.

.846). At this time, the facilitator had the coders meet face-to-face to resolve the differences. During this session, the two coders agreed with the final mapping of all elements.

Table 7 reports the final mapping. It illustrates the extent to which the sections of the strategic plan were related with the strategic factors—the count in each cell represents the number of elements from each section that were linked to a strategic factor. For example, of the 19 elements in the Alumni and Employer Relations section of the strategic plan (see the 2nd column of Table 7), one was linked to the Resources factor and the remaining eighteen were linked to the Visibility factor. All strategic factors were associated with at least one section of the plan.

### **Propositional Analysis**

The propositions are tested by assessing the magnitude of influence that each subgroup had on the strategic plan elements. To estimate the magnitude of influence that a subgroup (cognitive faction, rank/tenure, discipline) had on a section, we performed matrix multiplication of Table 3 by Table 7, Table 4 by Table 7 and Table 5 by Table 7 to calculate the influence values that we use as an indicator of the magnitude of influence as reported in Tables 8, 9, and 10 respectively. The amount of influence was computed by multiplying the relative weight of influence each subgroup had on the generation of concepts for each factor by the percent influence each factor had on each section. For example in Table 8, by multiplying 27% (Table 3 Resources row under CF1) by 5.26% (Table 7 Resources row under Alumni and Employer Relations) we estimated that the magnitude of influence of CF1 on Alumni and Employer Relations was 41%. We see that all three cognitive factions influence the content of the Alumni and Employer Relations section (see the 2nd column of Table 8); CF1 had 41%, CF2 had 43%, and CF3 had 16%. In this case, CF1 and CF2 subgroups had considerably more influence on the Alumni and Employer Relations section<sup>8</sup>. Tables 9 and 10 provide similar information with regards to the individual power (rank/tenure) and the group-level power (discipline) subgroups.

	Strategic Plan Section							
Cognitive	Alumni and	External	Master's	PhD	Research	Service	Undergraduate	Average
Factions	Employer	Funding	Program	Program		Program	Programs	Influence
	Relations		_	_		_	_	
CF1	41%	29%	50%	37%	37%	31%	39%	38%
CF2	43%	53%	31%	35%	32%	45%	32%	39%
CF3	16%	18%	10%	11%	14%	20%	9%	14%
Other			9%				20%	4%

Table 8: Cognitive Faction Sub-Group Influence on Strategic Plan Section

Reported percentage represents amount of influence based on Tables 3 and 7.

Proposition 1 stated that: It is expected that the beliefs of the cognitive factions will be reflected in the content of the strategic plan. A review of Table 8 shows that indeed the content of the strategic plan was mostly driven by the beliefs of the cognitive factions. In fact, on the average, only about 4% of the total content of the plan could not be traced back to a specific cognitive faction (see Average Influence of Other in Table 8) and all of these were associated with only two sections of the plan (Master's Program and Undergraduate Programs). However, by carefully working through Table 8, qualitatively speaking, we see that the different cognitive factions had a differing amount of influence on the different sections of the plan. In the case of CF1, relative to CF2 and CF3, we see that CF1 had considerable influence on all but two sections of the plan (External Funding and Service Program). Relative to CF1 and CF3, CF2 had considerable influence on all but the Master's Programs section. However, relative to CF1 and CF2, CF3 only had a marginal influence on any of the sections. Based on these results, since all three factions influenced the plan, we conclude that there is support for Proposition 1.

<sup>&</sup>lt;sup>8</sup> Given the way in which we are calculating the influence values, great care should be taken in interpreting these percentages; it is better to simply use them as "ballpark" or qualitative estimates. In this case, to state that CF1 and CF2 had greater influence than CF3 is justified, but to state that CF2 has greater influence than CF1 is debatable.

Proposition 2a stated that: It is expected that the beliefs of more powerful individuals (rank and years with the organization) will be reflected in the content of a strategic plan to a greater degree than those with less power. Based on our results, this proposition is not supported (see Table 9). In fact, on the average we see that the opposite occurred: Junior faculty (54%) had more influence than Senior faculty (24%) which had more influence than the Chaired faculty (18%). In fact, the only section that was not dominated by the Junior faculty was External Funding. However in this case, the Junior faculty (38%) still had more influence than the Senior faculty (19%).

		Strategic Plan Section						
Rank/	Alumni and	External	Master's	PhD	Research	Service	Undergraduate	Average
Tenure	Employer	Funding	Program	Program		Program	Programs	Influence
	Relations	0	0	0		0	0	
Chaired								
High Power	26%	44%	14%	12%	10%	10%	9%	18%
Senior								
Mod. Power	25%	19%	18%	21%	31%	37%	17%	24%
Junior								
Low Power	49%	38%	59%	67%	59%	52%	54%	54%
Other			9%				20%	4%

Table 9: Rank/Tenure Sub-Group Influence on Strategic Plan Section

Reported percentage represents amount of influence based on Tables 4 and 7.

Proposition 2b stated that: It is expected that the beliefs of more powerful group (discipline) will be reflected in the content of a strategic plan to a greater degree than those with less power in the other groups. In this case, we find that the least powerful discipline had the greatest average influence: Discipline-1 had 30%, Discipline-2 had 25%, and Discipline-3 had 41% (see Table 10). In fact, Discipline-3 had the greatest influence on all but two of the sections: Alumni and Employer Relations and External Funding. Even though the most powerful discipline (Discipline-1) had the greatest influence on both the Alumni and Employer Relations and External Funding sections, it only dominated the External Funding section. Moreover, in the case of the Alumni and Employer Relations section, Discipline-3 essentially had the same amount of influence as Discipline-1 (41% and 43%, respectively).

	Strategic Plan Section							
Discipline	Alumni and	External	Master's	PhD	Research	Service	Undergraduate	Average
	Employer	Funding	Program	Program		Program	Programs	Influence
	Relations							
Discipline-1								
High Power	43%	53%	16%	22%	26%	32%	19%	30%
Discipline-2								
Mod Power	16%	18%	26%	31%	29%	23%	29%	25%
Discipline-3								
Low Power	41%	29%	47%	47%	42%	45%	33%	41%
Other			9%				20%	4%

Table 10: Discipline Sub-Group Influence on Strategic Plan Section

Reported percentage represents amount of influence based on Tables 5 and 7.

# Discussion

As reported above, we found support for Proposition 1, but did not find support for either Propositions 2a or 2b, which suggests that the most powerful members and coalitions did not dominate the content of the strategic plan. In this section of the paper, we discuss the implications of these findings.

The strategic planning process in this case study employed anonymous brainstorming and anonymous cognitive faction material in the development of a strategic plan. By supporting anonymity, the variety of the comments was encouraged in a non-threatening environment (Diehl and Stroebe, 1987; Jablin et al., 1977). Through the use of cluster analysis, the anonymous cognitive faction belief structures provided a way to influence the strategic plan in a non-power based manner that also facilitates task conflict (Tegarden et

al., 2009). By separating the contributions from the contributors, a more objective evaluation of the concepts and the strategic factors is possible (Hiltz et al., 1989; Nunamaker et al., 1987). This can be very important when an organization is facing the level of uncertainty and risk that was faced by this department (Bryson, 2004).

However, the concepts that were linked to the strategic plan stemmed primarily from cognitive factions CF1 and CF2; not CF3. At first glance, this could be a sign that the identified cognitive factions were not sufficient. We chose to use Ward's agglomeration method, since it better handled outliers (Aldenderfer and Blashfield, 1984), to guarantee that contributions from all participants were included in the plan. When we look at the results of the cluster analysis (see the dendogram in Figure 2), we can clearly see that there were three cognitive factions. However, since CF3 was identified much later, in many ways we could consider these three members as outliers. Given this, it is not that surprising that CF3 only weakly influenced the contents of the plan.

Support for Proposition 2a was not found. The beliefs and values associated with the most powerful members (Chaired faculty) were not a substantial influence on the contents of the plan (See Table 9). Furthermore, our findings showed that the beliefs of the least powerful members (Junior faculty) had a stronger influence on the plan content in 6 of the 7 sections of the plan. Given the individuals that are associated with each of these groups and the time period in which this data was collected, the focus of the groups is not surprising. For example, the Junior faculty was highly concerned with changing expectations on the promotion and tenure requirements. This led them to be highly motivated in assuring that concepts that addressed these issues would be included in the plan (see Table 4). In this case, the Junior faculty generated 85 of the 143 concepts. These included issues related to the increasing research emphasis of the university (including a new emphasis on externally funded research) without a corresponding decrease in teaching and service responsibilities, the quality of the students being recruited, and the changing reward structure that would focus exclusively on research be included as input to the strategic planning process.

Given that the strategic planning committee was only given the results of the GSS sessions, as they were related to the overall group and to the cognitive factions, it does seem that the anonymity associated with the cognitive factions did indeed de-fuse the structural power associated with the individual-level (rank/tenure) power dimension (Brass, 1984; Tegarden et al., 2009; Tushman and Romanelli, 1983). Moreover, when we open up the cognitive faction membership using the rank/tenure subgroupings, we see that the Chaired faculty were spread across all three cognitive factions, the Senior faculty were only members of CF1 and CF3, and the Junior members were only members of CF1 and CF2. Finally, when reviewing the membership similarity of the cognitive factions and the rank/tenure subgroups, we see that only a moderate level of agreement was reached for two of the nine cells (CF1/Junior and CF2/Junior) suggesting that the individual-level (rank/tenure) power dimension represented a different grouping than that of the cognitive factions.

	Rank/Tenure						
Cognitive	Chair Senior Junior						
Factions	High Power	Mod Power	Low Power				
CF1	.09	.27	.38				
CF2	.14	.00	.40				
CF3	.20	.33	.00				

Table 11: Jaccard Similarity of Cognitive Faction Membership with Rank/Tenure Membership

Similarly, support for Proposition 2b was not found (see Table 9). Our results indicate that the least powerful discipline (Discipline-3) influenced the content of the plan to a much greater level than the other two disciplines in every section except the Alumni and Employer Relations and External Funding sections. Given the relationship of faculty in Discipline-1 with the department's external stakeholders, it is not surprising that they influenced the content of these sections. However, given the little interaction that the faculty members in Discipline-3 had with the external stakeholders, what was surprising was (1) the level of influence that Discipline-3 had on the Alumni and Employer Relations section was essentially the same as Discipline-1 and (2) that Discipline-2, which also had substantial contact with the department's external stakeholders, seemed to only have minimal influence over the content of either of these sections. As such, the only section that Discipline-3 did not either highly influence or dominate the content was External

Funding. In many ways, Discipline-1 and Discipline-2 can be viewed as a single discipline. In fact, all "outsiders" always view them as a single discipline. Whereas, Discipline-3 has rarely, if ever, been viewed as part of the same discipline with Discipline-1 and Discipline-2. In fact, in most universities, Discipline-3 is located in a completely different department. Consequently, the level of influence over the content of the strategic plan attained by Discipline-3 was completely unexpected and completely different than in the past. Furthermore, given the zero-sum game situation (e.g., Gunz, 1989; Gunz and Whitley, 1985; Pfeffer, 1981) that the department faced, these results are even more surprising.

So, as with the individual dimension of power (rank/tenure), the group-level power (discipline) dimension seems to have been de-fused through the use of the anonymity-driven cognitive factions (Pfeffer and Salancik, 1978; Tegarden et al., 2009). In this case, when we open up the cognitive faction membership using the discipline subgroupings we see again that the most powerful disciplines (Discipline-1 and Discipline-2) were spread across all three cognitive factions while Discipline-3 was split across CF1 and CF2. In this case, when we review the level of similarity reached between the two classifications, we see that only one of the intersections (CF1/Discipline-2) reached a moderate level of agreement implying that, like the rank/tenure power dimension, the discipline power dimension represented a different grouping than that of the cognitive factions.

	Discipline						
Cognitive	Discipline-1 Discipline-2 Discipline-3						
Factions	High Power	Mod. Power	Low Power				
CF1	.08	.45	.27				
CF2	.25	.09	.25				
CF3	.33	.11	.00				

Table 12: Jaccard Similarity of Cognitive Faction Membership with Discipline Membership

Finally, given that the cognitive faction groupings were different than those of the rank/tenure and the discipline power groupings, and that the rank/tenure and discipline power dimensions were defined at different levels (Brass, 1984; Hambrick, 1981; Pfeffer and Salancik, 1978; Tushman and Romanelli, 1983), we wanted to be sure that the two power groupings were indeed different from each other. In this case, we found that only two of the cells reached a moderate level of agreement: Senior/Discipline-1 and Junior/Discipline-3 which suggests that these two dimensions are indeed different.

	Discipline							
Rank/Tenure	Discipline-1	Discipline-3						
	High Power	Mod. Power	Low Power					
Chair	.14	.25	.00					
High Power								
Senior	.43	.09	.11					
Mod. Power								
Junior	.08	.33	.40					
Low Power								

Table 13: Jaccard Similarity of Rank/Tenure Membership with Discipline Membership

As in all case studies, there are set of limitations. First, one should be very careful in attempting to generalize beyond the data. The data used in this study is somewhat dependent upon the GSS-driven data collection method used. However, our approach can be easily adapted to other approaches that support anonymity. Second, the analysis performed in this study was done in a post-hoc fashion, i.e., the original data collection was not performed with this study in mind; it was collected for actual strategic planning purposes. Third, the framing statement used (see Figure 1), drove the entire strategic planning process. A different framing statement could have different results.

### **Implications for Power and Strategic Planning Literatures**

This case study provides descriptive details about whose beliefs and values were incorporated in the actual strategic plan. Given the direct and indirect ways that power can impact decisions, reducing the impact of power in strategic planning settings is an important aspect to consider. This study reinforces that strategic

planners should explicitly manage power effects through anonymity and GSSs (Dennis et al., 1991). While this literature recognizes that task conflict can enhance decision-making and that power is often associated with task conflict, reducing the impact of power while increasing task conflict may be important to control. As noted by Ackermann and Eden (2011), a GSS that utilizes anonymity can protect relationships and retain the social order. Furthermore, the explicit use of tools and processes that promote anonymous cognitive factions to increase task conflict (Tegarden et al., 2009) may also reduce the impact of power that can be detrimental to the decision. To accomplish this in a strategic planning context, we explored how the use of a GSS that provides anonymity in brainstorming and the generation of cognitive factions. While further research is needed to generalize the results found in this study, the joint use of anonymity and cognitive factions merits further investigation for managing both task conflict and power in strategic planning settings.

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# Part VII Shareholders' rights

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# Say on Pay in the Context of Shareholder Rights

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**Abstract**: There is a global movement to give shareholders a greater role in the corporate process. Say on Pay, which gives shareholders the right to cast binding or advisory votes on executive compensation, is one important way to safeguard the rights of shareholders as a group vis a vis managers and boards of directors. This study reviews the evolution of diverse forms of Say on Pay in an international context: legislated vs. shareholder-initiated votes and binding vs. non-binding votes.

Keywords: Say on Pay, Executive Compensation, Shareholder Rights.

## Introduction

In April 2012, Citigroup shareholders voted to reject the company's executive compensation plan during its annual stockholders meeting after critics and proxy advisory firms complained that there was a pay for performance disconnect, a failure to properly disclose the value of incentives, and too many discretionary award opportunities. The proposal received just 45 percent of votes cast and followed Citigroup's announcement that profit fell 2 percent from a year earlier - missing analyst expectations - and that a dividend increase or share buyback program would not happen because in mid-March the bank failed the Fed's stress tests that measure banks' potential strength in adverse economic conditions.

A month later, European investors revolted over executive pay voting down Aviva Plc's compensation plan with a 54 percent majority, while 37 percent of investors opposed UBS AG's plan and 40 percent opposed Inmarsat Plc's plan. Four years of stagnant or negative economic growth since the Global Financial Crisis of 2008 (Crisis) coupled with the European Debt Crisis and a growing disparity between the compensation of executives and average workers had pushed shareholders to protest "excessive" compensation practices. In all the instances, it was Say on Pay that allowed the shareholders to vote on the proposed compensation packages.

Several months after the failed Say on Pay votes, Vikram Pandit, the CEO of Citibank, and Andrew Moss, the CEO of Aviva, resigned after the clashes over pay. In another case, Sly Bailey stepped down as head of Trinity Mirror after a decade at the newspaper publisher because shareholders were objecting to her \$2.7 million compensation package and had threatened to vote against it. She resigned before the Say on Pay vote was held. These are just a few of the well-known examples of the impact of shareholders exercising their rights with Say on Pay.

This is the preliminary stages of an investigation of the impact of Say on Pay using a multilevel meta-analytic study, comprising prior tests derived from a number of primary studies nested in several countries. Studying Say on Pay enhances our understanding of underlying corporate governance themes such as the agency conflicts between shareholders and managers and between shareholders and directors, as well, as the conflicts between shareholders, managers, and various other stakeholders. As a precursor to the meta-analysis, we attempt to chronicle Say on Pay through the lens of these conflicts in an attempt to understand the group dynamics at play when shareholders are a dispersed and heterogeneous group, the processes of negotiation between the involved groups, and the decision-making on the votes.

Since the Crisis, various initiatives have tried to identify the root causes of the worst crisis since the Great Depression of the 1930s. Although multiple factors played a role, many analysts, politicians, media sources, and economists raised the issue of the inappropriate incentives created by the compensation structure of the financial sector. Some suggested that the culture of awarding exorbitant bonuses appears to have spurred senior executives to take unacceptable risks, while the practice of giving large severance payments often rewarded rather than penalized them for such conduct. (e.g., Geithner, 2009; Dong et al., 2010; Bebchuk and Spamann, 2010; Belkhir and Chazi, 2010; DeYoung et al., 2011).

Similar behavior, as well as, the disconnect between compensation and firm profits/growth were also ascribed to executives of other large publicly traded firms during the bursting of the dotcom bubble in 2000 and the corporate scandals that triggered the collapse of well-known firms such as Enron, WorldCom,

Parmalat, and Adelphia. After these corporate disasters, Business Week noted that those issues forced many companies to get serious about governance and that boards had finally started to grapple with the most egregious governance failure of the 20th century: astronomical executive pay.<sup>9</sup> Although the Enron-era produced sharp criticisms of executive pay structures, the Crisis moved executive compensation from the shareholder agenda to the regulatory agenda amid concern for wider financial market stability. The G20 and the Financial Stability Forum (FSF) held meetings to set out a series of principles for determining executive compensation, which would be implemented by national regulators but overseen by the FSF.<sup>10</sup>

The scandals and the Crisis prompted some debate about the nature of markets and capitalism, the objectives of the corporation, the role of corporate governance, and the effect of executive compensation. (see, for example, the series of articles published by the Financial Times on "The Future of Capitalism' in 2009<sup>11</sup>). Executive compensation regulation became the subject of numerous national policy efforts, two G20 summits in 2009, and several stock exchange initiatives. These groups challenged the traditional primacy of the shareholder following the ascendancy of shareholder value as a mode of corporate governance in recent decades (Krippner, 2005, p.181; and see also Dore, 2000, pp.4-5).

There are differences in beliefs about which interests business should serve that arguably reflects the perceived significance of the issue for wider society. The central dispute concerns the right of one particular stakeholder group in business, the shareholder group, to have its interests maximized. While there are a number of different models of capitalism in developed economies, a distinction is often made between two broad approaches: the Anglo-American stock market model in which shareholder maximization is the typical objective of companies, and the social market model associated with a number of continental European countries and Japan in which a balance is struck between the interests of different stakeholders. (Albert, 1993; Coates 2000; Dore, 2000; Hutton, 1995; 2003).

Many have suggested that a wider stakeholder view is needed as the systemic risks from poor compensation structures have become clearer. The high profile cases of corporate malfeasance and the perceived excessive executive compensation highlighted the need for stakeholders to more actively engage in corporate governance. To mitigate the probability of rent extraction by powerful executives, some shareholders/stakeholders sponsored proposals and proxy advisory firms created campaigns to monitor firm operating performance (Del Guercio et al., 2008) and executive compensation (Ertimur et al., 2011). These efforts, however, were not enough to reduce the levels of risk-taking or the executive compensation as the Crisis pointed towards corporate governance failures as a primary reason that forced governments to use taxpayer funds to prevent large insolvencies and potential ripple effects in the private sector.

"Of all the issues associated with the field of governance that have arisen since the commencement of the economic crisis, few have attracted levels of press attention or invoked public anger to the same degree as the issue of executive pay. Criticisms of existing executive pay regimes have focused both on the social justice issues associated with the salaries of 'top earners' and the implications for good corporate governance. Pay policies involving multi-year guaranteed bonuses and multi-million dollar payments for the executives of 'failed' firms or those who have received public funding have been portrayed as excessive and inefficient." (Prosser, 2009) Further, the allegation that pay practices that were inconsistent with firm's capital bases and that insufficiently linked pay to sound risk-taking were a key precipitating factor of the economic crisis has been made by the FSF.

Although some academics have defended existing executive pay regimes, a consensus appears to have formed in the international policy community that the topic requires serious regulatory attention. Kaplan (2012) argues that the relative pay of large company CEOs is similar to its average level since the 1930s, and that the ratio of large company CEO pay to firm market value also has remained roughly constant since 1960, however that is in stark contrast to the claim in Bebchuk and Fried (2006) that, "flawed compensation arrangements have not been limited to a small number of 'bad apples'; they have been widespread, persistent, and systemic."

<sup>9</sup> Lavelle, Louis The Best & Worst Boards, Business Week, October 6, 2002

<sup>&</sup>lt;sup>10</sup> Stewart, Heather, G20: Bankers' pay to be linked to risk in regulatory overhaul, The Gnardian, April 2, 2009

<sup>&</sup>lt;sup>11</sup> See http://www.ft.com/indepth/capitalism-future

In many countries, regulators expected that companies would be able to control the risks associated with compensation design and tackle excessive bonuses themselves through the application of corporate governance measures. However, as the connection between pay and performance has become progressively more distorted, as executive compensation has increased exponentially over the past several decades with a widening gap between it and that of the average worker, and as the conflict among various parties to the corporate governance structure has been studied, governments, convinced that self-regulation would no longer work, considered regulations to diminish the potential for compensation structures that encourage the excessive risk-taking that contributed to various scandals and the Crisis. A variety of mechanisms have been adopted, such as caps on executive compensation.

Several countries mandated Say on Pay including the United Kingdom (U.K.), Australia, the Netherlands, Sweden, Norway, Denmark, the United States (U.S.), South Africa, Portugal, Germany, Finland, Belgium, Italy, and Switzerland. Shareholders of companies in France, Spain, Canada, and Ireland are allowed to initiate votes regarding executive compensation; the European Union (EU) outlined recommendations for shareholder votes on compensation; the European Commission (EC) considered a bill to mandate the votes; and a number of other countries, including Israel and India, have considered adopting shareholder votes on executive compensation but have stopped short of passing new legislation.

Hart (1995) says "governance structures can be seen as a mechanism for making decisions that have not been specified by contract." Corporate governance encompasses the relationships and ensuing patterns of behavior between different agents in a corporation; the way managers and shareholders but also employees, creditors, key customers and communities interact with each other and give shape to a company's strategy and identity in the capital, goods and labor markets. Compensation governance is a subset of corporate governance. Absent Say on Pay, decisions about executive compensation are made exclusively by the board of directors, upon a recommendation issued by the compensation committee of the board. Directors are subject to various local legal requirements to act on their stakeholders' (shareholders') behalf when making decisions, including about compensation. Excessive compensation must be framed within a corporate governance setting because bad governance can easily lead to value-destroying pay practices, and good governance can mitigate the agency problems between board members and shareholders. There is empirical evidence that poor governance is associated with excessive compensation (Core et al. 1999).

# Say on Pay Forms and Practices

Say on Pay is the right of shareholders to vote on the compensation of their firm's executives. Its goals are to spur shareholder participation in corporate governance, to protect their rights to the residual income of the firm, to rein in excessive CEO compensation, and to help reduce executives' incentives to chase shortterm profits. Although different forms of Say on Pay have been enacted in a dozen countries, they are highly complex and diverge from jurisdiction to jurisdiction. Because there is no universal system of corporate governance, there is no universal system of Say on Pay. The tenets vary across countries in part due to differing political, cultural/religious, geographical, and economic that have shaped local compensation and corporate governance practices. There are also notable country-specific differences related to industry, size, and shareholder base, as well as for legal system, shareholder/creditor protection, market/banking orientation, ownership concentration, individual wealth, level of diffusion of the press and labor markets.

Say on Pay can be implemented in two forms: either it is adopted voluntarily following a shareholder proposal or it is required by law, with the government specifying its terms. In addition, shareholders can sell their shares or replace the incumbent management. Votes can be implemented for compensation packages, incentive plans, or other components. They may be binding or advisory; may be comply with or explain recommendations or ordinary recommendations; may be taken annually or not; may be forward looking at the compensation to be set in the future or retrospective - examining compensation as executed in the past; may cover compensation policy, a compensation report, compensation of individual executives/directors, or specific elements of the compensation package such as share-based compensation; and may be a separate vote on compensation or a vote on compensation as a part of the annual report as a whole.

Following are the countries with Say on Pay, grouped by type:

	Binding Votes	Advisory Votes
Legislated Say on Pay	Italy (banks), Denmark (variable pay), Sweden, Netherlands (policy change), Norway, Switzerland (coming)	Australia, Belgium, Germany, Italy, South Africa, Portugal, United Kingdom, United States
Shareholder-Initiated Say on Pay		Canada, Ireland, Spain, France, Switzerland

Table 1: Countries with Say on Pay

Form notwithstanding, Say on Pay was intended to provide a check on potential problems with executive compensation and offers an opportunity to alter the level, growth rate, pay-to-performance sensitivity, pay dispersion, and composition of compensation packages. When shareholders vote, they signal to the board whether or not they agree with the plan's details and provide the board with their position regarding the proposed plan (Brownstein and Kirman, 2004; Cheffins and Thomas, 2001). Boards could choose to become more proactive and consult directly with major shareholders when structuring executive pay (i.e., before even putting them to vote) (Davis, 2007; Brownstein and Kirman, 2004). Boards have an incentive to engage in such direct negotiations because negative press coverage from a "No" vote on an executive pay plan can damages the firm's reputation. In fact, boards may use Say on Pay as a form of leverage when negotiating with executives, who can pressure the board to implement sub-optimal pay plans (Davis, 2007). The shareholders' voice via Say on Pay may even increase the board's legitimacy when justifying their decisions to executives.

In the shareholder initiated mode, two stages are necessary to implement Say on Pay. First, a proposal is submitted by a shareholder for vote in order to institute an annual vote on the executive pay plan proposed by the board of directors. This proposal will fail or pass depending on the votes required for a formal pass as defined in the corporate charter. If the proposal passes, the firm would be required to hold a vote that either accepts or rejects the executive compensation proposed by the board of directors. A shareholder proposal forces the board to prepare a response, and thus to consider the reasons for its own position. Boards may partially or entirely implement an executive pay resolution that is formally adopted (Brownstein and Kirman, 2004) and may also reconsider executive pay plans that fail to be adopted. Directors have incentives to consider the outcome of Say on Pay votes because they may not be re-elected to the board if shareholders feel that their opinion regarding executive pay is ignored.

In the regulatory mode, governments require firms to submit an executive compensation report for shareholders to vote on. According to Mulherin (2007), economists have developed at least two distinct regulatory models: the public interest theory and the special interest theory. The public interest theory holds that regulation is supplied in response to the demand of the public for the correction of inefficient or inequitable market practices and may be an attempt to improve social welfare (for a critique, see Chapter 25 of Alchian and Allen (1964)). The special interest theory, by contrast, argues that regulation responds to political pressure from well-funded yet narrowly focused political interest groups (special interests). The motivation for this alternative depiction was the observation that many regulations appear aimed not at consumer protection but instead at producer protection (Stigler, 1971).

Because regulation can have different originations, there is significant regulatory variation within and across countries. The provisions of the legislation determine the follow-up action to Say on Pay voting to be taken by the board of directors. In a binding vote regime, boards are not allowed to move forward with the proposed pay plan, however in an advisory vote environment, the board can proceed in the way it chooses. Variations in follow-up actions also exist depending on whether shareholders are voting on compensation

ex-ante or ex-post, whether the directives are comply or explain, and whether the vote is solely on compensation or on compensation as a part of the annual report.

# Evolution of Say on Pay

During the 1990s, waves of massive employee downsizing by British firms that had seemingly excessive compensation, coupled with a series of corporate governance failures, led to intense policy debates on governance and the appropriate role of shareholders in the process. The Cadbury Report (1992) was published and recommended, among other things, that boards of directors of publicly traded companies include at least three non-executive (i.e., outside) directors as members and that the positions of Chairman of the Board and Chief Executive Officer of these companies be held by two different individuals. In addition, recommendations related to the compensation committee of the board of directors were made. The apparent reasoning underlying the Committee's recommendations is that greater independence of a corporate board would improve the quality of board oversight. (Dahya et al, 2002)

Contemporaneously, a push was being made for similar regulations in the U.S. by candidates in the 1992 presidential election. Consistent with Time magazine's labeling of CEO pay as the "populist issue that no politician can resist," high CEO salaries emerged as a bipartisan campaign issue among the leading candidates in the election. In February 1992, the Securities and Exchange Commission (SEC) expanded the scope of allowable topics for shareholder proxy proposals to include executive compensation issues in order to lower the cost to shareholders of monitoring executive compensation policies. The SEC announced that proposals about executive compensation would no longer be disallowed under the "ordinary business" exclusion. Then, in 1993, Congress passed Internal Revenue Code Section 162(m) as part of the Omnibus Budget Reconciliation Act of 1993, which limited tax deductions for executive compensation at \$1 million<sup>12</sup> to reduce the excessive, non-performance-based compensation that 1992 presidential candidate William Jefferson Clinton had campaigned against. (Balsam, 2012) These initiatives in the U.K. and U.S. in 1992 were the beginnings of the global Say on Pay movement.

Executive pay came into the spotlight again in the 2000s after the burst in the Internet bubble, the accounting scandals at companies such as Enron, Adelphia, WorldCom, Tyco, and Computer Associates in the U.S. and Royal Ahold, Vivendi, and Parmalot in Europe, and the option backdating scandal. These events revived the debate over executive compensation, and new regulations related to executive compensation were initiated in the U.K. and U.S. In 2002, the U.K. introduced the Directors' Remuneration Report regulations, which mandated boards of directors at public companies to produce a comprehensive remuneration report and submit it to an advisory shareholder vote at the firm's Annual General Meeting (DRR, 2002). This was the first legislation of Say on Pay, however, even before the regulations were put in place, companies had started submitting remuneration committee reports to a vote as early as 2001. (Hodgson, 2009)

Australia (2004), the Netherlands (2004), Sweden (2006), Norway (2007), Denmark (2007), Portugal (2009), and Germany (2009), soon enacted Say on Pay legislation following similar corporate scandals and concomitant public anger. In 2004, the EC issued recommendations on compensation which suggested the implementation of Say on Pay by firms in the jurisdiction.

In the U.S., the disclosure of executive compensation was expanded significantly in 2006. The new rules required disclosure of the option grant dates and the date when the grant was formally approved by the board, identification of the names and roles of all consultants who provided advice on executive compensation, and disclosure of whether the compensation consultants are engaged directly by the compensation committee or by the management. (Murphy and Sandino, 2010)

As firms were absorbing the new SEC disclosure regulations, a major shareholder campaign to introduce an advisory vote on executive compensation was launched. The campaign, orchestrated by a significant group of institutional stockholders, led to the launch of shareholder resolutions at over 50 major U.S. corporations. During the DRR debate in the U.K., market participants in the U.S. claimed that the practice

<sup>&</sup>lt;sup>12</sup> Section 162(m) applies only to public firms and only to compensation paid to the CEO and the four highest-paid executive officers as disclosed in annual proxy statements (compensation for all others in the firm is fully deductible, even if in excess of the million-dollar limit). It also does not apply to compensation considered performance-based for the CEO and the four highest-paid people in the firm.

would never catch on in the United States, but as far back as 2005, Escala Group, Inc. issued a proxy statement on October 28 noting that management would put both the outgoing CEO's, Greg Manning, and the incoming CEO's, Jose Miguel Herrero, compensation packages up for a shareholder vote. That initiative was an outlier at the time, but then came the 2007, 2008, and 2009 proxy seasons, and the Say on Pay campaigns.

During the 2007 proxy season, there were about 50 shareholder resolutions calling for an advisory vote on executive pay. In 2008, this number rose to more than 90 resolutions. Resolutions garnered average support of 40.8 percent in 2007, and a majority of support at eight companies. In 2008, average support increased to 41.7 percent, and two companies had the first Say on Pay votes. In the aftermath of the Crisis, the American Recovery and Reinvestment Act (ARRA) required that all companies receiving funds from the U.S. Treasury place a Say on Pay vote on their ballot. While these were mostly banks, other companies, such as Motorola and Verizon, also introduced votes as a result of resolutions supported by a majority of their shareholders.

In total, Say on Pay was the subject of more than 200 shareholder proposals over the three proxy seasons between 2007 and 2009. Some companies, like Apple and Motorola, introduced Say on Pay votes, whereas others, such as Ingersoll-Rand, ignored the majority of their shareholders and made no such moves. (Hodgson, 2009) In 2008 and 2009, bills calling for Say on Pay began to circulate in Congress, including the Protection Against Executive Compensation Abuse Act sponsored by Representative Barney Frank, Senator Charles Schumer's Shareholder Bill of Rights, the Treasury Department's financial stability rules, and the SEC's own agenda. The U.S. formally enacted Say on Pay in 2010 as a component of the Dodd-Frank Wall Street Reform & Consumer Protection Act.<sup>13</sup>

The country was spurred to action as a result of executive behavior following the Crisis. Billions of dollars in federal bailouts of financial institutions followed by executives of the institutions receiving what was perceived as excessive bonuses after years of outsized equity incentives in the years running up to the Crisis, galvanized the public and Congress. In the search for a scapegoat, the large bonuses paid to individuals at these institutions served to provide public officials with a convenient target by which to deflect attention from misguided or poorly executed government policies that may have contributed significantly to the Crisis.

On the heels of the U.S. action, the EC amended its recommendation on Say on Pay and issued a new one targeted at directors and executives of financial institutions. In addition, a mandatory bill for Say on Pay could be introduced for all listed companies across the 27 member states of the EU as a result of recent proposals outlined by the EC. South Africa (2011), Belgium (2012), Italy (2012), and Switzerland (2013) also enacted Say on Pay legislation, and the British government has even proposed converting to a binding shareholder vote from its current advisory regime.

Currently, firms in France, Spain, Canada, and Ireland can adopt shareholder proposals regarding Say on Pay. In 2012, France's new government started considering potentially sweeping reforms for all public companies including allowing shareholders to have binding or advisory votes on compensation, while in 2013, Spain announced that it was planning to give shareholders a binding vote on executive pay in the banking sector.

# Effects of Say on Pay

There have been a number of incidents at large U.K. companies in which shareholders have revolted against the size of pay packages since the Say on Pay legislation was introduced, starting with GlaxoSmithKline (GSK), which had 50.72 percent of the votes cast against a  $\pm 22$ m bonus salary and stock severance package for CEO Jean-Pierre Garnier. Several other major shareholder actions caused a serious media frenzy in 2003.

Further cases of shareholder dissent were well publicized in 2003 at other British firms including Vodafone, Royal & Sun Alliance, ITV, and Berkley Property. Vodafone shareholders voted 10% against with 30% in abstention on £13m in shares for CEO Sir Chris Gent. Royal & Sun Alliance shareholders voted 28%

http://www.banking.senate.gov/public/\_files/070110\_Dodd\_Frank\_Wall\_Street\_Reform\_comprehensive\_summary\_Final.pdf

against a £250,000 retention bonus for CFO Julian Hance and £1.44 million severance pay for CEO Bob Mendelsohn after the share price dropped; ITV shareholders voted 40% against a £15 million payoff to Chairman Michael Green; and Berkley Property had 47% of shareholders vote against paying the CEO £1.2 million (out of £4.7 million) under a long term incentive scheme that he had not actually belonged to. In subsequent year, high profile votes were lodged against Unilever, Tesco, and Barclays.

In the first year of voting in the U.S., 37 Russell 3000 companies failed to receive majority support from shareholders, while in the second year of voting, 44 Russell 3000 companies failed in the first half of the year, including: Nabors Industries, whose shareholders voted against in both 2011 and 2012 (75% opposition in 2012) given concerns over the company's high CEO pay and severance payments. Shareholders also voted against the company's new incentive bonus plan and long-term incentive plan in 2012. Hewlett Packard failed its vote in 2011 in light of new CEO Léo Apotheker's employment agreement and the company's stock performance, and Citigroup failed with 55% opposition in 2012 after giving CEO Vikram Pandit three retention grants valued at \$27.9 million.

In other countries, notable "no" votes were lodged at Royal Bank of Scotland (RBS), Royal Dutch Shell of the Netherlands, French auto parts maker Valeo, and Canda's QLT. RBS was subject to shareholder lawsuits and share price collapse at the time of its failure, so CEO Fred Goodwin agreed to a 50 percent cut in his pension. Shell's decision to pay out its performance shares even though the company did not hit the targets it had set led to a majority vote against the package. Further, a substantial severance package for Valeo's CEO, Thierry Morin, was rejected by 98.62 percent of shareholders following the release of secret conversations between the board and the CEO. QLT was the first Canadian company to lose its Say on Pay vote, reporting that 58 percent of shareholders voted against its pay program.

Despite the media depictions of the Shareholder Spring, empirical evidence generally shows that shareholders are satisfied with compensation. For example, Conyon and Sadler (2010) note that typically less than 10% of shareholders abstain or vote against the mandated Directors' Remuneration Report (DRR) resolution in the U.K. However, the impact of Say on Pay on compensation itself is less clear.

Examining Say on Pay in the UK, Ferri and Maber (2013) "find no evidence of a change in the level and growth rate of CEO pay after the adoption of say on pay" although they do find some evidence of "mitigation of rewards for failure." Similarly Conyon and Sadler (2010) "find limited evidence that, on average, 'say on pay' materially alters the subsequent level and design of CEO compensation." In contrast, Carter and Zamora (2009) find some evidence that boards respond to past negative votes (not necessarily rejection, but percentage of negative votes) by reducing excess salary, the dilutive effect of stock option grants, and improving the link between pay and performance, while Alissa (2009) finds that Say on Pay is associated with a reduction in excess compensation and greater CEO turnover.

In the U.S., because the enactment has been recent, there have been few studies to investigate the impact. Cai and Walking (2011) investigated the market reaction to the passage of the legislation by the House of Representatives on April 20, 2007 and find that stocks of firms with positive abnormal CEO compensation and low CEO pay for performance react in a significant, positive manner. They also examine the relation of previous votes on executive incentive compensation plans and the level of abnormal CEO pay and find that the market views Say on Pay as value-creating for the companies with inefficient executive compensation and relatively poor corporate governance but value-destroying for other companies. Burns and Minnick (2011) analyzed firms that had shareholder Say on Pay proposals and found those firms altered the composition of their executive compensation package after the proposal.

Balsam and Yin (2012) looks at compensation changes in advance of the mandated Say on Pay votes and finds that firms reduced compensation and made it more performance-based, with that decrease being greater for firms that previously overpaid their CEOs. They also find the percentage of votes cast against executive pay is lower when the firm reduced executive compensation in advance of the initial Say on Pay vote, but higher when the firm pays higher total compensation, has a large increase in compensation, has a larger amount of compensation that cannot be explained by economic factors, or has a higher amount of "other compensation," a category which includes perquisites. Beckerman (2012) noted that as of June 2012, 103 companies had failed to reach 50% approval in the Say on Pay vote. He analyzed those companies around the date of the failure and found that none of the average cumulative abnormal returns for the three

event windows were significant at any level, and there was no evidence that failing the Say on Pay vote corresponded to an increase or decrease in stock market returns.

There is however, some evidence on the sensitivity of pay to external pressure in the U.S. Core et al. (2008) "find little evidence that firms respond to negative press coverage" pertaining to executive compensation by decreasing that compensation. In contrast Ertimur et al. (2011) find that "Firms with excess CEO pay targeted by vote-no campaigns experience a significant reduction in CEO pay (\$7.3 million)." The difference in results between these two studies can be attributed to the identity of those applying the pressure, i.e., the press versus shareholders of the company. Wagner and Wenk (2012) is the only study testing a market other than the U.K. or U.S. They we assess the stock market reaction to the unexpected announcement of that the Swiss government would try to enact binding Say on Pay. Over 70% of Swiss public corporations responded with negative abnormal stock returns.

While shareholders continue to deliver overwhelming support for existing pay practices, with more than 90 percent of companies passing with at least a 70 percent approval rate, the vote continues to be a high-profile issue. The evidence in the U.K. and U.S. indicates that the failure rate declines over time and companies with failed Say on Pay votes in one year typically receive passing scores in the next year. These findings suggest that companies act upon the prior results and engage shareholders effectively.

Companies and compensation committees have realized that the approval process cannot be undertaken solely during the proxy season. They have learned that the disclosure and approval of executive compensation is a year-round process. Many companies have found that shareholder advisory firms have a lot of influence over the voting process. A significant portion of the companies that received a negative recommendation from an advisory firm experienced failed Say on Pay votes. In addition, where a company received shareholder approval despite a negative report an advisory firm, the average shareholder support was significantly lower than for those companies receiving a positive report from an advisory firm. (Jaffari and Bobrin, 2012) The influence of such firms may be caused by investor vote fatigue. With the large number of Say on Pay votes taking place each proxy season, many investors do not have the time or the resources to analyze each company's executive pay practices.

As we move forward, pay for performance continues to draw significant attention. Companies need to be able to clearly and effectively articulate to shareholders the connection between executives' pay and the company's performance to secure support for future votes. In most cases where an advisory firm issued a negative recommendation, it indicated a disconnect between pay and performance.

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# A Shareholder Bill of Rights

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**Abstract**: This paper explores the development and nature of shareholder rights, the key groups charged with protecting shareholder rights, and the failure of these groups to safeguard the rights of small shareholders. We suggest treating the relationship between a firm and its shareholders as contracts between those two groups, whose terms can be negotiated to attract capital by offering small shareholders the level and type of protection that they seek.

Keywords: Shareholder rights, shareholder activism, agency theory, board of directors, auditor-client relationship, SEC, FASB, PCAOB

## Introduction

The agency relationship between managers and shareholders is a long-standing issue (Jensen and Meckling, 1976). For shareholders to be willing to invest in capital markets, they need useful information about the firm's financial condition and protection from the possibility that managers have made choices contrary to the shareholders' best interests.

When events shake investors' confidence in the information value of financial statements or the protection of shareholders' interests, actions are taken to restore that confidence. After the stock market crash of 1929, Congress passed the Securities Act of 1933, requiring uniform disclosure for initial public offerings, and the Securities Exchange Act of 1934, creating the Securities and Exchange Commission (SEC) to oversee secondary stock trades (www.sec.gov). In 1973, the SEC created the Financial Accounting Standards Board (FASB) to establish financial accounting and reporting standards for publicly held firms (www.fasb.org). In response to a series of accounting scandals, Congress passed the Sarbanes-Oxley Act of 2002 (SOX), which created the Public Company Accounting Standards Board (PCAOB) to generate new rules for improving the independence of auditors, oversight by the board of directors, certification of financial statements and internal controls by top management, and stronger penalties for fraudulent financial reporting (www.pcaobus.org).

## Shareholder Rights

Traditionally, shareholders receive rights in exchange for their investment in a firm's common stock, but how much are these rights really worth? Shareholders' right to sell their shares has little value if new information causes share prices to fall. They can vote on nominees to the board of directors, although nominees often run unopposed, and shareholders may lack information on the nominees' views. They also have the right to nominate directors or propose shareholder resolutions. However, this right only benefits shareholders if they can act together. Shareholders receive any declared dividends, but have no way to influence this decision or determine whether it represents the highest use for their capital. They also have a preemptive right to purchase any new shares issued, although the value of this right depends on the relevance and reliability of financial reporting. Finally, their right to share residual assets upon liquidation has little economic value and thwarts shareholders' original objectives for investing.

Eisenberg (1989) describes shareholders' ability to influence management as nominal if shareholders fail to vote, tainted if institutional investors have economic ties to management, coerced if management couples attractive benefits with provisions not in shareholders' best interests, and impoverished if management limits their choices. Given that shareholders have little ability to protect themselves, who is in charge of protecting their interests?

## **Shareholder Protections**

#### **Board of Directors**

Shareholders elect the board of directors as their agents to choose managers who will run the firm in a way that will enhance shareholder value. Legally, directors are charged with the duty of loyalty to shareholders

and the duty of care in selecting and negotiating with top executives, overseeing how the business is being managed, reviewing the firm's financial goals, and approving the firm's external auditor and choices of accounting principles (American Law Institute, 1992). However, the board has limited ability to protect shareholders. As with any agency relationship, directors may be effort-averse or self-dealing. In addition, it is infeasible for board members to extend their oversight to the firm's daily operations. Furthermore, board characteristics, such as its size, the proportion of inside and outside directors, and whether the CEO acts as its chair, may affect directors' ability to monitor managers.

### Managers

The board of directors hires managers to protect shareholders' interests and increase their wealth. However, this separation of ownership from control creates agency problems because managers' and shareholders' interests are different. Managers can make decisions that benefit themselves, not the shareholders, and conceal their actions through information asymmetry (Fama and Jensen, 1983). Theoretically, shareholders can protect their interests by directing the board to design appropriate incentives for managers and then incurring the associated monitoring costs (Jensen and Meckling, 1976).

### Auditors

One of the board's responsibilities is to hire the external auditor to assess whether managers have followed Generally Accepted Accounting Principles (GAAP) in the firm's external financial reports and maintained internal controls over financial reporting. However, the degree of protection that this arrangement offers depends on whether the auditor, as an employee of the firm, is truly independent of management. Many accounting scandals have shown that this is not always the case, and the PCAOB was designed, in part, to mitigate the problem of auditor independence.

## PCAOB

The PCAOB should be an ideal protector of shareholder interests since it was created to regulate the relationships among the board of directors, managers, and the auditor. However, as Stigler (1971) explains, regulation of any industry fails in the long run. Firms have tremendous incentives to co-opt their regulators, since their benefits are large and concentrated, whereas losses to the public are small and diffuse. Thus, regulation alone cannot protect shareholders.

#### Institutional Investors

When ownership is diffuse, and investors' portfolios are diversified, it becomes expensive for small shareholders to monitor management (Berle and Means, 1991). Since institutional investors, such as pension funds, mutual funds, and insurance companies, own large blocks of stock, they could be effective monitors for all shareholders, but only if their interests match with the smaller shareholders. This may not be true since small shareholders are risk-averse, active traders who want to do well, whereas institutional investors may also vote against small shareholders' interests if they have economic or social relationships with management.

## Legal Remedies

Shareholders can sue for damages as a result of securities fraud (www.sec.gov). However, the legal standards are strict, lawyers' fees are high, settlements are too small to compensate shareholders or deter self-interested managers, and 40-60% of funds are never claimed (Scott and Silverman, 2012). The SEC has resisted low-cost arbitration under the 1925 Federal Arbitration Act.

Under Senator Charles Schumer's Shareholder Bill of Rights Act of 2009, shareholders could vote on executive pay annually and include their own board nominees in proxy statements, board members must receive a majority of votes to be elected, board elections cannot be staggered, and the CEO cannot serve as board chair. However, this measure was defeated.

# Proposed Shareholder Bill of Rights

The essence of ownership is control. Yet shareholders, especially small shareholders, have no control over what happens to their share of the firm's net assets or residual income, and no way to protect themselves from managerial manipulations. The market is inefficient because information is asymmetrical and monitoring costs are high, so it needs the SEC, FASB, and PCAOB to help small shareholders feel protected precisely because their rights as owners are ill-defined and difficult to enforce.

Perhaps the problem lies in thinking of shareholders as owners. We propose treating the firm-shareholder relationship as a set of business contracts that grant specific protection and compensation to shareholders in exchange for their investment. In that case, the firm and shareholders can negotiate any terms they choose. As long as the terms are transparent and enforceable, the market should allocate capital efficiently (Coase, 1960).

Under this system, firms can issue different classes of shares, depending on their need for capital and investors' preferences for remuneration and protection. One type of contract could include voting rights and the benefits from residual income. This would attract active, informed investors who want to influence firm management and can protect themselves by voting. Other types of contracts might not confer votes or an interest in residual income, but would offer specific, enforceable benefits and protections in the form of covenants, such as limiting executive compensation or tying it to some auditable measure of firm profitability, dividends defined as a percentage of executive compensation or firm profitability, and/or insurance against the possibility that the firm's financial reports are misstated (Palmon and Sudit, 2009).

In this scenario, firms compete against each other for investor capital by offering attractive contracts, investors can choose from a range of options to suit their risk-tolerance and investment goals, and the market for capital replaces many of the regulations currently in place and disciplines self-interested managers. Therefore, shareholder rights would include:

- The right to know the terms of all contracts;
- The right to invest in a contract that suits their needs;
- The right to receive the benefits and protections promised under that contract; and
- The right to sue in Accounting Court (Spacek, 1958) if the firm fails to uphold its side of the contract.

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# The Impacts of the Ownership Discrepancy between Cash-Flow Rights and Voting Rights on Firms' Soft Asset Investment Decisions: Evidence from Large Business Groups in South Korea

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**Abstract**: This study investigates the impacts of the ownership discrepancy between cash flow rights and voting rights on firms' soft asset investment decisions in large business groups in South Korea. We find that controlling (or ultimate) shareholders are more likely to avoid firms' investments in soft assets that are indispensable to business success in long-term and strategic perspectives when controlling shareholders have higher voting rights than cash flow rights, exploiting minority shareholders' rights.

Keywords: Corporate governance; Ownership structure; Shareholders rights; Business group

We investigate the impacts of the magnitude of the ownership discrepancy between cash flow rights and voting rights (hereafter the ownership discrepancy) on firms' soft asset investment decisions in large business groups in South Korea, especially for intangible assets, human resources, and marketing and advertisement, which are essential for business success in long-term and strategic perspectives. This study examines whether controlling (or ultimate) shareholders have more incentives to reduce firms' investments that are indispensable to long-term success by exploiting minority shareholders' rights when controlling (or ultimate) shareholders have flow rights.

The ownership discrepancy refers to the magnitude of the difference between cash flow rights and voting rights by controlling (or ultimate) shareholders. The difference between cash flow and voting rights represents the degree of deviations from 'one share-one vote.' The ownership discrepancy is usually achieved through something similar to a pyramid structure, and firms with a high level of the ownership discrepancy are more likely to have managerial agency problems (Lins, 2003). Through ownership structures such as pyramids and cross-holdings, controlling shareholders exercise voting (or control) rights greater than they actually possess (cash flow rights). The magnitude of the ownership discrepancy implicitly represents the latent possibility of controlling shareholders to infringe on minor shareholders' rights and interests. In addition, the extent of the difference between cash flow rights and voting rights can lead to the creation of an environment conducive to invading minor shareholders' rights and benefits. Therefore, the magnitude of the ownership discrepancy is an important measure of the quality of ownership structure, implying a tension between controlling and minority shareholders.

Firms' strategic decisions on their investments, especially for long-term perspective investments (e.g. soft assets), is subject to the conflicts of interest between ultimate shareholders and minority shareholders. Strategic investments in soft assets are aimed at the business success in long-term perspectives with high risk. Thus, ultimate shareholders and management are more likely to have an adverse opinion in high risk investments because those investments hardly generate short-term returns which can be reflected shortly in the reported earnings. Instead, ultimate shareholders may prefer to use those surplus resources for their own private benefits.

Prior literature documents that a higher ownership discrepancy leads controlling shareholders to pursue their own interests at the expense of minority shareholders (Zhang, 1998; Johnson, Boone, Breach, and Friedman, 2000; Claessens, Djankov, Fan, and Lang, 2002; Kim and Yi, 2006)<sup>14</sup>. Some studies suggest that the ownership structure is an important factor determining the level of firms' investments (Baysinger, Kosnik, and Turk, 1991; Zhang, 1998; Cho, 1998; Filatotchev, Kapelyushnikov, Dyomina, and Aukutsionek,

<sup>&</sup>lt;sup>14</sup> For example, Zhang (1998) suggests that the controlling shareholders are less likely to invest to risky projects than minor shareholders and therefore the controlling shareholders under-invest in the projects.

2001; Lopez-Iturriaga and Rodriguez-Sanz, 2001; Lee and O'Neill, 2003; Yoshikawa, Phan and David, 2005; Wei and Zhang, 2008; Chen and Hsu, 2009). These studies mainly focus on the effects of ownership concentration or ownership types on R&D or capital expenditures only. In addition, studies on ownership structure around the world find that relatively few firms are widely held. For example, studying data on the ownership structure of large corporations in 27 wealthy economies, La Porta, Lopez De Silanes, and Shleifer (1999) find that few of these firms are widely held and instead are controlled by families or the state. Only 36.48% of their sample has a widely held ownership structure. This result implies that the ownership structure in which large corporations are controlled by a few ultimate owners is more common worldwide than the widely held ownership structure.

Most leading companies in South Korea are affiliated with a large business group.<sup>15</sup> South Korea is well known as a strong family-oriented culture; therefore, in many cases, large Korean business groups are controlled by a few ultimate owners based on family ownership. Typically, a founder and his/her family are the control group. Those family-based ultimate owners exercise much greater voting rights than their actual cash flow rights to control a whole business group, which is achieved through a pyramid or a cross-holding structure. As a result, the ownership structure of large Korean business groups can remarkably well reflect the conflict of interest between ultimate shareholders and minority shareholders. However, there is little indepth research that focuses on the relationship between the ownership discrepancy and firms' soft asset investment decisions specifically in large Korean business groups.

Considering the fact that the extent of the ownership discrepancy implicitly involves the latent possibility of infringing on minor shareholders' rights and interests, it is necessary to trace the relationship between the ownership discrepancy and firms' soft asset investment decisions. Based on theory and empirical evidence in the literature, we therefore expect that firms with greater magnitude of ownership discrepancy are less likely to invest in strategic soft asset investments for long-term business success, such as intangible assets and human resource. While we conjecture the negative association between the ownership discrepancy and investment in marketing and advertisement because characteristic of investments in marketing and advertisement contain both short-term and long-term return generating perspectives. If the expenditures in marketing and advertisement are more long-term effects oriented, the sign of association can be negative, or vice versa.

Using data from large Korean business groups from the 2000 to 2010 fiscal years, we conduct an empirical analysis to investigate whether the magnitude of ownership discrepancy is associated with firms' soft asset investment decisions. We use three categories of soft asset investments as dependent variables: investments in intangible assets, investments in human resources, and investments in marketing and advertisement. Investments in intangibles are further broken down into two measures based on the perspective of accounting treatment: (1) intangibles expensed and (2) intangibles capitalized.<sup>16</sup> For regression analysis, we estimate our regression model using two-way clustered standard errors that account for firm and year correlations in the residuals.

Consistent with our expectation, we find that the ownership discrepancy is negatively associated with the level of investments intangible assets. We also find that there is a significant relationship between the ownership discrepancy and the level of investments in human resources, which supports our hypotheses. Furthermore, the ownership discrepancy is positively related to the level of investment in marketing and advertisement. This finding indicates that most marketing and advertising expenditures are mainly aimed at short-term sales promotion, inducing the increased reported earnings.

In summary, our findings suggest that firms' propensity for investing in soft assets is negatively related to the magnitude of the ownership discrepancy, implying that the ultimate shareholders have incentives to

<sup>&</sup>lt;sup>15</sup> A large Korean business group is often referred to as a 'Chaebol' in other literature.

<sup>&</sup>lt;sup>16</sup> Intangible assets expensed are calculated by dividing research expense, ordinary research and development expense, and ordinary development expense by total assets. All of these items are reported on the income statement. Intangible assets capitalized are calculated by dividing development, industrial property, and other intangibles by total assets. Industrial property indicates patents, trademarks, etc. All of these items are reported on the statement of cash flows. Investments in human resources are calculated by dividing employee training program and fringe benefits expenses by total assets. All of these items are reported on the income statement. Investments in marketing and advertisement are calculated by dividing advertising and overseas marketing expenses by total assets. All of these items are also reported on the income statement.

avoid long-term investments in soft assets. In other words, the ultimate shareholders are more likely to use firms' resources for their own interests by exploiting the rights of minority shareholders when the voting rights of the ultimate shareholders exceed their cash flow rights.

Our study contributes to the literature in several aspects. First, it adds evidence to the literature that the magnitude of the ownership discrepancy is associated with the level of firms' investment decisions. Second, this study revisits and extends prior studies on the role of the quality of ownership structure and its implication to shareholders and investors. Finally, this study improves the understanding of large Korean business groups' ownership structure as well as their investing behavior in soft assets for long-term business success. The findings of our study also suggest that the ownership discrepancy is one of the most crucial proxies, which clearly indicates the conflicts of interests between two groups - controlling (or ultimate) shareholders and minority shareholders.

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# Managers' Audit Negotiation Judgments Around an Initial Public Offering

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Abstract: Auditor-client negotiations are a common and critical part of the financial reporting process, yet we know little about contextual factors that influence negotiation judgments from the manager's perspective, particularly post-SOX (e.g., Gibbins et al. 2001; 2007). Managers have financial reporting incentives to behave opportunistically since audit negotiation outcomes often materially impact financial reports and managerial compensation. However, managers also have reporting reputation incentives to accommodate auditors since unresolved negotiation issues may result in a qualified audit report and damage firm and managerial reputation (Salterio 2011). Prior research suggests that a strong audit committee curbs managers' opportunities to act on their financial reporting incentives (e.g., Agoglia et al. 2011); and that a contentious past relationship with the auditor compels managers to report more conservatively (e.g., Sanchez et al. 2007). Unlike these studies, our study focuses on the unique period around a firm's initial public offering (IPO), where managers are faced with two opposing incentives to either opportunistically report their financial performance (given the higher information asymmetry between managers and potential investors); or to establish a reputation for quality reporting (given the heightened scrutiny from a variety of IPO monitors). In the IPO setting, we expect that relative to other conditions, managers faced with a strong audit committee and a contentious past auditor relationship will make the most conservative offer in an audit negotiation. To test our main hypothesis we use a 2 x 2 experimental factorial design with audit committee strength (stronger or weaker) and past auditor relationship (contentious or cooperative) manipulated between-subjects. We also manipulated the IPO setting (pre-IPO or IPO-year) within-subjects to test whether and which incentive effect continues to dominate. Participants are 137 experienced CFO/controllers who provide pre-negotiation judgments concerning a subjective inventory write-down issue. Results indicate that participants propose and expect the largest inventory write-down when the audit committee is stronger and when faced with a contentious past auditor relationship. The effects are even more pronounced in the IPO-year. These results are consistent with managers acting less on their financial reporting incentives and more on their reporting reputation incentives in the presence of strong monitoring mechanisms around an IPO.

Keywords: auditor-client negotiation; management incentives; negotiation strategy; negotiation relationship; audit committee; initial public offering

## Introduction

We examine the impact of managerial incentives and opportunities around an initial public offering (IPO) on managers' pre-negotiation judgments in resolving a contentious financial reporting issue with auditors. Except for a few studies (e.g., Agoglia et al. 2011; Perreault and Kida 2011), prior research has largely focused on the auditor's perspective (Brown and Wright 2008; Salterio 2011) or on the pre-Sarbanes-Oxley (SOX) period (e.g., Gibbins et al. 2005; Bame-Aldred and Kida 2007; Gibbins et al. 2007). Examining the manager's perspective post-SOX is important since the financial statements are the result of a joint resolution process between managers and the auditor, and SOX substantially changed the roles and responsibilities of the auditor and the audit committee, arguably the two most pervasive monitoring parties of the financial reporting process for a company (Gibbins et al. 2001; 2005, Brown-Liburd and Wright 2011). Examining audit negotiations around an IPO is important, because this is when companies raise funds from the capital markets and managerial incentives shift and opportunities to act on these incentives heighten.

Managers have *financial reporting incentives* to behave opportunistically when negotiating with auditors since outcomes often result in a material impact on financial reports (Gibbins et al. 2007) and on managers' compensation (Antle and Nalebuff 1991). However, managers also have *reporting reputation incentives* to accommodate auditors since unresolved issues may result in an audit qualification or auditor resignation (Salterio 2012) which would damage managerial reputation (Melumad and Ziv 1997). If managers view that a stronger audit committee will bolster the auditor's bargaining power (Ng and Tan 2003; Brown-Liburd and Wright 2011), this may curb their opportunistic behavior (Rubin and Brown 1975, Greenhalgh et al. 1985; Gibbins et al. 2001); and if managers view that a contentious past auditor relationship may lead to a

negotiation impasse (Bame-Alded and Kida 2007), then we expect that managers will behave most conservatively with a stronger audit committee and a contentious auditor.

We focus on the initial public offering (IPO) setting where managers are faced with two opposing incentives: to opportunistically present their financial performance (given higher information asymmetry between managers and potential investors) but also to establish a reputation for quality reporting (given heightened scrutiny from a variety of IPO monitors) (Teoh et al. 1998a, 2008; Ball and Shivakumar 2008; Venkataraman et al. 2008; Bedard et al. 2008; Lo 2008). Prior IPO research provides mixed results as to how these incentives manifest. <sup>17</sup> If financial reporting incentives drive manager's judgments in negotiations around an IPO, then we expect IPO-year earnings management attempts. Alternatively, if reporting reputation incentives dominate, then we expect the effects of the strong monitoring devices to be more pronounced.<sup>18</sup>

We test our predictions we use a 2 x 2 ANOVA design with audit committee strength (stronger or weaker) and past auditor relationship (contentious or cooperative) manipulated between-subjects. We also manipulate the IPO setting (pre-IPO or IPO-year) as a within-subject manipulation. One hundred and thirty-seven experienced CFOs/controllers (henceforth referred to as managers for brevity) participating in an executive training seminar engage in planning for an upcoming negotiation with an auditor involving a subjective estimate for an inventory write-down. Participants identify a preferred position and acceptable range of alternatives, and then anticipate the position of their auditor counterpart. We find that while the inventory write-down is significantly larger (i.e., conservative reporting) when the audit committee is stronger (versus weaker) and when the past auditor relationship is contentious (versus cooperative), the largest write-down is when both of these conditions interact. We also find that these effects are more pronounced in the IPO-year relative to pre-IPO year. These results are consistent with managers acting less on their financial reporting incentives and more on their reporting reputation incentives in the presence of strong monitoring mechanisms around the time of an IPO.

We contribute to both the auditor-client negotiations and IPO streams of research in a number of ways. First, we respond to calls to examine key contextual factors (Salterio 2011) in managers' judgments in the audit negotiations process post-SOX (Gibbins et al. 2001; Gibbins et al. 2007; Bame-Aldred and Kida 2007). For example, to our knowledge, the only other study to examine the impact of the strength of the audit committee on managers' reporting actions was conducted by Agoglia et al. (2011), who investigated the impact of rules-based versus principles-based accounting standards. However, that study used a general manipulation (i.e., the degree to which the audit committee complied with SOX requirements) of a strong vs. weak audit committee and did not examine the auditor-client negotiation context. Our manipulation provides a richer definition of audit committee strength and specifically addresses the audit committee's role in mediating contentious issues between management and auditors,<sup>19</sup> since audit standards specifically require auditors to bring these types of issues to the attention of the audit committee.

Second, we extend our understanding of the complex dynamics that influence auditor-client negotiations by focusing on the IPO setting where managers arguably have greater opportunities to act on incentives to manage earnings, but also where there is heightened scrutiny from a variety of monitors (Lo 2008). We also contribute to archival research on earnings management in IPOs that examine post-audit financial statements (e.g., Teoh et al. 1998a, 1998b; Ball and Shivakumar 2008) by designing an experiment with exante conditions that capture managers' judgments. Indeed, Nelson et al. (2002) note that post-audit financial

<sup>&</sup>lt;sup>17</sup> In this study, we do not make any claims as to whether managers should or should not act on their financial reporting incentives and hence opportunistically in negotiating with auditors. For example, inflated or smooth earnings can be construed as undesirable earnings management, which implies a motive to mislead users and/or to unduly influence contractual outcomes (Schipper 1989) and thereby extract rents from IPO subscribers. Alternatively, inflated or smooth earnings could represent what users (e.g., IPO subscribers and current shareholders) desire and expect, and managers are merely delivering on what is expected of them (Lo 2008).

<sup>&</sup>lt;sup>18</sup> In practice, the strength of the audit committee and the auditor may not be independent. That is, a strong audit committee is likely to appoint a quality auditor who may utilize a contentious negotiating strategy. However, since negotiating strategy is an individual choice, prior research has shown a range of negotiating strategies by auditors within the same auditing Big 4 firm (e.g., Brown-Liburd and Wright 2012). In our experiment, we manipulate and randomly assign the two constructs (audit committee strength and auditor strategy) in order to tease out the combined effect incremental to the main effects.

<sup>&</sup>lt;sup>19</sup> In addition to the responsibility to hire external auditors, SOX 404, Section 301 requires the audit committee to oversee audit adjustments and mediate auditor-management negotiations that may occur as a result of audit adjustments.

statements are the joint output of auditor-client negotiations, and thus cannot be used to disentangle managers' from auditors' actions. In particular, our experiment complements studies of audit-related factors that impact managerial opportunism around IPOs (Venkataraman et al. 2008; Bedard et al. 2008) and allows us to isolate the manager's decisions separate and distinct from the auditor's.

Finally, we complement survey research on the importance of building a company's reputation via the IPO. Brau and Fawcett (2006) survey CFOs to obtain their perspective on the IPO process and find that CFOs' primary motives for going public is to fund growth opportunities, to establish a market price/value for the firm, and to enhance the company's reputation. In particular, our experiment examines one mechanism through which managers undergoing an IPO can enhance their company's reputation for quality reporting - by proactively working with auditors to minimize the risk of not obtaining a timely and unqualified audit opinion.

The remainder of this paper is divided into four sections. The next section provides a review of the relevant literature and develops the research hypotheses. This section is followed by a description of the method and presentation of the results. The final section is devoted to a discussion of the major findings and their implications for practice and future research.

## **Background Literature and Hypotheses Development**

#### Auditor-Client Negotiations from the Client's Perspective

Managers prepare the financial statements and thus essentially make the first offer in audit negotiations. Further, negotiating with auditors is a common and critical part of the CFO's function and often results in a material impact not only on financial reports (Gibbins et al. 2007), but also on the manager's compensation (Antle and Nalebuff 1991). As a result, managers have *financial reporting incentives* and hence may act opportunistically in audit-client negotiations. However, failed negotiations with auditors may give rise to a potential audit qualification or auditor resignation (Salterio 2012) and may thus, damage managerial reputation (Melumad and Ziv 1997). As a result, managers have *reporting reputation incentives* and hence may accommodate auditors in audit-client negotiations. Though we know little about factors that influence managers' actions on these incentives, we can draw from Brown and Wright's (2008) review of the literature and Salterio's (2011) discussion which generally describe auditor-client negotiations as being influenced by the interplay between the parties, the contextual environment, and the accounting issue of interest.

Managers and auditors remain the primary direct parties engaged in negotiations to resolve an ambiguous reporting issue (Cohen et al. 2010). Prior survey research characterizes the manager's general approach and perceptions of audit negotiations. Gibbins et al. (2005) find that surveyed CFOs focus on accounting issues separately, approach negotiations as a win-lose proposition, and place less emphasis on prior negotiation outcomes and audit committee roles than auditors. In contrast, Bame-Aldred and Kida (2007) investigate the initial negotiation positions and tactics of both clients and auditors in a pre-negotiation context.<sup>20</sup> They report that clients are more flexible than auditors and more accurate in predicting their negotiating counterpart's positions. Similarly, Gibbins et al. (2007) interview matched pairs of CFOs and audit partners and find that CFOs recall considering it more important for them (rather than the auditors) to reach an agreement, that they had a better analysis of and sensitivity to the issue, but that the auditors had a better understanding of GAAP.

Common among the above studies is that they were conducted prior to SOX. However, SOX changed the environment in that it substantially increased the role and responsibilities of the auditor and the audit committee. Further, these studies do not examine the impact of the audit committee on managers' negotiation judgments. For example, Tan and Trotman (2010) find that the auditors' strategies affect the final negotiated offers of financial officers, and they specifically identify (but do not test) past relationships

<sup>&</sup>lt;sup>20</sup> Our study likewise focuses on the pre-negotiation stage when negotiating parties identify their interests, options, alternatives, goals, and initial position, as well as consider those of their counterpart (Brown and Wright 2008). Pre-negotiation judgments are important because they potentially influence negotiation tactics, expectations about the counterpart's position, and the likely outcome. Further, accurate perceptions of the other party's preferences results in the negotiator being better prepared for the negotiation (Bazerman et al. 2000; Fisher et al. 1981; Pruitt and Carnevale 1993; Trotman et al. 2005).

and the role of the audit committee as important contextual factors that likely impact managers' negotiation judgments.

Managers' negotiation judgments are also influenced by their perception that when the accounting issues are not clearly defined by GAAP and subjectivity and judgment are present, they have greater opportunities to persuade auditors to accept their position. However, prior research suggests that managers also consider how accounting issues are monitored. Nelson et al. (2002) finds that interviewed auditors believe managers take more conservative positions when applying a less precise standard versus a more precise standard because managers perceive there is greater uncertainty in how regulators will interpret the less precise standard. Likewise, research directly examining managers' judgments find that managers are less aggressive in a principles-based (versus a rules-based) environment (Agoglia et al. 2011); their final negotiation judgments are affected by auditors' strategies (Tan and Trotman 2010); they are more creative in resolving an ambiguous revenue recognition conflict than auditors (Bame-Aldred and Kida 2007); and they are willing to trade-off one issue for another (Sanchez et al. 2004; Bame-Aldred and Kida 2007).

Taken together, prior research indicates that managers have both financial reporting incentives and reporting reputation incentives. Managers in audit negotiations consider their opportunities to act on these incentives given the accounting issue at hand and applicable standards, and in the context of the monitoring environment. The following subsections discuss two important and pervasive contextual factors identified in the audit negotiation literature (Gibbins et al. 2001; 2005) - past auditor relationship and audit committee strength.

#### The Initial Public Offering (IPO) Context

We examine the impact of these above-mentioned complementary monitors in audit negotiations around an IPO because this is a unique setting when managerial incentives shift and opportunities to act on these incentives heighten. First, prior research on why firms go public describes a shift in managerial incentives. Early reviews of the IPO literature (e.g., Ritter and Welch 2002) suggest that firms go public to raise external capital to fuel growth and to increase liquidity. More recent articles suggest that IPOs increases firm reputation by establishing a first-mover advantage or by creating an analyst following (e.g., Bradley et al. 2003). Further, Brau et al. (2006) find that one of CFOs' primary motives for going public are to fund growth opportunities, to establish a market price/value for the firm, and to enhance the company's reputation. Second, the IPO setting provides heightened opportunities for managers to act on two opposing incentives: to opportunistically present their financial performance (given higher information asymmetry between managers and potential investors) but also to establish a reputation for quality reporting (given heightened scrutiny from a variety of IPO monitors).

Pre-IPO, managers have an information advantage over potential IPO subscribers, and this advantage provides managers with greater opportunities to inflate earnings in the IPO year (Lo 2008), especially if doing so will enable them to meet or exceed earnings, growth or performance expectations (e.g., Teo et al. 1998a; 1998b). One mechanism that potentially provides managers the opportunity to influence earnings is the audit negotiations process, which typically entails a considerable amount of judgment. For example, Marquardt and Wiedman (2004) find no significant difference in the unexpected inventory for firms issuing equity, including those undertaking IPOs. One explanation is that managers use the unobservable audit negotiations process to arrive at estimates (e.g., inventory obsolescence) that in turn result in desirable earnings patterns (e.g., smooth earnings), which are then observable post-audit. Hence, if higher information asymmetry in the IPO-year (versus pre-IPO) presents greater opportunities for managers to act on their *financial reporting incentives*, then we expect managers to offer a smaller inventory write-down in the IPO-year than prior to the IPO.<sup>21</sup>

The IPO setting also shifts financial statement users' demand up for quality financial reports, and this compels managers to establish such a reputation. Prior research finds that listed firms provide higher quality reports than private firms (Ball and Shivakumar 2008); and that accruals in IPO firms are not systematically opportunistic (Armstrong et al. 2008). Audit-related monitors play an especially important role in firms engaged in an IPO (Willenborg 1999; Lo 2008). Prior research suggests that audit fees (and hence audit effort) are higher in the IPO-year (Venkataraman et al. 2008); and audit committee effectiveness (i.e.,

<sup>&</sup>lt;sup>21</sup> An alternative expectation is that managers offer a larger write-down in the pre-IPO year such that the IPO-year financial performance may be interpreted as relatively better. Our findings allow us to explore this possibility.

financial expertise and independence) reduces IPO underpricing (Bedard et al. 2008).<sup>22</sup> Further, Greek IPO investors react negatively to an audit qualification (Ghicas et al. 2008); and small IPO firms with a going concern opinion delist within two years (Willenborg and McKeown 2001). Hence, if higher demand for quality financial reports in the IPO-year (versus pre-IPO) presents managers with opportunities to act on their *reporting reputation incentives*, then we expect managers to accept a larger auditor proposed inventory write-down in the IPO-year.

Taken together, IPOs create an environment where managers have incentives to misreport (i.e., exceed earnings expectations) and the judgment inherent in accounting estimates provides an opportunity to exploit the subjective nature of the standards through the auditor negotiation process. However, when faced with increased monitoring that occurs around an IPO, managers may be dissuaded from acting on their financial reporting incentives and instead accommodate auditors to resolve accounting issues (i.e., act more on their reporting reputation incentives).

#### Past Auditor Relationship

General negotiation research finds that a negotiation relationship normally continues over time (McGrath 1966) and impacts negotiation judgments (Gruder 1971; Savage et al. 1989) and outcomes (Schei and Rognes 2003; O'Connor et al. 2005). Prior interactions with a counterpart trigger expectations regarding the ease with which an appropriate resolution will be reached and can produce higher levels of cooperative or contentious interactions (e.g., Greenhalgh and Chapman, 1998; Gibbins et al. 2007). For example, an individual expecting to face a counterpart who has previously viewed the negotiations as distributive in nature (i.e., where one party wins at the expense of their counterpart) will perceive her counterpart's intentions less favorably (Kahan 1968), and this perception persists throughout the negotiation (Tinsley et al. 2002).

Prior research examining the pre-SOX period suggests that CFOs consider prior interactions with auditors in setting expectations and tactics for future negotiations. Sanchez et al. (2007) find that managers have more conservative negotiation limits and initial offers, and are more willing to ultimately post significant income-decreasing adjustments when auditors are willing to make only small concessions (i.e., waive inconsequential adjustments). Further, Bame-Aldred and Kida (2007) find that managers are better at predicting the auditor's negotiation position, are more willing to cooperate, are more flexible, generate a wider set of solutions and are more likely to trade-off one issue for another than auditors. Gibbins et al. (2007) examine CFOs recollections of actual auditor-client negotiation situations and report that CFOs are amenable to finding a common resolution. Fontaine and Pilote (2011) survey client management and find that clients prefer not to influence their auditor but rather have a cooperative, trusting, and information-sharing relationship.

This description of the manager as an accommodating negotiator is consistent with findings in general negotiations research that one party is able to strategically reach a profitable outcome by being flexible and adaptable. This description is also consistent with the manager's aversion to ending the negotiation in an impasse (O'Connor and Arnold 2001). As a result, negotiators expecting a competitive opponent become less competitive by setting lower reservation prices (i.e., the point beyond which the negotiator is unwilling to agree) and making lower counteroffers (Diekmann et al. 2003).

These findings are in contrast to auditors who have been found to be more competitive when faced with a client that has been contentious in past negotiations (Brown-Liburd and Wright 2011). Auditors tend to follow a conservatism bias when faced with contentious matters (Smith and Kida 1991) or when the risk of financial loss to the auditor is high (Hackenbrack and Nelson 1996). The auditor's objective is not to just obtain agreement with the client but also to achieve the optimal negotiation outcome. This focus is likely

<sup>&</sup>lt;sup>22</sup> IPO underpricing is generally defined as setting, for IPO subscribers, an offer price that owner-managers know to be lower than the intrinsic value of the firm. Because owner-managers have private information about the firm's future cash flows and risks, a lower offer price essentially attracts new investors by paying them a premium for investing in a risky firm wherein they have an information disadvantage. As such, IPO underpricing results in a wealth transfer from owner-managers to IPO subscribers (Filatotchev and Bishop, 2002). Although managers have an incentive to attract new investors through IPO underpricing, managers also have an incentive to signal strong financial performance (Brau and Fawcett 2006) and thereby maximize their financing. Bedard et al. (2008) provide evidence consistent with audit committee effectiveness providing a signal of financial reporting quality through the committee's oversight of the firm's IPO prospectus containing the firm's historical financial performance.

especially important to auditors in the post-SOX era where auditors face greater regulatory scrutiny. Additionally, the PCAOB utilizes a risk-based approach to select accounts or specific audit areas to examine (Riley et al. 2008). Therefore, auditors are likely to be sensitive to areas where there are higher risks of misstatement and unwilling to acquiesce to the client's preferred position.

#### Audit Committee Strength

General negotiation research suggests that power in competitive negotiations is associated with the number and strength of alternatives available to the negotiator (Pinkley et al. 1994); and that stronger individuals use their power to obtain better outcomes than the weaker party (Rubin and Brown 1975, Greenhalgh et al. 1985). Accordingly, to bolster their bargaining power when negotiating with management, auditors look an important ally, namely the audit committee, when they expect to interact with management to resolve a difficult matter and when they raise contentious issues with the audit committee if management is unwilling to acquiesce to the auditor's preferred position. For example, Ng and Tan (2003) find that when authoritative guidance is lacking, auditors perceive that the negotiated outcome will result in the client recording an adjustment when the audit committee is effective but not when it is ineffective.

SOX 404 defined better the means by which the audit committee can be effective by increasing their role in providing oversight over financial reporting and disclosures. In addition to requirements that the audit committee be independent of management, have a member with financial expertise, and meet on a regular basis, the audit committee is also responsible for exercising due diligence over the financial reporting process. Specifically, the audit committee is expected to review complex estimates and accounting judgments made by management and mediate disputes that may arise between management and auditors over accounting issues. Further, auditors are required to report to the audit committee any audit adjustments or disagreement or difficulties encountered with management during the audit (AICPA SAS 90 2000; Blue Ribbon Commission 1992).

Given this expanded role, an audit committee that is more substance (i.e., diligently oversees the financial reporting process) than form (i.e., meets the minimum requirements under SOX) is likely to have a greater impact on how managers negotiate contentious issues. Thus, the impact of the audit committee in inhibiting managers' opportunities to act on their financial reporting incentives depends heavily on the strength of the committee (DeZoort et al. 2003). A stronger audit committee will provide oversight over the negotiation process and advocate for proper financial reporting, and as a result, enhance the relative bargaining power of the auditor. Indeed, Brown-Liburd and Wright (2011) find that in the presence of a strong audit committee, auditors are more likely to propose a higher inventory write-off (first and final offers) during negotiations with the client.

In turn, if managers perceive that a strong audit committee that exercises due diligence by overseeing auditor-management negotiations over contentious issues bolsters the auditor's bargaining power, then managers are likely to engage in less opportunistic behavior when negotiating with the auditor. Further, managers, perceiving that a stronger audit committee that is independent of management, will behave less opportunistically. For example, using pre-SOX data, Gibbins et al. (2007) found that CFOs in their survey were more likely to make concessions or compromise with the auditor when the audit committee was viewed as being independent.

#### **Complementary Monitors**

In practice post-SOX, the strength of the audit committee and the auditor may not be independent. That is, a strong audit committee is likely to appoint a quality auditor who may utilize a contentious negotiating strategy. From management's perspective, the audit committee will be able to exercise greater due diligence over the financial reporting process in the presence an auditor who has a reputation for tough negotiations. In this situation, management may perceive that they have less bargaining power relative to their auditor counterpart, and as a result take on a more flexible pre-negotiation position. Therefore, we expect a joint effect in that managers will offer the largest inventory write-down (i.e., more conservative reporting) when faced with a contentious past relationship with the auditor, who is then supported by a stronger audit committee. Thus, the two monitors (the auditor and the audit committee) are expected to have complementary (rather than substitution) effects, and that the existence of both strong monitors has a significant incremental impact on curbing management opportunism. Said another way, one without the other results in a substantially weaker constraint on management - the auditor serves to detect potential

misstatements and bring these issues to the attention of the audit committee, who in turn serves as a potential ally and provides the power for the auditor to stand firm. Figure 1 depicts the general form of the expected ordinal interaction effect of past auditor relationship and audit committee strength. This discussion leads to the following hypothesis:

Managers will offer the largest inventory write-down with a stronger audit committee and a contentious past auditor relationship than all other conditions

## Method

#### **Participants**

We recruited CFOs/Controllers attending an executive education training session to participate in the study since these individuals are routinely responsible for negotiating with auditors (Brown and Wright 2008; Gibbins et al. 2001). Table 1 contains demographic information for the sample of 137 managers and indicates that these participants have sufficient direct task experience in negotiating disputed accounting matters with a mean of 6.7 times in which they have resolved a contentious matter with auditors. Participants also have an average of 13.2 years in their current position and 13.8 years of audit experience. One-hundred and twelve (112 or 81%) had the title of either CFO (56%) or controller (25%). Further, 96% of the participants are CPAs, 65% work for a public company, and 98% work in a company with an audit committee. Of those participants in a company with an audit committee, there was an average of 2.5 instances when they have worked with the audit committee to resolve an accounting or auditing issue. In all, participants have the requisite task and domain knowledge necessary for the experiment.

#### Overview

The experiment uses a 2 x 2 factorial design where the independent variables are past auditor negotiation relationship (contentious or cooperative) and strength of the audit committee (stronger or weaker), both of which are manipulated between-subjects. Participants were randomly assigned to the four between-subjects experimental conditions. With the exception of participants' negotiation experience and company type (public vs. private), there were no significant demographic differences (p > .10) between the four experimental conditions, suggesting successful random assignment of participants. Negotiation experience and company type were significantly different (p = .026 and .040, respectively) across conditions, with participants in the strong audit committee/contentious past relationship having the greatest amount of negotiation experience (mean = 7.32) and participants in the weak audit committee/cooperative past relationship having the lowest percentage of participants in publicly held companies (49%). To ensure that our results are not driven by these two variables, we conducted the analysis with and without negotiation experience and company type as covariates. The results of both models are qualitatively similar.

#### **Experimental Tasks**

Participants received a realistic case adapted from that used by Trotman et al. (2005) with the permission of the authors. Specifically, the case was shortened to focus on the issue at hand (inventory obsolescence) and to introduce the manipulation of the independent variables. The case is based on an actual client situation in which the audit team questioned whether the raw material inventory for a joystick manufacturing company should be written down due to obsolescence, given deteriorating aging and a short product life cycle in the industry. Thus, the issue is a subjective matter (i.e., application of a less precise standard), which can lead to auditor-client negotiations.<sup>23</sup>

Background information was provided about the company (industry, history, overall controls, and summary financial statements) and the issue at hand. Three risk indicators of the potential for a material misstatement(s) were present in the case. First, the company was planning to go public in the near future such that there were significant pressures to report strong financial performance. Second, the auditor is proposing an inventory write-down that would significantly decrease net income. Third, a number of key performance indicators show the inventory situation is of concern (e.g., slower inventory turnover than from the prior year and in comparison to competitors). Following prior research using the experimental task with auditor participants (Brown-Liburd and Wright 2011; Trotman et al. 2005), participants were

<sup>&</sup>lt;sup>23</sup>CFOs in Gibbins et al.'s (2007) survey recall that asset write-downs are one of a few main negotiations issues that materially impact financial reporting outcomes.

provided the current inventory write-down already recorded by the company of \$300,000 as well as an additional \$500,000 inventory write-down for obsolescence proposed by the audit team. Participants were then asked to provide judgments in preparation for discussions with their counterpart (i.e., the audit partner) regarding their position and that expected of the audit partner (preferred write-down and range).

### Manipulation of the Independent Variables

As noted, two variables are manipulated between subjects: past auditor relationship (*PAR*) and audit committee strength (*ACS*). Exhibit 1 shows the manipulations. The past auditor relationship is one in which the counterpart has been either contentious or cooperative in negotiations. The contentious past auditor relationship (*Contentious PAR*) is where past negotiations have been difficult and prolonged, since the audit partner has followed a pattern of adopting a position and then been largely intransient in revising his position in light of counter-arguments. In contrast, a cooperative past auditor relationship (*Cooperative PAR*) is one where the partner has been willing to accept reasonable counter arguments. These descriptions are similar to those provided to auditors in prior research (e.g., Brown-Liburd and Wright 2011; Hatfield et al. 2008; Bame-Aldred and Kida2007).<sup>24</sup>

Audit committee strength is manipulated as either stronger or weaker. In a review of the literature, DeZoort et al. (2002) identify four elements that determine audit committee strength: composition (expertise, independence, integrity, and objectivity), authority, resources, and diligence. Consistent with these elements, the stronger audit committee condition (*Stronger ACS*) was described as independent, diligent, and knowledgeable in accounting and auditing. Further, the audit committee was granted sufficient power from the board to achieve its objectives, and the board will side with the audit committee in disputes with management that are contentious.

The weaker audit committee condition (Weaker ACS) is one where the audit committee meets minimal regulatory standards in form (e.g., independent members, one financial expert, and all financially literate) but is weak in substance since it meets infrequently, asks few questions, and has limited power from the board to exercise its authority. Further, the board rarely sides with the audit committee when there is a contentious issue involving management. In all, the weak condition is one where it is unlikely the audit committee will or can stand up to management in a dispute with the auditor. Our manipulations are consistent with Institutional Theory (Cohen et al. 2008; Fogarty and Rogers 2005; Gendron et al. 2004; Orton and Weick 1990; Kalbers and Fogarty 1998, 1993). In form an audit committee must meet regulatory requirements while in substance it may not truly be able to fully accomplish its responsibilities. Further, our manipulation builds on previous studies that have examined audit committees (e.g., Agoglia et al. 2011; Ng and Tan 2003). These studies generally manipulate audit committee strength based on the level of compliance with regulatory requirements. For example, Agoglia et al. (2011) describe a strong audit committee where all members are independent, financial experts and the committee meets frequently. Our manipulation, not only describes a strong audit committee that is independent, diligent and knowledgeable, but also one that is actively involved in mediating accounting disputes that arise between the auditor and management to protect shareholders' interests. Thus, we make salient to the participants that the audit committee does not merely rubberstamp the financial statements issued by management.

#### **Dependent Variables**

Our first pre-negotiation measure is OFFER RATE which is a measure of the manager's intended initial offer given the audit team's proposed write-down adjustment amount of \$500,000. A larger initial offer relative to the audit team's proposed write-down indicates that the manager is beginning the negotiation with a cooperative mindset. For example, if the manager offers an initial write-down of \$400,000 as compared to \$500,000 proposed by the audit team (i.e., OFFER RATE = 80%), then the manager is entering the negotiation with an opening position that potentially allows for a solution that satisfies both parties since it is relatively close to the auditor's position. However, if the manager offers a lower write-down, say \$100,000 (i.e., OFFER RATE = 20%), this suggests that the manager is entering the negotiation attempting to reach an agreement closer to her goals by potentially employing a bid high/concede later negotiation tactic. This dependent variable has the important advantage of providing a measure of the manager's negotiation taction.

<sup>&</sup>lt;sup>24</sup> Perreault and Kida (2011) also examine cooperative vs. contentious negotiation styles. However, their focus is on the auditor's communication style used to persuade the client to accept their position. Our manipulation focuses on the auditor's past behavior during negotiations (i.e., whether the auditor was willing to make concessions vs. being intransient).

strategic position relative to that of the auditor, since it is representative of the first offer they would make after learning of the write-down proposed by the audit team.

Our second measure of pre-negotiation judgment is ULTIMATE W/D, which represents the manager's perceived final negotiated outcome that will be reflected in the financial statements. This judgment is reflective of the manager's aspiration which is the best outcome that the negotiator can reasonably expect from the negotiation (White et al. 1994; White and Neale 1994). Prior research shows that the ultimate perceived write-down amount is significantly positively related to the actual negotiated outcome (White and Neale 1994).

## Results

### Manipulation Checks

We employed two manipulation check questions to determine whether participants encoded the experimental conditions as intended. For the past relationship manipulation, the question stated: "What do you think best describes the past relationship you have had with the audit partner in his approach to dealing with difficult accounting issues?" Responses were on a scale from one (cooperative) to seven (contentious). The untabulated mean (standard deviation) responses were 1.51 (0.84) and 6.91 (1.28) for participants in the cooperative past auditor relationship and the contentious past auditor relationship conditions, respectively. The difference in means is in the expected direction and significant (t = -25.98, p < .001).<sup>25</sup>

For the audit committee strength manipulation, we asked: "In the case you just completed how strong do you think the audit committee at VCC is in helping to resolve contentious accounting issues?" Relevant to our study is the extent of involvement of the committee in dealing with contentious reporting matters, which enhances the likelihood of the committee's support for and, hence, the bargaining power of management. Thus, the manipulation check question focuses specifically on the role of the audit committee in resolving difficult reporting issues. Responses were on a scale from one (very weak) to seven (very strong). The untabulated mean (standard deviation) responses were 1.48 (.50) for participants in the weaker audit committee and the stronger audit committee conditions, respectively. The difference in means is in the expected direction and significant (t = -55.98, p < .001).

## **Descriptive Results**

Table 2 provides the means and standard deviations of the participants' pre-negotiation positions of both dependent variables (*OFFER RATE* and *ULTIMATE W/D*). Panel A presents these descriptive statistics for the experimental conditions. Mean comparisons of pre-negotiation positions for audit committee strength and past relationship are consistent with our expectations in the pre-IPO year (Panel A).

## Test of Hypotheses

To investigate the effects of past auditor relationship and audit committee strength on pre-negotiation judgments, we conducted a MANOVA using participant-provided assessments of inventory write-downs (*OFFER RATE* and *ULTIMATE W/D*). Contentious PAR is coded 1 for a contentious past auditor relationship and 0 otherwise. Stronger ACS is coded 1 for a stronger audit committee and 0 otherwise. Untabulated MANOVA results indicate significant main effects Contentious PAR (p = .000); Stronger ACS (p = .000); and a significant interactive effect of Contentious PAR x Stronger ACS (p = .013). Given the significant effects of the MANOVA, individual ANOVAs are conducted for each of the dependent variables to test the hypotheses.

Table 3 presents the results of our tests. First, and consistent with prior audit negotiation research pre-SOX (e.g., Sanchez et al. 2007), we find a significant main effect for *Contentious PAR* for our dependent variables *OFFER RATE* (F = 102.5, p = .000) where the effect is larger when the past auditor relationship is contentious versus cooperative (means = 70% and 55%, respectively, t = 5.64, p < .001). Likewise, we find a significant main effect for *ULTIMATE W/D* (F = 174.9, p = .000) resulting in a larger write-down when the past auditor relationship is contentious versus cooperative (means = \$377,300 and \$316,900, respectively, t = 5.05, p < .001). These results suggest that in contrast to auditors who are more likely to employ a contending strategy when facing a contentious counterpart (Brown-Liburd and Wright 2011;

<sup>&</sup>lt;sup>25</sup> Four participants failed the past relationship manipulation check question. We ran the analyses excluding these participants and the results were qualitatively similar. We include these participants in the reported results.

Gibbins et al. 2010), managers are more flexible and adaptive and as such, employ a cooperative approach (Bame-Aldred and Kida 2007; Thompson 2009).

Second, and consistent with prior research in settings other than audit-client negotiations (e.g., Agoglia et al. 2011), we find a significant main effect for *Stronger ACS* for *OFFER RATE* (F = 201.8, p < .001) where the effect is larger for a stronger audit committee vs. a weaker audit committee (means = 74% and 49%, respectively, t = 13.29, p < .001).<sup>26</sup> There is also a significant main effect for *ULTIMATEW/D* (F = 453.2, p < .001) for a stronger versus weaker audit committee (means = \$406,900 and \$279,300, respectively, t = 17.90, p < .001). These results highlight the importance of having a stronger audit committee that provides effective governance and monitoring to mitigate opportunistic behavior by management, which is consistent with regulatory efforts in SOX (Salterio 2011).

Turning to our main prediction, we expect that relative to all other conditions, participants will propose the largest inventory write-down in the presence of a contentious past auditor relationship and a stronger audit committee. Consistent with our hypothesis, we find a significant interaction effect of *Contentious PAR* x *Stronger ACS* for OFFER RATE (F = 7.9, p <.005) and ULTIMATE W/D (F = 6.7, p <.001). The largest effect occurs in the contentious past auditor relationship/stronger audit committee condition relative to all other conditions (means for OFFER RATE = 79% and 59%, respectively, t = 17.28, p < .001 and means for ULTIMATE W/D = \$421,900 and \$317,000, respectively, t = 10.51, p < .001).

Because our hypothesis posits an ordinal interaction, we also employ contrast coding (Buckless and Ravenscroft 1990). Specifically, we coded the position of managers in the contentious past auditor relationship/stronger audit committee condition as 3 and the position of managers in the other three groups as -1.<sup>27</sup> Consistent with our hypothesis and as reported in Table 3, we find that managers in the target group adopt a significantly more conservative position than an equally weighted composite group from the other experimental conditions (*OFFER RATE* [t = 15.125, p = 0.001]; *ULTIMATE W/D* [t = 21.531, p = 0.001]). Figure 2 presents the effects of past auditor relationship and audit committee strength on each dependent variable (*OFFER RATE* and *ULTIMATE W/D*). These results suggest that a contentious past auditor relationship and a stronger audit committee together serve as effective monitoring mechanisms, resulting in less managerial opportunism (i.e., higher OFFER RATE and ULtimate W/D).

Taken together, these results suggest that participants are prepared to enter negotiations with auditors with a more cooperative mindset around the time of an IPO, and hence act more on their reporting reputation incentives than on their financial reporting incentives. These results are consistent with findings by Ball and Shivakumar (2008) who suggest that IPO firms are less opportunistic because financial statement users demand higher quality financial reports for firms going public and, consequently, there is increased scrutiny from various monitors (Lo 2008).<sup>28</sup>

#### **Additional Analyses**

To explore if there are differential effects for the pre-IPO and IPO periods, we also conducted a second phase where participants were told that it is one year later and the company has decided to go ahead with an IPO which will provide for the infusion of capital to fund an increase in research and development to give the company an expected edge on competitors. Participants are also told that commensurate with similar IPOs, as part of their compensation contract, each member of the management team, including the CFO stand to receive a significant increase in compensation. The inventory situation is again raised as an issue in the current year's audit and the audit partner is recommending an additional write-off. Participants were provided the current year's recorded inventory write-down of \$200,000 as well as the proposed adjustment by the audit team of \$500,000. With respect to the inventory issue from the prior year,

<sup>&</sup>lt;sup>26</sup>All probabilities are one tailed where the findings are directionally consistent with expectations, otherwise, two-tailed.

<sup>&</sup>lt;sup>27</sup> To test the robustness of the results we also explored the effect of using an alternative set of contrast weights. Specifically we also tested: +4 Contentious PAR/Stronger ACS; -0.5 Contentious PAR/Weaker ACS; -1.5 Cooperative PAR/Stronger ACS; and -2 Cooperative PAR/Weaker ACS. The premise here is that the auditor has the primary responsibility to detect and monitor potential misstatements and then the audit committee helps by supporting the auditor. These weights mirror the nature of the expected interaction in Figure 1. Using this alternative set of contrast weightings also yields inferentially similar highly significant results.

<sup>&</sup>lt;sup>28</sup> We also gathered exploratory data on managers' expected negotiation strategies. However, this topic is outside the scope of the current paper and is thus the focus of a separate manuscript.

participants were told that they were able to resolve the issue with the audit partner last year.<sup>29</sup> Participants were then asked again to provide judgments in preparation for discussions with their counterpart (the audit partner) regarding their position and that expected of the audit partner (preferred write down and range).

An ANOVA (untabulated) reveals a significant difference for *IPO YEAR* for *OFFER RATE* (F = 633.5, p = .001) and *ULTIMATE W/D* (F = 378.6, p = .001). This is consistent with research suggesting that in an IPO year, managers are motivated by establishing a reputation for quality reporting in anticipation of increased scrutiny from external parties (i.e., auditors, regulators, venture capitalists), and are thus less likely to manage earnings (e.g., Moresfield and Tan 2006; Bedard et al. 2008). The interaction is also significant in both models (F=X.X; p=.001) and contrast tests are once again consistent with our hypothesis (*OFFER RATE* [t = 9.322, p = 0.00]; *ULTIMATE W/D* [t = 12.357, p = 0.00])

## Conclusions

A common and critical part of the CFO's function is to resolve difficult, complex accounting and disclosure issues through auditor-client negotiations. However, there is limited research that investigates the manager's perspective, particularly since the Sarbanes-Oxley Act significantly altered the financial reporting landscape by increasing the roles and responsibilities of both auditors and audit committees. Thus, it is important to examine factors that drive managers' pre-negotiation position, especially in situations such as an IPO where, on the one hand, financial reporting incentives may lead managers to exploit the subjectivity inherent in standards such as accounting estimates, but, on the other hand, reporting reputation incentives may lead managers to accommodate auditors in order to avoid an impasse leading to a qualified audit opinion. We conduct a controlled experiment to examine the impact of two pervasive contextual factors [the strength of the audit committee (stronger or weaker) and the past auditor relationship (cooperative or contentious)] on managers' pre-negotiation planning judgments in both the pre-IPO year. Consistent with expectations, we find that managers propose the largest inventory write-down (i.e., will be least opportunistic) with a contentious past auditor relationship, and with a stronger audit committee, and the write-down is largest when the past auditor negotiation relationship is contentious AND the audit committee is stronger.

• In additional analyses we also find that in the IPO-year managers are willing to take a larger inventory write-down, suggesting less opportunistic behavior. This result is consistent with expectations given the presence of the auditor and audit committees as monitoring mechanisms. Future research can examine whether the presence of other types of monitoring such as regulators serve to further constrain opportunistic behavior by managers engaged in an IPO. Another promising avenue for research is the manner in which auditors behave in negotiations with firms undergoing an IPO, an issue not examined in prior studies.

Our findings contribute to the auditor-client negotiations literature by providing greater insight into managers' judgment processes in a post-SOX environment where greater accountability is expected from managers, auditors, and the audit committees. We provide evidence that, despite the opportunity to do so, managers around the time of an IPO are less likely to exploit the subjectivity inherent in accounting estimates in the presence of strong monitoring mechanisms. Rather, and in contrast to the distributive view of auditors (e.g., Brown-Liburd and Wright 2011), managers appear to often view audit negotiations as integrative or cooperative.

Further, we contribute to the research on IPOs in that we provide evidence that managers act less opportunistically and appear to respond to the demand for higher financial reporting quality when strong monitoring mechanisms (i.e., audit committee and auditors) are present. Finally, our study examines a two-period negotiation over the same issue which is generally indicative of the multi-period nature of negotiations between auditors and management. As a result we are able to begin to investigate how managers' judgment and negotiation strategies evolve over time.

<sup>&</sup>lt;sup>29</sup>To ensure that the past negotiation relationship manipulation was consistent across phase one and two of the experiment; the experimental materials remain silent with respect to the resolution of the inventory issue to minimize the possibility that the outcome in the pre-IPO year may drive participants' judgments in the IPO-year. For example, if we told participants that the outcome was a relatively high write-down of \$400,000, then this would signal that the negotiated outcome was consistent with the auditor's desired outcome and may have confounded the manipulation for those participants in the cooperative past relationship condition.

Our results highlight the importance of auditors and the audit committee who remain firm in their positions as monitoring mechanisms to constrain opportunistic financial reporting by managers. Therefore, from a policy and a regulatory perspective our findings highlight the importance of initiatives advanced in SOX related to communications between auditors and the audit committee and the authority and responsibility of the audit committee. Additionally, our findings provide evidence that in the presence of strong monitoring, IPO underpricing may not be as big a problem as initially presumed. This highlights the importance of auditor skepticism when management's reporting behavior appears questionable. Auditors who remain firm and resist management's pressure to acquiesce make a difference and help to ensure higher financial reporting quality.



Figure 1: Expected Effect of Past Auditor Relationship and Audit Committee Strength on Manager's Pre-Negotiation Judgments

This is a grahical representation of the expected ordinal interactive effect of past auditor relationship (weaker or stronger) and audit committee strength (cooperative or contentious) on the manager's pre-negotiation judgment. A lower pre-negotiation judgment indicates that the manager is being more opportunistic by offering a smaller inventory write-down amount (i.e., resulting in higher net income) while a higher prenegotiation judgment indicates that the manager is being less opportunistic by offering a larger inventory write-down amount (i.e., resulting in lower net income).



Figure 2: Panel A: Effects of Past Auditor Relationship and Audit Committee Strength on the Offer Rate and Ultimate Write-down (Pre-IPO Year).

Stronger ACS

Audit Committee Strength

Weaker ACS



Figure 3: Panel B: Effects of Past Auditor Relationship and Audit Committee Strength on the Offer Rate and Ultimate Write-down (IPO Year)

	Cooperative PAR	Cooperative PAR	Contentious PAR	Contentious PAR	
	&	&	&	&	
	Weaker	Weaker	Weaker	Stronger	-
Variables	ACS	ACS	ACS	ACS	Total
	N = 32	N = 36	N = 32	N = 37	N = 137
Audit Experience	13.1 (3.8)	13.4 (4.6)	12.3 (4.2)	13.7 (4.9)	13.8 (4.4)
Negotiation Experience	6.1 (1.9)	6.4 (1.5)	6.7 (1.7)	7.3 (1.8)	6.7 (1.8)
Position					
CFO	25 (78%)	18 (50%)	20 (63%)	14 (38%)	77 (56%)
Controller	3 (10%)	9 (25%)	8 (25%)	15 (40%)	35 (25%)
Other	4 (12%)	9 (25%)	4 (12%)	8 (22%)	25 (19%)
Certification					
СРА	31 (97%)	35 (97%)	30 (94%)	36 (97%)	132 (96%)
Other	1 (3%)	1 (3%)	2 (6%)	1 (3%)	5 (4%)
Company Type					
Public	26 (81%)	24 (64%)	22 (69%)	18 (49%)	89 (65%)
Private	6 (19%)	12 (36%)	10 (31%)	19 (51%)	48 (35%)
Company has Audit Committee	32 (100%)	36 (100%)	31 (97%)	35 (95%)	134 (98%)
Audit Committee Experience	2.5 (0.72)	2.6 (1.00	2.3 (1.1)	2.6 (0.89)	2.5 (0.94)

#### Table 1: Sample Demographics

Note: This table presents demographic data for each of the experimental conditions and the total sample. The four conditions are weaker audit committee and cooperative past auditor relationship (Weaker ACS & Cooperative PAR), stronger audit committee and cooperative past auditor relationship (Stronger ACS & Cooperative PAR), weaker audit committee and contentious past auditor relationship (Weaker ACS & Contentious PAR) and stronger audit committee and contentious past auditor relationship (Stronger ACS & Contentious PAR).

Table 2: Pre-negotiation Judgments

		Mean	Audit Committee Strength			
	Variable	(SD)	Weaker	Stronger	Total	
		0.00 ₽.4	0.40	0.69	0.55	
		Oller Rate	(0.07)	(0.05)	(0.16)	
	Cooperative	Liltimate W/D	241.2	384.1	316.9	
ip		Ultimate w/D	(32.8)	(21.7)	(76.9)	
ush		Ν	32	36	68	
litor Relation	Contentious	Offer Rate	0.59	0.79^^^	0.70***	
			(0.03)	(0.13)	(0.14)	
		Ultimate W/D	317.4	429.1^^^	377.3***	
			(14.6)	(35.6)	(62.6)	
Auc		Ν	36	37	69	
Past /	Total	Offer Rate	0.49	0.74†††	0.63	
			(0.11)	(0.11)	(0.16)	
		Ultimate W/D	279.3	406.9†††	347.3	
			(45.9)	(37.1)	(76.1)	
		Ν	64	73	137	

# Panel A: Pre-IPO year

## Panel B: IPO-year

		Mean	Audit Committee Strength			
	Variable	(SD)	Weaker	Stronger	Total	
		Offer Date	0.58	0.74	0.67	
		Oner Kate	(0.04)	(0.06)	(0.10)	
	Cooperative	Liltimate W/D	325.50	405.80	368.00	
ip		Olumate W/D	(39.7)	(30.0)	(53.2)	
ush		Ν	32	36	68	
litor Relation	Contentious	Offer Data	0.74	0.84^^^	0.79***	
		Oller Kale	(0.04)	(0.14)	(0.11)	
			397.10	460.3^^^	431.0***	
		Olumate W/D	(23.0)	(44.1)	(47.7)	
Auc		Ν	32	37	69	
Past /	Total	Offer Date	0.65	0.79†††	0.73000	
		Oner Kate	(0.09)	(0.11)	(0.12)	
		Liltimata W/D	361.30	433.4†††	399.7000	
		Offiniate W/D	(48.4)	(46.5)	(59.4)	
		Ν	64	73	137	

Note: These tables present the mean (standard deviation) and number of observations for the pre-IPO year (Panel A) and the IPOyear for the dependent variables (Panel B) by experimental condition and in total. Offer Rate represents the participant's initial prenegotiation position for inventory write-down scaled by the audit team's proposed write-down amount. Ultimate W/D represents the amount (in thousand dollars) that the participant thinks will ultimately be recorded for the inventory write-down. \*\*\* and ††† represent two-tailed significance at the 0.01 level that the row and column total assessment in the cell condition is larger than that in the corresponding, alternative cell condition, respectively.^^^ represents two-tailed significance at the 0.01 level that the mean assessment in the cell condition is larger than that in the three other cell conditions combined. WW represents two-tailed significance at the 0.01 level that the overall total assessment in the IPO-year is larger than that in the pre-IPO year.

Panel A: ANOVA Results						
Variable	Hypothesis	Offer Rate	Ultimate W/D			
Contentious DAP	⊥ U1	1.25	260811.2			
Contentious FAR	+ ΠI	102.5***	174.9***			
Stronger ACS	± H2	2.45	675637.8			
Stronger ACS	$\pm \Pi 2$	201.8***	453.2***			
Contantious DAD * Stronger ACS	+ H3	0.09	9979.3			
Contentious I AK Stronger ACS		7.9***	6.7**			
IDO year	$H_{10}/\pm H_{10}$	0.80	200394.2			
	- 114a / + 1140	633.5***	378.6***			
IPO year * Contentious DAD		0.006	106			
n o year · Contentious i AK		4.6**	0.2			
IPO year * Stronger ACS		0.22	52679.8			
n o year stronger Aes		177.0***	99.5***			
IPO year * Contentious PAR * Stronger ACS		0.03	848.9			
n o year comentious i AR Stronger ACS		1.2	1.6			

#### Table 3: Results of Hypothesis Tests

#### **Panel B: Planned Contrast Results**

	Pre-IPO Year			IPO Year		
H3: Contrast Weights (-1, -1, -1, +3)	t-Statistic	DF	p-Value	t-Statistic	DF	p-Value
Offer Rate	15.125	133	0.000	9.322	133	0.000
Ultimate W/D	21.531	133	0.000	12.357	133	0.000

Note: These tables present the results of mixed model ANOVA (Panel A) and planned contrast results (Panel B). Values in cells represent the mean square and the F-value. \*\*\*, \*\*, and \* represent one-tailed significance at the 0.01, 0.05, 0.10 level, respectively, for H1, H2 and H3, and two-tailed significance, respectively, for H4a and H4b. Offer Rate represents the participant's initial prenegotiation position for inventory write-down scaled by the audit team's proposed write-down amount. Ultimate W/D represents the amount (in thousand dollars) that the participant thinks will ultimately be recorded for the inventory write-down. Variables are described further in Table 1. Contrast coefficients for the respective cell conditions are -1 for the cooperative past auditor relationship/ weaker audit committee and (Cooperative PAR/Weaker ACS), -1 for the cooperative past auditor relationship/ stronger audit committee (Contentious PAR/ Weaker ACS), -1 for the contentious past auditor relationship/weaker audit committee (Contentious PAR/Stronger ACS), -1 for the contentious past auditor relationship/stronger audit committee (Contentious PAR/ Weaker ACS), and +3 for the contentious past auditor relationship/stronger audit committee (Contentious PAR/Stronger ACS).

# Exhibit1

## Manipulation of Independent Variables

#### Audit Committee Strength (labeled as "Corporate Governance" in instrument):

Strong Audit Committee Manipulation (Strong AC):

VCC has a board of directors of nine members, three from management (including the president) and six independent, outside individuals. The audit committee is composed of three individuals, who are all independent. Two of the members have extensive experience in public accounting and the third member is financially literate. You have been very impressed with the audit committee's high level of diligence in representing shareholders' interests. They ask many probing questions and meet very frequently. Finally, the board has granted the audit committee a high level of power in executing its authority and almost always sides with the audit committee on contentious issues involving management.

Weak Audit Committee Manipulation (Weak AC):

VCC has a board of directors of nine members, three from management (including the president) and six independent, outside individuals. The audit committee is composed of three individuals, who are all independent. One of the members is a CPA and has 5 years of experience in public accounting. The

other two members are financially literate. Your experience with the audit committee is that they ask very few questions and meet two times a year. Finally, the board has granted the audit committee limited power in executing its authority and very rarely will the board side with the audit committee on contentious issues involving management.

#### Past Negotiation Relationship:

Contentious Relationship Manipulation (Contentious PAST):

In the past you have had a difficult relationship with the audit partner in resolving difficult issues. The audit partner tends to stick to his position and be intransient, failing to listen to counter arguments. As a result, interactions involving contentious issues have been prolonged and difficult.

Cooperative Relationship Manipulation (Cooperative PAST):

In the past you have had a cooperative relationship with the audit partner in resolving difficult issues. He has been willing to accept reasonable counter arguments. As a result, interactions involving contentious issues have not been prolonged or difficult.

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# The Relationship of Cognitive Effort, Information Acquisition Preferences and Risk to Simulated Auditor-Client Negotiation Outcomes

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**Abstract**: The auditor-client relationship is a legally-mandated relationship whose structure gives rise to potential negotiations. This study examines cognitive factors and risk preference factors that may impact the negotiations. Questionnaire and simulated auditor-client negotiations were used to generate the data, with masters students playing key auditor/client roles. We find that participant cognitive characteristics impacted the negotiator's negotiation success. The implications for auditor-client relationship research and negotiations are presented.

Keywords: auditor, client, negotiation, role playing, cognitive characteristics, risk preferences, risk assessment

# Introduction

The auditor-client relationship is, in the US and much of the world, a legally-mandated relationship in which one party, the auditor, is hired and paid by the auditee (the client) to inform third party stakeholders as to whether the client firm's financial statements are presented in conformity with national financial accounting standards. When the auditor finds that the financial statements are not presented in conformity with national financial financial accounting standards, the auditor will report that to client governance authorities and suggest revisions to the statements. Based on the client's reaction to the auditor's request, a negotiation situation may arise in which the auditor is presumed to act in defense of shareholders and creditors, the stakeholders in the corporation. The client management often, then, may feel forced to defend its numbers. The result is a negotiation between the auditor and client (e.g., Salterio, 2012, Brown and Wright, 2008).

This study examines cognitive factors and risk preference factors that may impact the negotiation both in the setting of each side's negotiation position and on the outcomes of that negotiation using simulated auditor-client negotiations. Brown-Liburd and Wright (2011), based on Neale and Bazerman, 1991, note that auditor-client negotiations take place in three stages (see also Brown and Wright, 2008). These stages are prenegotiation planning in which the party's preferred position is formulated, the actual negotiations in which strategies are employed, and the outcome or final resolution to the negotiation. Our study encompasses all three stages. Research of this nature is rare in the accounting literature due to the difficulty in obtaining the cooperation of practicing auditors and clients (e.g., Salterio, 2012; Brown-Liburd and Wright, 2011). While some research (e.g., Brown-Liburd and Johnstone, 2009) uses a computer to simulate one party to the negotiation, such a method would not be adequate for our purposes since differences between cognitive elements and negotiation outcomes could not be meaningfully assessed. Accordingly, this study uses students in the last semester of a full time professional accounting/MBA and MS in Accounting program to play the roles of auditors and clients. We specifically explore the impact of each individual's information search and acceptance profile, their need to think through problems thoroughly, and their risk assessments on their prenegotiation preferences for a reported client net income, the negotiated net income, and on the strength of their willingness to argue for their prenegotiation income once negotiations with their assigned counterpart begin. Next, we present background information on auditor-client relationships. Subsequently, relevant theory and prior literature that underlies this study is presented. Then the research method and design are presented, followed by the results and a discussion. A concluding section follows.

# Background on Auditor-Client Relationships.

The auditor-client relationship is one of the most difficult relationships in the modern business world. In the United States and much of the world, the auditor is hired, paid, and either retained or fired by the client, with the role of the auditor at his work being to come to a conclusion about the quality of the client's

financial statements and internal control systems. With respect to the financial statements themselves, the auditor's role is to ascertain whether the client's financial statements are materially misstated and, if so, to propose corrections to the financial statements in order to bring them into compliance with the criterion in the US, of being 'fairly stated' in accordance with US Generally Accepted Accounting Principles. Failure to influence the client to accept changes to the financial statements sufficient to make the statements not materially misstated may force the auditor to either issue such-to the client-undesirable audit opinions as a qualified or an adverse opinion, or to just accede to the client wishes and issue an unqualified (i.e., desirable from the client perspective) opinion. In the former case, the auditor stands to lose the client and the revenue stream that the client represents for him, and in the latter case the auditor faces potential litigation costs, regulatory discipline, and/or reputational damage if discovered. From the client side, receiving a qualified or adverse opinion may damage the client's ability to raise capital for future expansion or other use. Receiving such an opinion may also result in a drop in the price of the client's stock as investors flee the client's shares, no longer being certain as to the quality of financial information that research says influences the choice of investing in the client firm. Attempts to avert receiving a qualified or adverse opinion may require the client to make financial statement revisions that show the client corporation as being less profitable than it would otherwise be without the revisions. In the latter case, the price of the company's stock may fall because stock market participants may perceive a diminished future dividend stream or capital growth opportunities from owning the stock. It is also possible that the auditor and client may negotiate away their differences, with each aware that the more each gives up from its ideally preferred situation, the more risk that that entity bears. Developing a negotiating position, then, requires understanding the broader environmental situation facing both one's own side and the counterparty's side, as well as the potential consequences of arriving at a wrong decision. Accordingly, such negotiations require the use of informational resources, such as those that can be gathered through observation of, at least, the business world, the motivation to utilize such resources as are on hand to thoroughly evaluate the presenting situation in order to develop arguments that may lead to a preferred solution, and a willingness to take risks.

# Theory and Hypotheses Development

The relationship between auditors and clients has been the subject of interest for many years due to its crucial use in helping to assure the investing public of the quality of corporate financial statements. In the US and in most of the world, the client hires/pays and fires the auditor. The auditor's responsibility is to help assure that the corporate financial statements are 'fairly presented' in accordance with (in the US) Generally Accepted Accounting Principles and in Europe and elsewhere, International Financial Reporting Standards. Given the inherently contentious nature of the relationship, and the importance for both sides of issues being resolved through negotiation, it becomes important to understand the cognitive determinants that help each side become more successful negotiators. Research of this nature is unusual in the accounting literature. Research on interacting individuals is especially rare (e.g., Salterio, 2012). In an attempt to gain insight into the factors that impact interactions within an auditor-client context, Kleinman, Palmon and Lee (2003) developed and tested a model of elements that had the potential to impact auditor decision making performance. This model held that individual personality and hierarchical level in a group influenced each member's satisfaction with a team-derived solution and impacted the perceptions of team atmosphere. The Kleinman et al. (2003) research also posited that conflict style would impact individual perceptions of the team atmosphere and solution satisfaction as well. The authors found, using structural equation modeling, that their results were generally supportive of their expectations. Kleinman et al. (2003) used MBA and MS in Business and Accounting students to document their model. The use of MBA and MS students in the accounting and business arenas was justified due to the extreme difficulty that researchers have in gaining access to practicing professionals, a difficulty noted as far back as 1974, by Montagna (1974) and voiced also by Salterio (2012).

Fu, Tan and Zhang (2011) looked at the interaction of auditor negotiation experience and client negotiating style. They found that the auditors' negotiation experience and client negotiation style had an impact on the auditor's perception of the final negotiation outcome with respect to the conflict issue, an asset impairment writedown. Auditors with higher levels of negotiation experience were found to perform better when the client had a contentious, but not collaborative, negotiation style. Brown and Wright (2008) noted that existing research examines whether such factors as auditor incentives and experience, client knowledge and negotiation expertise, and such environmental factors as governance, risk and regulation impact auditor-

client negotiation outcomes. As can be seen, the extant research does not examine whether cognitive factors may impact the auditor-client negotiation.

Kleinman et al. (2003) did not address the missing cognitive factors, but instead focused on personality and conflict style variables in their attempt to understand what goes on in groups grappling with auditor/client related issues. Subsequently, Kleinman, Anandarajan, Medinets and Palmon (2010) noted that the earlier work in the field excluded the impact that such judgment variables as expertise, cognitive heuristics and affect might have on auditor decision-making (see also Nelson and Tan, 2005). Kleinman et al.'s (2010) work, though, was solely theoretical. It drew on earlier writings of Mayer (2003) and Libby and Luft (1993), etc., in order to develop a model of cognitive factors that the authors argued could impact auditor performance. In that work, Kleinman et al. cite Romer (2000) as noting that decisions stem from at least two subsystems. One is feeling-based and the other is thought-based. The Kleinman et al. (2003) paper largely draws on influences on behavior that can be considered feeling-based. This effort, which explores the impact of need for cognition (Cacioppo et al. (1996), actively-openminded thinking (Stanovich, Sà and West, 2004) and risk perceptions and preferences (Center for Behavioral and Experimental Economic Science, hereafter CBEES) on decision-making in an auditor-client context, draws on behavior that can be considered to explore the second of the two subsystems identified by Romer (2000), the thought-based decision-making influences. As such, it extends previous theoretical work exploring the impact of cognitive biases on auditor decision making in groups, such as that seen in Kleinman and Palmon (2009).

Kleinman and Palmon (2009) note that the behavioral auditing area has little to say with respect to how individual differences in cognitive ability and fallibility (cognitive heuristics) impact the group decisionmaking process and are in turn impacted by that process. Fundamentally, the authors considered whether group decision making in an auditor-client context is likely to experience process gains (i.e., be improved by having decisions made in that setting) or process losses (i.e., be hindered by having decisions made in that setting.) The authors then presented a theoretical discussion with respect to how the stages of group decision making may interact with each individual's presenting cognitive heuristics and ability, with the outcome ultimately determined at the close of the group process. Kleinman and Palmon (2009) did not empirically study the interaction of cognitive ability and fallibility in the determination of the group decision outcome. The research reported here, though, focuses on two aspects of cognitive characteristics. Specifically, this research focusses on the individual's need for cognition, that is, the person's drive to think through information and solve problems, and the individual's information acquisition and discrimination patterns, more typically known as actively open minded thinking. Actively openminded thinking examines the individual's openmindedness to new information, including information that may contradict or challenge what he/she already believes. This paper, therefore, draws on the commonplace that individuals both need information to think about, and the willingness to think hard, in order to come to a better decision. LeGault (2006, p. 41) citing Ruggiero (2003), states that

Critical thinkers acknowledge what they don't know whereas uncritical thinkers pretend they know more than they do; critical thinkers regard problems and controversial issues as exciting challenges, whereas uncritical thinkers regard problems and controversial issues as exciting challenges, whereas uncritical thinkers regard problems and controversies as nuisances and threats to their egos; critical thinkers base judgments on evidence rather than personal preference, whereas noncritical thinkers base judgments on first impressions and gut reactions...

What ties critical thinking, need for cognition and actively openminded thinking together? As LeGault (2003) continues (p. 41-42), "Broad wide ranging knowledge is also important. It endows us with a discerning intellectual framework in which to evaluate incoming or new information....[This can] "pave the way to lateral thinking and improved problem-solving ability, even though the specific knowledge may not be directly related to a given problem."

Individuals decisions are also impacted by their perceptions of risks and rewards that attend different decisions, and presumably based on these evaluations, may choose different decisions. Evaluation of risk and reward depends on the information available to the decision maker. Given this, openness to new information is useful in shaping risk assessments unless that new information is received but discounted, whether due to the receiver's authoritarianism or dogmatism, or simple belief that he/she knows the right answer already and is simply seeking further confirming evidence. The actively-open-minded variable as developed by Stanovich, Sa and West (2004) measures willingness to receive new information and tendencies to discount that information due to the person's authoritarian or dogmatic tendencies. Rigidity

of stance in the face of new information, whether received from the general environment or perceived during one's interactions with a negotiating partner, may lead to dysfunctional negotiating behaviors and ultimately a failed negotiation, or a poor outcome arising from the negotiation.

Accordingly, the variable actively open minded thinking, hereafter, AOT, is examined here because it purports to measure openness to new information as well as a levels of dogmatism and authoritarianism. We argue that individuals who measure more highly on the actively open minded thinking construct will seek and absorb more information, as well as take a more flexible approach in both setting their net income targets in the game—further described below—and in conducting the negotiation with their counterpart. Flexibility in this regard does not necessarily mean giving way to the other person's arguments, but rather being willing to consider the other person's arguments and develop an appropriate response given the background information each participant was provided prior to the negotiation's start. Brown and Wright (2008), in describing the principled negotiation approach, note that "This approach highlights the importance of explicit consideration of the interests, options, alternatives, and goals of both the negotiators and their counterpart, since failure to understand their interests and position can result in suboptimal outcomes (Galinsky and Moskowitz 2000; Trotman et al. 2005)." We argue that willingness to collect information on, and be flexible in considering, a wide variety of factors may impact the negotiations explored here as well.

### Accordingly, we hypothesize that:

H1: Individuals who score more highly on the Actively OpenMinded Thinking Scale will be more likely to

- a) State that they will work aggressively to achieve their preferred outcome once the negotiation begins (i.e., AOT will be positively related to PRESTRONG), and
- b) Achieve their negotiating goals in the simulated auditor-client negotiation session (i.e., AOT will be positively related to STD\_ADJ\_DIF\_INCOME).

The variable need for cognition is examined here because it measures the individual's willingness and drive to expend mental energy in understanding the presenting situation and developing solutions to presenting problems. Need for cognition has been defined as "an individual difference in the motivation to engage in and enjoy thinking and cognitively challenging tasks (Petty, Brinol, Loersch, & McCaslin, 2009: cited in Hill, Foster, Elliott, Shelton, McCain and Gouvier, 2013). The ability of those higher in need for cognition to perform better is enhanced because, as Hill et al. (2013) found, need for cognition is significantly and positively related to some aspects of intelligence, including general intelligence, fluid intelligence, and crystallized intelligence. It has also been found related to greater information searching, greater information elaboration, stronger behavioral intentions, and greater attributional complexity, but less anxiety in information processing tasks and less subjection to hindsight and primacy biases (Verplanken, Hazenberg, and Palenewen, 1992). The literature suggests, therefore, that individuals with greater motivation and drive to think through problems are also less likely to fall subject to cognitive biases. Further, they are also likely to exhibit greater fluid intelligence. It should be noted that individuals with greater fluid intelligence possess higher ability to solve novel problems using deductive or inductive reasoning without regard to acquired knowledge (Hill, 2013, p. 22). Greater crystallized intelligence, on the other hand, refers to the semantic knowledge the individual has gathered over his or her lifetime. The combination of greater intelligence, greater motivation to thoroughly understand a presenting problem, greater information search and a reduced likelihood of falling prey to certain common cognitive heuristic errors suggests that these individuals may be superior negotiators.

H2: Individuals who score more highly on the Need for Cognition Scale will be more likely to

- a) State that they will work aggressively to achieve their preferred outcome once the negotiation begins (i.e, NCOG will be positively related to PRE\_STRONG), and
- b) Achieve their negotiating goals in the simulated auditor-client negotiation session (i.e., NCOG will be positively related to STD\_ADJ\_DIF\_INCOME)

We use as our third key variable a set of risk-related measures drawn from the CBEES instrument. All negotiations are risky and the participants in this study were assigned to roles in which failed negotiations could be a problem. As was detailed in the case, to be discussed further below, the auditor faced risks of

either losing the client by taking a tough stance or faced the risk of potential legal liability should he/she give in to the client. The client faced the risk of losing out on a profitable merger opportunity or losing the business and bonuses. The impact of the perception of risk, the perceived benefits of taking the risk, and the indicated willingness to take the risk, therefore, are useful in helping us understand the interplay of risk and reward anticipations in a simulated auditor-client negotiation setting. Since it is impossible to measure the impact of an individual's risk aversions to given levels of potential reward, we offer only a null hypothesis.

H3: Measures of individual risk assessment and perceived rewards will not be related to the outcomes of the auditor-client negotiation, specifically

- a) BENTRISK will not be related to STD\_ADJ\_DIF\_INCOME, and
- b) BENTRISK will not be related to PRE\_STRONG.

It is logically clear that individuals who are more willing to argue strongly for their position should be more likely to achieve their goal, other things equal. Thus, we hypothesize that:

H4: The stronger an individual's premeeting belief that he/she will argue strongly for his/her position, the more likely he/she is to achieve his/her desired net income goal (i.e., PRE\_STRONG will be positively related to STD\_ADJ\_DIF\_INCOME).

It could be argued, given the negotiation design of this study, that if each negotiating pair has equally high levels of actively-open-minded thinking, need for cognition, or a stated and presumably felt belief that he/she will argue strongly for the his/her preferred premeeting net income, then we are unlikely to find an effect of the equally matched variables. We argue that that may very well be true, but that that makes our test of the relevant hypotheses a very conservative feature of our design.

Finally, we hypothesize that there will be a direct link between the degree to which a person achieves his/her premeeting negotiation result and our measure of the individual's happiness with the result. Accordingly,

H5: The greater the correspondence between the individual's premeeting net income goal and the achieved (post meeting) net income goal, the happier the individual will report being with the outcome of the meeting (i.e., STD\_ADJ\_DIF\_INCOME will be positively related to MEETING\_HAPPY.)

Next we present our research method and design.

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# Combining Quantity Competition with Budget Restriction in Duopolistic Telecom Procurements

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Abstract: There have been many debates over the past years about procurement auctions and related mechanism designs. Very often Telecom procurements involve more than one supplier for the acquisition of the required products and services. There is a limited number of suppliers who are able to deliver products that comply with the specifications issued by the service provider and compete in an oligopolistic environment. Much of the literature focuses on evaluating different forms of procurement mechanisms such as price-based and buyer-determined auctions from a comparative perspective. Our paper targets competition in quantities under the assumption of budget restriction. The buyer has already performed a pre selection of preferred suppliers and selected the market leader and one follower. The price depends on the available product quantities delivered by the selected suppliers. In this document we propose a model combining Cournot/Stackelberg competition and Budget Restriction, with one single leader and one single follower. The theoretical framework relies on Cournot and stackelberg competition. The leader and the follower compete on quantity, simultaneously (a la Cournot) and Sequentialy (a la Stackelberg). The price is determined by an inverse demand function known to both sellers and to the buyer. We assume that the sellers have different marginal costs and that the leader has a lower marginal cost than the follower. The empirical part of the article shows the results of computerized procurement auctions with one buyer and two suppliers. Finally, the article shows that by combining Cournot/Stackelberg models with Budget Restriction the buyer can acquire higher quantity at lower budget comparing to Cournot and Stackelberg competition.

Keywords: Telecom, Procurement, Oligopoly, Cournot, Stackelberg, Budget Restriction

# Introduction

In Telecommunication procurement auctions, bidders provide turnkey solutions based on products and services in compliance with requirement specification issued by the auctioneer (the buyer). Procurement auctions are a powerful mean by which buyers can stimulate competition and increase the value.

Very often the buyer decides to have more than one supplier to reduce dependency on unique supplier. This also has an impact on the quality and the buyer business case as competition may reduce the cost of procured products. The products shall be substitutable and at any time the buyer can increase/decrease the quantity from one supplier to the advantage/disadvantage of the other supplier. Each supplier controls his own production.

We assume in our research that the buyer has selected two suppliers to compete in a duopoly. The suppliers shall compete on quantity under budget restriction and each supplier is capable of satisfying the complete demand of the buyer.

The procurement mechanism is built up in several stages (rounds). The suppliers are rational and try to maximize their profits and in the same time comply with the budget restriction stipulated by the buyer. The unit price of the product is determined by an inverse market demand and the suppliers have different marginal costs, each supplier knows his own marginal cost only.

# **Research Question**

This section highlights our question of research pertaining to quantity competition under budget restriction. Much of the literature on procurement auctions has strong ties with mechanism design and comparison between price competition and quantity competition. The central goal of this research is to provide an indepth assessment of quantity competition by incorporating budget restriction into conventional models of Cournot and Stackelberg. Our attention is directed toward understanding interactions between the buyer and the bidders and analyzing the impact of budget restriction information on bidders' quantities and social welfare. Existing contributions about this topic can be found in Edgeworth (1881), Murphy et al (1982), Kreps & Scheinkman (1983), Millner (1989), Hazledine (2006) and Kutlu (2009).

Given the actual state of literature, our research question can be stated as follows:

What is the optimal design for procurement of quantities from a leader and a follower with the objective of maximizing quantities and welfare under budget restriction?

# Literature Review

### Literature on Optimal Mechanism Design

Literature about optimal multi-dimensional auctions includes (Avery & Henderschott, 2000), (Armstrong, 2000), and (Malakhov & Vohra, 2009). Studies on optimal auction with externalities can be found in (Jehiel et al., 1999). According to (Laffont & Tirole, 1987) and (Che, 1993), optimal auction mechanism is achieved when private information is one-dimensional. The quality is strongly correlated with the cost (marginal cost quality). Asker and Cantillon (2004) and Chen-Ritzo et al. (2005) state that in a multi-dimensional auction, non-monetary attributes are endogenously determined by the bidders and that in the case of a price-based auction, the bidders will provide the minimum on the non-monetary attributes as they are not rewarded by the buyer.

### Literature on Auctions and Incumbency

Demski et al. (1987), Riordan and Sappington (1989), Cabral and Greenstein (1990), Bajari et al. (2007) state that incumbents entrenchment is behind awarding contracts to them even with high prices.

Greenstein (1993) found that incumbents are more likely to win supply contracts in federal computer procurement auctions than new entrants.

De Silva et al. (2003) made a comparison study between incumbent and new entrants bidding behaviors in the government road construction auctions. The outcome of the study was that new entrants are bidding more aggressively than incumbents.

Elmaghraby and Oh (2006) show that in a learning-by-doing process, incumbents are in a strong position to win procurement auctions.

Zhong and Wu (2006) show through an experiment that Incumbents have three times higher chance than other bidders to win manufacturing contracts.

Tuna, Wu and Zhong (2010) provided empirical study about procurement auctions where quality is explicitly announced as an attribute by the buyer. In the same paper, they provided recommendations on how to improve industrial buyer's efficiency in procurement auctions.

Tuna, Wu and Zhong (2010) also mentioned the non-binding aspects of some procurement auctions where the buyers keep the right not to commit to the auction's result when awarding the contract. As an example, they studied a non-binding auction mechanism used by General Electric.

Tuna, Wu and Zhong (2010) tested the incumbent bias hypothesis in procurement auctions. They show that when quality is taken into consideration, the incumbent bias may disappear. They also show that in case of a non-binding auction, incumbents are usually not favored over non-incumbents.

### Literature on Information, Reputation and Games

In (Kreps et al., 1982), (Milgrom & Roberts, 1982) players in the context of finitely repeated games can increase their payoffs by creating a reputation for cooperating or fighting in case of uncertainty about the type of players.

In a similar way, Klein and Leffler (1981) and Shapiro (1983) show that companies can create a reputation for supplying high-quality goods and charge high prices.

Private information issues during the bidding process in the context of price-based auctions have been investigated by Manelli and Vincent (1995) and Rezende (2004). Manelli and Vincent (1995) focused on the

endogenous quality information among bidders while Rezende (2004) studied buyers' private information about their preferences.

In (Snir & Hitt, 2003), buyers may use auctions to collect information on prices and re negotiate with their incumbent suppliers.

Rezende (2004) proposed a quality adjustment mechanism offered by the buyer to his preferred suppliers who will then compete on the price regardless of the quality.

In (Rothkopf & Whinston, 2007), reputation in procurement is an attractive field for future research.

Haruvy and Katok (2008) studied the impact of information transparency on sealed-bid and dynamic buyerdetermined auctions assuming that bidders are aware of the buyer's valuation of their own non-monetary attributes. Haruvy and Katok (2008) found that sealed-bids offer higher value to the buyer when information about non-monetary attributes is exogenous.

A calculation of equilibrium predictions for sealed-bid buyer-determined auction and dynamic price-based auction with bidding credit was provided by Shachat and Swarthout (2010). Their calculation shows that buyer-determined auction is socially efficient while price-based auction provides higher value to the buyer. Brosig and Heinrich (2011) added that the actual behavior deviates from (Shachat & Swarthout, 2010) predictions since the experiment shows that sealed-bid buyer-determined auction gives higher value to both buyers and bidders due to non-optimal bidding credits and non-equilibrium bidding situation.

Brosig and Heinrich (2011) stated that procurement auctions become multi-dimensional as soon as bidders' reputation is involved in the bidding process. They refer to previous empirical studies comparing bidders' behavior in price-based and buyer-determined procurement auctions involving price, quality and bidders' reputation. In (Brosig & Heinrich, 2011), the focus was put on studying moral hazard, non-contractibility aspects of quality and the role of reputation as an incentive for bidders to provide high quality.

### Literature on Sequential Mechanisms

Sequential auctions with bargaining have been analyzed by Bulow and Klemperer (1996), Elyakime et al. (1997), Wang (2000), Engelbrecht-Wiggansand Katok (2006), Huh and Park (2009) and Olivares et al. (2010). There are also an increasing number of researches on combined bargaining-auction with take-it-or-leave-it offer from the buyer before the auction takes place. Moreover, most of the auction-bargaining mechanisms consist of an auction in the first phase followed by bargaining.

Bulow and Klemperer (1996) proposed a sequential auction-bargaining model under incomplete information, where the first phase is an open-bid second price auction and the second phase consists of a take-it-or-leave-it price decided by the buyer. Their model shows that there is a dilemma for the buyer between selecting one winner in the first phase and having an additional seller in the bargaining phase which might increase the buyer's expected profit.

Elyakime et al. (1997) proposed a single-unit sequential auction model where the first phase consists of a first price sealed-bid auction and a secret sealed-bid reserve price submitted by the buyer. The bargaining takes place in the second phase between the buyer and his preferred bidders if none of them meets the proposed reserve price which becomes public information. Based on an equilibrium bidding strategy, this model shows that both the buyer and the bidders have a preference for a sequential bargaining auction over a single phase auction.

Wang (2000) presented a model where the buyer does not submit any bid about his private reserve price. The buyer selects the bidder with the most attractive bid and decides between to accept the bid as such or enter a bargaining phase where the winner's cost becomes known and the buyer reserve price remains private. The model shows a typical dynamic game with information asymmetry.

Mathews (2004), Budish and Takeyama (2001), Hidvegi et al. (2006), Caldentey and Vulcano (2007), and Gallien and Gupta (2007) state that combined bargaining-auction mechanism can increase the buyer's profit when the bidders show impatience.

Engelbrecht-Wiggans and Katok (2006) studied a combined bargaining-auction model where bargaining starts prior to the auction. In the bargaining phase, the buyer will select his preferred suppliers and ask them

to commit to a price that is going to be determined in the second phase of the auction. Such sellers are then excluded from the second phase of the auction which will be a second price auction type.

Salmon and Wilson (2008) proposed a sequential auction-bargaining model where the buyer procures two identical units. The first one is acquired through an auction in the first phase while the second unit is procured through a take-it-or-leave-it offer from the bidder with the second highest bid in the first phase. Their experiments show such mechanism gives higher profit to the buyer than in the one where both first phase and second phase are auctions.

Huh and Park (2009) proposed bargaining model with complete information which considers relative bargaining power of the buyer and the seller. Huh and Park (2009) found that (Bulow & Klemperer, 1996) results might be biased if the bargaining model used in the second phase is not a "take-it-or-leave-it" type.

Olivares et al. (2010) states that sequential auctions can stimulate competition and provide advantage to the buyer under the assumption of employing certain market share restrictions.

# Literature on Optimal Mechanism Design

Literature about optimal multi-dimensional auctions includes (Avery & Henderschott, 2000), (Armstrong, 2000), and (Malakhov & Vohra, 2009). Studies on optimal auction with externalities can be found in (Jehiel et al., 1999). According to (Laffont & Tirole, 1987) and (Che, 1993), optimal auction mechanism is achieved when private information is one-dimensional. The quality is strongly correlated with the cost (marginal cost quality). Asker and Cantillon (2004) and Chen-Ritzo et al. (2005) state that in a multi-dimensional auction, non-monetary attributes are endogenously determined by the bidders and that in the case of a price-based auction, the bidders will provide the minimum on the non-monetary attributes as they are not rewarded by the buyer.

### Literature on Collusion in Auctions

Literature on collusion in the context of auctions can be found in Robinson (1985), Graham and Marshall (1987) and Klemperer (1999). Collusive behavior in the context of strategic demand reduction can be found in Brusco and Lopomo (2002) and Ausubel and Cramton (2002). Jap (2002) found that industrial reverse auctions are non-binding since they don't determine a winner. Jap (2003) and Jap (2007) stated that sealed-bid auctions have less negative effect on buyer-seller relationships than dynamic non-binding auctions.

Katok and Wambach (2008) investigated the dynamic non-binding auctions with regard to collusion and found that there are two main reasons that motivate bidders to collude. The first one is the dynamic aspect of the bidding procedure that enables each bidder to react on others' bids and the second one is the lack of information about the buyer's valuation of the non-monetary attributes.

### Literature on Price and Quantity Competition

The foundations for analyzing price and quantity competition models in oligopolies were first established by Bertrand, Cournot and Stackelberg. Cournot (1838) studied interactions, collusion between bidders and provided a comparison between perfect competition and his solution concept. Cournot model is based on quantity competition where the sellers' profits are determined by the total production of all sellers. Each of the sellers can only control his own production. A price competition model was proposed by Bertrand (1883). In such model, the price is controlled by the sellers while the quantities are decided by the buyer. Each seller is supposed to deliver the entire quantity requested by the buyer. In Edgeworth (1881) price competition model, the total quantity requested by the buyer is split between the sellers with respect to a given splitting rule.

Kreps & Scheinkman (1983) proposed a seminal paper where Bertand and Cournot competitions were jointly studied. Stackelberg (1934) analyzed the situation where the duopoly is characterized by the existence of a leader and a follower. He shows that the leader's profit is greater than the profit of the follower at the equilibrium and also greater than Cournot duopolists' profits.

Single-period quantity competition model using mathematical programming was analyzed by Murphy et al (1982). Single-product, multi-period combined pricing and inventory control was studied by Zabel (1972), Thomas (1974), Dada and Petruzzi (1999) and Federgruen and Heching (1997). The two-stage model proposed by Eliashberg and Jeuland (1986) considers a monopoly situation that turns into a duopoly with

the entry of a second seller. Their model analyzes the sellers' dynamic pricing behavior in situations where the incumbent anticipates or does not anticipate the entry of the second seller. Bertsimas and Perakis (2001) propose a method of linking dynamic price setting of a product to joint demand learning between competitors in a duopolistic environment.

Dockner and Jørgensen (1988) studies optimal pricing strategies for oligopolistic markets from a marketing perspective. Bernstein and Federgruen (1999) investigated inventory models for supply chain; their stochastic general equilibrium model involves inventory control, prices and service levels with linear demand.

Robinson (1933), Schmalensee (1981) and Varian (1985) examines the impact of price discrimination on social welfare in monopolies. Formby and Millner (1989) studied the relationship between competition and price discrimination. They made a comparison between Cournot competition and price discrimination from social welfare perspective. Hazledine (2006) investigates quantity competition with different aspects of price discrimination. One of his findings is that the level of price discrimination does not impact the average price in the market. He also shows that in his model, the quantity produced in the market differs from the standard Cournot model. Kutlu (2009) finds after incorporating price discrimination in the Stackelberg model that the leader does not use price discrimination.

### Contribution

Substantial number of articles about procurement through price and quantity competition can be found in the literature. However, the number of papers considering budget restriction in procurement auctions is rather limited. Our paper complements the literature by introducing a procurement mechanism which incorporates budget restriction into conventional Cournot and Stackelberg procurements. We show in our contribution that under budget restriction sequential bidding with a leader and a follower (a la Stackelberg) provides more satisfying results than concurrent bidding (a la Cournot) with regard to total quantity and welfare.

# **Model Description**

We first run Cournot competition in a learning phase until the equilibrium is reached. This will reveal the suppliers' costs to the buyer. The buyer will then run a Stackelberg competition to find out the new equilibrium and confirm information about the supplier' costs.

Once the bidders' costs are known to the buyer, the later can determine the theoretical relationship between the budget and the bidders' quantities.

Given a budget range or a budget limit established by the buyer and by combining suppliers' reaction functions and budget function, the buyer will be able to determine the optimal total quantity expected from the suppliers. He can also determine what quantity to be requested from the leader to reach the total optimal quantity with the given budget. Such quantity is a solution to the following:

$$B = \frac{-b}{4}q_1^2 + \frac{c_2}{2}q_1 + \frac{a^2 - c_2^2}{4b}$$

#### The Cournot Competition

In the case of simultaneous move, the leader and the follower will try to maximize their outcomes simultaneously. We define  $\prod_{q_1} 1$  as the profit for the leader and  $\prod_{q_2} 2^2$  as the profit for the follower.

The profit maximization is calculated using FOC as follows:

$$\frac{\partial \prod_{q_1}^{1}}{\partial q_1} = a - 2bq_1 - bq_2 - c_1 = 0 \qquad \text{and} \qquad \frac{\partial \prod_{q_2}^{2}}{\partial q_2} = a - 2bq_2 - bq_1 - c_2 = 0$$

This leads to the following reaction functions for the leader and the follower

$$q_1 = \frac{a - c_1 - bq_2}{2b} = \frac{a - c_1}{2b} - \frac{q_2}{2}$$
 and  $q_2 = \frac{a - c_2 - bq_1}{2b} = \frac{a - c_2}{2b} - \frac{q_1}{2}$ 

The reaction functions are drawn as follows:



Fig. 1. Reaction functions for the leader and the follower and Cournot Equilibrium

At COURNOT equilibrium, we obtain quantities  $q_{1c}$  and  $q_{2c}$  as follows:

$$q_{1c} = \frac{a - 2c_1 + c_2}{3b}$$
 and  $q_{2c} = \frac{a - 2c_2 + c_1}{3b}$ 

The marginal costs  $c_1$  and  $c_2$  can be determined by solving:

$$-2c_1 + c_2 = 3bq_{1c} - a$$
and
(1)

 $c_1 - 2c_2 = 3bq_{2c} - a$ 

Solving (1), we can easily see that

$$c_1 = a - 2bq_{1c} - bq_{2c}$$
 And  $c_2 = a - bq_{1c} - 2bq_{2c}$ 

### The Stackelberg Competition

In Phase-1, we use a pure Stackelberg competition which consists of 2 periods. In the first period, the leader chooses its quantity. This decision is irreversible and cannot be changed in the second period. The leader might emerge in a market because of historical precedence, size, reputation, innovation, information, and so forth. In the second period, the follower chooses its quantity after observing the quantity chosen by the leader. The quantity chosen by the follower must, therefore, be along with its reaction function.

Let's assume a linear demand:

$$P = a - b(q_1 + q_2)$$
 with marginal costs  $MC_1 = c_1$  for the leader and  $MC_2 = c_2$  for the follower.

In sequential games we first solve the problem in the second period and afterwards the problem in the first period. In the second period, the follower chooses  $q_2$  given what the leader has chosen in the 1st period  $(q_1)$ . His profit function is given as follows:

$$\prod_{q_2}^2 = (P(q_1 + q_2) - c_2)q_2 = (a - b(q_1 + q_2) - c_2)q_2$$

In the first period, the leader chooses  $q_1$  knowing that the follower will react to it in the second period according to its reaction function  $q_2 = R_2(q_1)$ . His profit function is given as follows:

$$\prod_{q_1}^{1} = (P(q_1 + q_2) - c_1)q_1 = (a - b(q_1 + R_2(q_1)) - c_1)q$$

We can summarize this situation by saying that both the leader and the follower want to maximize their profits, as indicated by the following First Order Conditions:

$$\frac{\partial \prod_{q_1}^{1}}{\partial q_1} = a - 2bq_1 - bR_2(q_1) - bq_1R'_2(q_1) - c_1 \qquad \text{and} \qquad \frac{\partial \prod_{q_2}^{2}}{\partial q_2} = a - 2bq_2 - bq_1 - c_2$$

Where 
$$q_2 = R_2(q_1) = \frac{a - bq_1 - c_2}{2b}$$
 (1)

The buyer will run a pure Stackelberg scenario in the first phase to determine the marginal costs of both sellers. At Stackelberg Equilibrium, the quantities are as follows:

$$q_{1s} = \frac{a + c_2 - 2c_1}{2b}$$
 and  $q_{2s} = \frac{a + 2c_1 - 3c_2}{4b}$  (2)

Solving (2), the marginal costs  $c_1$  and  $c_2$  are as follows:

$$c_1 = a - \frac{3b}{2}q_{1s} - bq_{2s}$$
 and  $c_2 = a - bq_{1s} - 2bq_{2s}$ 

### **Budget considerations**

The total budget for the buyer is expressed as follows:

$$B = [a - b(q_1 + q_2)](q_1 + q_2)$$
(3)

Combining (1) with (3), we obtain:

$$B = \frac{-b}{4}q_1^2 + \frac{c_2}{2}q_1 + \frac{a^2 - c_2^2}{4b}$$
(4)

Solving B = 0, the solutions are:

$$q_{11} = \frac{c_2 + a}{b}$$
 And  $q_{12} = \frac{c_2 - a}{b}$ 

The maximum budget is obtained using FOC as follows:



Fig. 2. Total budget and quantity from the follower  $(q_2)$  as function of quantity from the leader  $(q_1)$ 

Solving (4) for a given budget  $B = B_0$ , we obtain solutions for  $q_1$  as follows:

$$q_{11}(B_0) = \frac{c_2 - \sqrt{a^2 - 4bB_0}}{b}$$
 and  $q_{12}(B_0) = \frac{c_2 + \sqrt{a^2 - 4bB_0}}{b}$ 

For the given budget  $B_0$ , the buyer shall request quantity  $q_1$  from the leader as follows:

$$q_1 = q_{12}(B_0) = \frac{c^2 + \sqrt{a^2 - 4bB_0}}{b}$$
(5)

With 
$$Q = q_1 + q_2$$
 and  $q_2 = \frac{a - bq_1 - c_2}{2b}$ 

(4) Becomes:

$$B = -bQ^2 + aQ$$

Using FOC, we obtain the maximum budget  $B_{\text{max}} = \frac{a^2}{4b}$  for  $Q = \frac{a}{2b}$ 

And by solving B = 0 the solutions are Q = 0 and  $Q = \frac{a}{b}$ 

The total quantity Q can also be expressed as function of q1 as follows:

$$Q = q_1 + \frac{a - bq_1 - c_2}{2b} = \frac{a + bq_1 - c_2}{2b}$$
 or  $q_1 = \frac{2bQ - a + c_2}{b}$ 



Fig. 3. Budget as function of the total quantity (q1+q2)

### Consumer Surplus (CS) and Welfare (W)

The consumer surplus can be expressed as follows:

$$CS = \frac{(a-p)Q}{2} = \frac{b}{2}Q^2 \qquad \text{where} \qquad Q = q_1 + q_2$$

The Welfare can be expressed as follows:

W = B + CS Where B is the Budget and CS is Consumer Surplus



Fig. 4. Welfare W, Consumer Surplus CS and Budget B as function of the total quantity (q1+q2)

After solving (4), we obtain 2 solutions  $q_{11}$  and  $q_{12}$  with  $q_{11} < q_{12}$ , as stated in (5),  $q_{12}$  is as follows:

$$q_{12}(B_0) = \frac{c2 + \sqrt{a2 - 4bB_0}}{b}$$

The buyer will request a quantity at greater or equal to  $q_{12}(B_0)$  from the leader. When the leader's quantity is known, the follower will use his reaction function to give his final quantity.

The buyer will then acquire a higher total quantity at a lower budget compared to what he would have at Cournot and Stackelberg equilibriums.

# **Empirical Setup**

The experiment consists of computerized simulations involving experienced and non-experienced bidders from Riyadh in Saudi Arabia and Paris. The experiments were conducted in seven (7) rounds as described in the model; 4 rounds as concurrent bidding (3 open budget and 1 restricted budget with a budget of 32) and 3 rounds as sequential bidding (1 open budget and 2 restricted budget with a budget of 31 and 28). We run 8 simulations in each round which gives a total of 56 simulations.

The simulation tool is based on excel and consists of 2 modules; one for the bidder and on for the buyer. Fig.5 shows the bidder's screen.

It is important to mention that bidders' were given incentives to participate in the experiment. The bidders are asked to provide their quantities simultaneously. Each of the bidders shall guess his competitor's quantity and use the response table (reaction function) to determine his best response to maximize his profit. The winner is the one who succeeds to maximize the sum of the profits over the 7 rounds of the bidding.

The profile of the bidders is shown as follows:

Total	16 (100 %)	8 (50%)
Services	2 (10 %)	1
Finance	2 (10 %)	2
Food Industry	2 (20 %)	1
Information Technology	4 (20 %)	2
Telecommunications	6 (20 %)	2
Activity sector	Number of bidders	Number of experienced bidders

Table 14. Bidders by Activity Sector

The simulations are based on Cournot and Stackelberg competition. The price is given by an inverse demand function; the marginal costs  $c_1$  and  $c_2$  are treated as private information. The input parameters can be depicted as follows:

$$P = 12 - q$$
  $c_1 = 1$   $c_2 = 2$ 

Each bidder (Firm) knows his cost but ignores the other bidder's cost.

The computed Cournot quantities and budget  $q_{1c}$ ,  $q_{2c}$ ,  $B_c$  and Stackelberg quantities and budget  $q_{1s}$ ,  $q_{2s}$ ,  $B_s$  are shown as follows:

$$q_{1c} = 4$$
  $q_{2c} = 3$   $B_c = 35$ 

 $q_{1s} = 6 \qquad \qquad q_{2s} = 2 \qquad \qquad B_s = 32$ 

For the budget restricted simulations, the budget is randomly drawn between the minimum budget  $B_{\min} = 20$  corresponding to  $Q = (q_1 + q_2) = 10$  and the maximum budget  $B_{\max} = 36$  corresponding to  $Q = (q_1 + q_2) = 6$ . The retained values for the budget limits are as follows:

- 32 for concurrent bidding (a la Cournot)
- 31 and 28 for sequential bidding (a la Stackelberg)

Tables 2a and 2b are respectively reaction functions of Firm-1 to Firm-2 and vice versa. The tables also give the price, the budget and the profit for each firm. Each firm reports its quantity by email to the buyer.

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10		I prop	pose quantity	q1: 5.25		02	$a_1 = f(a_2)$	Price	Profit-1	Budget						
12			My profi	t is: 10.56		0.5	5.25	6.3	27.5625	35.94						
13						1.0	5	6.0	25	36.00						
14		The requ	ested budge	t is: 32.94		1.5	4.75	5.8	22.5625	35.94						
15						2.0	4.5	5.5	20.25	35.75						
16						2.5	4.25	5.5	18.0025	35.44						
18						3.5	3.75	4.8	14.0625	34.44						
19						4.0	3.5	4.5	12.25	33.75						
20			Res	sult: 3.25		4.5	3.25	4.3	10.5625	32.94						
21						5.0	3	4.0	9	32.00						
22						5.5	2.75	3.8	7.5625	30.94						
25						6.5	2.25	3.3	5 0625	29.75						
25						7.0	2.23	3.0	4	27.00						
26						7.5	1.75	2.8	3.0625	25.44						
27						8.0	1.5	2.5	2.25	23.75						
28						8.5	1.25	2.3	1.5625	21.94						
29						9.0	1	2.0	1	20.00						
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Fig. 5. Firm-1 Bidding Form

Table-2a Firm-1 Reaction Function to Firm-2

Firm-1 response to Firm-2  $q_1=5.5-(0.5*q_2)$ 

<b>q</b> <sub>2</sub>	$q_1 = f(q_2)$	Price	Profit-1	Budget
0.5	5.25	6.3	27.5625	35.94
1.0	5	6.0	25	36.00
1.5	4.75	5.8	22.5625	35.94
2.0	4.5	5.5	20.25	35.75
2.5	4.25	5.3	18.0625	35.44
3.0	4	5.0	16	35.00
3.5	3.75	4.8	14.0625	34.44
4.0	3.5	4.5	12.25	33.75
4.5	3.25	4.3	10.5625	32.94
5.0	3	4.0	9	32.00
5.5	2.75	3.8	7.5625	30.94
6.0	2.5	3.5	6.25	29.75
6.5	2.25	3.3	5.0625	28.44
7.0	2	3.0	4	27.00
7.5	1.75	2.8	3.0625	25.44
8.0	1.5	2.5	2.25	23.75
8.5	1.25	2.3	1.5625	21.94
9.0	1	2.0	1	20.00

Table-2b Firm-2 Reaction Function to Firm-1

Firm-2 response to Firm-1  $q_2=5-(0.5*q_1)$ 

q <sub>1</sub>	$q_2 = f(q_1)$	Price	Profit-2	Budget
0.5	4.75	6.8	22.5625	35.44
1.0	4.5	6.5	20.25	35.75
1.5	4.25	6.3	18.0625	35.94
2.0	4	6.0	16	36.00
2.5	3.75	5.8	14.0625	35.94
3.0	3.5	5.5	12.25	35.75
3.5	3.25	5.3	10.5625	35.44
4.0	3	5.0	9	35.00
4.5	2.75	4.8	7.5625	34.44
5.0	2.5	4.5	6.25	33.75
5.5	2.25	4.3	5.0625	32.94
6.0	2	4.0	4	32.00
6.5	1.75	3.8	3.0625	30.94
7.0	1.5	3.5	2.25	29.75
7.5	1.25	3.3	1.5625	28.44
8.0	1	3.0	1	27.00
8.5	0.75	2.8	0.5625	25.44
9.0	0.5	2.5	0.25	23.75

# **Results and Analysis**

# Concurrent Bidding (Rounds 1, 2, 3 and 4)

Table-3 Cournot Simulations round-1, round-2 and round-3 with Open Budget

												Distance to
										Cournot	Cournot	Cournot
Simulation #	q1	q2	q1+q2	Price	Profit-1	Profit-2	Budget	Consumer Surplus	Welfare	q1	q2	Equilibrium
2	3.25	3.00	6.25	5.75	15.44	11.25	35.94	19.53	55.47	4.00	3.00	0.75
5	4.50	2.00	6.50	5.50	20.25	7.00	35.75	21.13	56.88	4.00	3.00	1.12
6	3.50	3.25	6.75	5.25	14.88	10.56	35.44	22.78	58.22	4.00	3.00	0.56
21	3.75	3.00	6.75	5.25	15.94	9.75	35.44	22.78	58.22	4.00	3.00	0.25
1	3.00	4.00	7.00	5.00	12.00	12.00	35.00	24.50	59.50	4.00	3.00	1.41
12	4.50	2.50	7.00	5.00	18.00	7.50	35.00	24.50	59.50	4.00	3.00	0.71
10	3.75	3.50	7.25	4.75	14.06	9.63	34.44	26.28	60.72	4.00	3.00	0.56
13	3.75	3.50	7.25	4.75	14.06	9.63	34.44	26.28	60.72	4.00	3.00	0.56
14	3.75	3.50	7.25	4.75	14.06	9.63	34.44	26.28	60.72	4.00	3.00	0.56
18	4.25	3.25	7.50	4.50	14.88	8.13	33.75	28.13	61.88	4.00	3.00	0.35
9	5.50	2.25	7.75	4.25	17.88	5.06	32.94	30.03	62.97	4.00	3.00	1.68
22	3.75	4.00	7.75	4.25	12.19	9.00	32.94	30.03	62.97	4.00	3.00	1.03
23	4.75	3.00	7.75	4.25	15.44	6.75	32.94	30.03	62.97	4.00	3.00	0.75
15	5.00	3.00	8.00	4.00	15.00	6.00	32.00	32.00	64.00	4.00	3.00	1.00
4	4.75	3.50	8.25	3.75	13.06	6.13	30.94	34.03	64.97	4.00	3.00	0.90
24	5.25	3.00	8.25	3.75	14.44	5.25	30.94	34.03	64.97	4.00	3.00	1.25
3	4.50	4.00	8.50	3.50	11.25	6.00	29.75	36.13	65.88	4.00	3.00	1.12
8	5.75	2.75	8.50	3.50	14.38	4.13	29.75	36.13	65.88	4.00	3.00	1.77
16	5.25	3.25	8.50	3.50	13.13	4.88	29.75	36.13	65.88	4.00	3.00	1.27
20	4.00	4.50	8.50	3.50	10.00	6.75	29.75	36.13	65.88	4.00	3.00	1.50
7	5.25	3.75	9.00	3.00	10.50	3.75	27.00	40.50	67.50	4.00	3.00	1.46
11	6.00	3.00	9.00	3.00	12.00	3.00	27.00	40.50	67.50	4.00	3.00	2.00
17	5.50	4.25	9.75	2.25	6.88	1.06	21.94	47.53	69.47	4.00	3.00	1.95
19	6.00	4.00	10.00	2.00	6.00	0.00	20.00	50.00	70.00	4.00	3.00	2.24
Mean:	4.55	3.32	7.88	4.13	13.57	6.78	31.55	31.47	63.03	4.00	3.00	1.11
Mode:	3.75	3.00	8.50	3.50	14.06	9.63	29.75	36.13	65.88	4.00	3.00	0.56
SD:	0.88	0.62	0.99	0.99	3.23	3.10	4.21	7.97	3.93	0.00	0.00	0.55

Simulations 1 to 8 are round-1, 9 to 16 are round-2 and 17 to 24 are round-3.

										D 11 . 1		Distance to
		_								Predicted	Predicted	Cournot
Simulation #	ql	q2	q1+q2	Price	Profit-1	Profit-2	Budget	Consumer Surplus	Welfare	q1	q2	Equilibrium
26	5.25	2.75	8.00	4.00	15.75	5.50	32.00	32.00	64.00	6.00	2.00	1.06
27	5.00	3.00	8.00	4.00	15.00	6.00	32.00	32.00	64.00	6.00	2.00	1.41
28	6.00	2.00	8.00	4.00	18.00	4.00	32.00	32.00	64.00	6.00	2.00	0.00
32	4.50	3.50	8.00	4.00	13.50	7.00	32.00	32.00	64.00	6.00	2.00	2.12
29	4.75	3.50	8.25	3.75	13.06	6.13	30.94	34.03	64.97	6.00	2.00	1.95
30	5.50	2.75	8.25	3.75	15.13	4.81	30.94	34.03	64.97	6.00	2.00	0.90
25	6.00	2.50	8.50	3.50	15.00	3.75	29.75	36.13	65.88	6.00	2.00	0.50
31	5.75	2.75	8.50	3.50	14.38	4.13	29.75	36.13	65.88	6.00	2.00	0.79
Mean:	5.34	2.84	8.19	3.81	14.98	5.16	31.17	33.54	64.71	6.00	2.00	1.09
Mode:	6.00	2.75	8.00	4.00	15.00		32.00	32.00	64.00	6.00	2.00	
SD:	0.57	0.50	0.22	0.22	1.51	1.17	0.99	1.83	0.83	0.00	0.00	0.71

Table-4 Cournot Simulations round-4 under Restricted Budget B=32



Fig. 6a. Cournot Quantities under Open Budget

(round-1, round-2 and round-4)



Fig. 6b. Cournot Quantities under Restricted Budget

(round-4)



Fig. 7. Budget vs Total Quantity for Open and Restricted Budget under Cournot Competition

Figure 6b (round-4) shows an increase of total quantity as all the points with q1and q2 as coordinates are above the reaction functions. However the average budget under budget restriction remains close the Cournout Equilibrium budget as evidenced in Figure 7.

# Sequential Bidding (rounds 5, 6 and 7)

Simulation #	q1	q2	q1+q2	Price	Profit-1	Profit-2	Budget	Consumer Surplus	Welfare	Stack. q1	Stack. q2	Distance to Stackelberg Equilibrium
1	4.75	1.25	6.00	6.00	23.75	5.00	36.00	18.00	54.00	6.00	2.00	1.46
2	4.00	3.00	7.00	5.00	16.00	9.00	35.00	24.50	59.50	6.00	2.00	2.24
3	4.00	3.00	7.00	5.00	16.00	9.00	35.00	24.50	59.50	6.00	2.00	2.24
4	5.50	2.00	7.50	4.50	19.25	5.00	33.75	28.13	61.88	6.00	2.00	0.50
5	4.75	3.00	7.75	4.25	15.44	6.75	32.94	30.03	62.97	6.00	2.00	1.60
6	6.00	2.00	8.00	4.00	18.00	4.00	32.00	32.00	64.00	6.00	2.00	0.00
7	5.75	3.00	8.75	3.25	12.94	3.75	28.44	38.28	66.72	6.00	2.00	1.03
8	4.25	4.75	9.00	3.00	8.50	4.75	27.00	40.50	67.50	6.00	2.00	3.26
Mean:	4.88	2.75	7.63	4.38	16.23	5.91	32.52	29.49	62.01	6.00	2.00	1.54
Mode:	4.75	3.00	7.00	5.00	16.00	5.00	35.00	24.50	59.50	6.00	2.00	2.24
SD:	0.79	1.04	0.98	0.98	4.47	2.11	3.24	7.45	4.37	0.00	0.00	1.05

Table-5 Stackelberg Simulations with Open Budget

**Table-6** Stackelberg Simulations under Restricted Budget B=31

												Distance to
										Predicted	Predicted	predicted
Simulation #	q1	q2	q1+q2	Price	Profit-1	Profit-2	Budget	Consumer Surplus	Welfare	q1	q2	vales
1	5.75	2.50	8.25	3.75	15.81	4.38	30.94	34.03	64.97	6.47	1.76	1.03
2	5.75	3.00	8.75	3.25	12.94	3.75	28.44	38.28	66.72	6.47	1.76	1.43
3	6.50	1.75	8.25	3.75	17.88	3.06	30.94	34.03	64.97	6.47	1.76	0.03
4	5.00	3.25	8.25	3.75	13.75	5.69	30.94	34.03	64.97	6.47	1.76	2.09
5	6.25	2.50	8.75	3.25	14.06	3.13	28.44	38.28	66.72	6.47	1.76	0.77
6	7.00	1.50	8.50	3.50	17.50	2.25	29.75	36.13	65.88	6.47	1.76	0.59
7	6.00	3.00	9.00	3.00	12.00	3.00	27.00	40.50	67.50	6.47	1.76	1.33
8	7.00	2.00	9.00	3.00	14.00	2.00	27.00	40.50	67.50	6.47	1.76	0.58
Mean:	6.16	2.44	8.59	3.41	14.74	3.41	29.18	36.97	66.15	6.47	1.76	0.98
Mode:	5.75	2.50	8.25	3.75			30.94	34.03	64.97	6.47	1.76	
SD:	0.68	0.64	0.33	0.33	2.12	1.19	1.70	2.80	1.11	0.00	0.00	0.63

**Table-7** Stackelberg Simulations under Restricted Budget B=28

										Predicted	Predicted	Distance to predicted
Simulation #	q1	q2	q1+q2	Price	Profit-1	Profit-2	Budget	Consumer Surplus	Welfare	q1	q2	vales
3	6.50	2.25	8.75	3.25	14.63	2.81	28.44	38.28	66.72	7.65	1.17	1.58
4	7.00	2.00	9.00	3.00	14.00	2.00	27.00	40.50	67.50	7.65	1.17	1.05
6	7.00	2.50	9.50	2.50	10.50	1.25	23.75	45.13	68.88	7.65	1.17	1.48
1	7.50	1.50	9.00	3.00	15.00	1.50	27.00	40.50	67.50	7.65	1.17	0.36
2	6.50	2.50	9.00	3.00	13.00	2.50	27.00	40.50	67.50	7.65	1.17	1.76
5	7.75	1.25	9.00	3.00	15.50	1.25	27.00	40.50	67.50	7.65	1.17	0.13
7	7.25	1.75	9.00	3.00	14.50	1.75	27.00	40.50	67.50	7.65	1.17	0.70
8	6.75	2.25	9.00	3.00	13.50	2.25	27.00	40.50	67.50	7.65	1.17	1.41
Mean:	7.03	2.00	9.03	2.97	13.83	1.91	26.77	40.80	67.57	7.65	1.17	1.06
Mode:	6.50	2.25	9.00	3.00		1.25	27.00	40.50	67.50	7.65	1.17	
SD:	0.45	0.46	0.21	0.21	1.57	0.58	1.32	1.91	0.59	0.00	0.00	0.60



Fig. 8a. Stackelberg Quantities Round-5



Fig. 8c. Stackelberg Quantities Round-7 (B=28)

12 11 10 9 8 7 Stackelberg Equilibrium 6 5 4 q2 3 2 1 0 9 10 11 12 3 4 5 7 8 0 1 2 6 q1

Fig. 8b. Stackelberg Quantities Round-6 (B=31)



Fig. 9. Budget vs Total Quantity for Open and Restricted Budget under Stackelberg Competition

Figures 8b and 8c (under restricted budget) show a clear increase in total quantity comparing to figure 8a (open budget). Moreover, Figures 8b and 8c show a small average distance between played quantities and predicted ones. The distance  $d_i$  in simulation i for quantities  $q_{1i}$  and  $q_{2i}$  is calculated as follows:

$$d_{i} = \sqrt{(q_{1i} - q_{1p})^{2} + (q_{2i} - q_{2p})^{2}}$$

Where  $q_{1p}$  and  $q_{2p}$  are predicted quantities.

As the model predicted, a decrease in the budget in the form of budget restriction led to an increase in total quantity as well as consumer surplus (CS) and Welfare (W).

### Conclusion

We show, by using such mechanism, that a Budget-Restricted buyer can acquire a total quantity higher than Stackelberg Equilibrium total quantity (which is higher than Cournot Equilibrium total quantity) with a lower budget than the one corresponding to Stackelberg Equilibrium (which is lower than Cournot Equilibrium budget). Consequently, Budget Restriction combined with Cournot/Stackelberg competition leads to higher quantity and higher welfare.

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# Admissibility concepts for group portfolio decision analysis

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**Abstract**: We present complementary decision evaluation methods for group portfolio multi-criteria decision analysis where stakeholders have differing preferences. The approach supports the analysis of a portfolio of actions (or projects) in the case where a large group of stakeholders have inconsistent opinions with respect to performance of each action and the criteria weights. The group of stakeholders is partitioned into two disagreeing groups based upon their views on the actions' performance levels and the portfolio is analyzed using a measure of consensus taking opinions of each stakeholder into account.

Keywords: Portfolio Decision Analysis, Group Decision, Interval Decision Analysis.

# Introduction and Problem Description

This paper presents complementary decision evaluation concepts for group portfolio decision analysis. The rationale behind the concepts put forward in this paper is that in recent research we have encountered multicriteria decision problems where the available options are not mutually exclusive, i.e. it is a portfolio decision problem, as well as a strong need for modeling and analysis of several stakeholder groups with differing preferences, cf. (Danielson, et al., 2008; Fasth & Larsson, 2012). For instance, in city planning one decision alternative is typically constructed from a set of choices regarding new buildings, streets, transports, and other facilities contributing to a stimulating urban environment.

In such situations a decision analysis approach may be ill-received by decision makers and stakeholders if the explicit goal with employing a decision analysis process is restricted to identify a "best" solution. Instead it is emphasized to exploit formal problem modeling in order to gain insight into consensus and disagreement levels in search for a portfolio of actions acceptable for at least the most important stakeholder groups. This paper suggests an approach to evaluate a portfolio of actions by means of its level of consensus as a complementary decision evaluation method when a single portfolio must be agreed upon. By using portfolio decision analysis on group decision-making problems is the analysis of several combinations of several projects instead of just analyzing a single project, which simplifies the problem of finding compromises between the stakeholders (Salo & Hämäläinen, 2010).

# Group Portfolio Interval Decision Analysis

In the approach suggested in this paper we assume that an *action* of a portfolio is assessed by a stakeholder in multi-criteria fashion by using some elaborated questionnaire for preference elicitation (for large sets of stakeholders this could for instance be web-based). We assume that we have a finite set of actions A, and the questionnaire relative to an action  $A_i \in \mathbf{A}$  consists of a set of questions regarding each evaluation criteria in a criteria set G. In the questionnaire, each action is assessed relative to each criterion, where the performance level of the action from the perspective of the stakeholder is assigned a utility value assuming a monotonic utility function equipped with a neutrality threshold *n*. The neutrality threshold *n* means that the stakeholder has a neutral preference regarding the given action. The neutrality threshold n is the midpoint value in a set of the stakeholders' view of the given action. For simplicity reasons, we herein use performance levels taking integer values on a fixed attribute scale ranging between -2 to 2 where a negative value indicate that the action is viewed counterproductive in pursuing the fundamental objective and a value of zero indicate a neutral position, i.e. the neutrality threshold n lies at zero which entails that the stakeholder view the action as being neither counterproductive nor contributing in this strive. In addition for each stakeholder, each criterion is associated with a stakeholder specific weight<sup>30</sup>. Then when conforming to the additive utility function the utility value of an action is given from the sum  $\sum_j w_{jk} v_{jk}$  where  $w_{jk}$  is the stakeholder S<sub>j</sub>'s weight for criterion  $G_k$  and  $v_{jk}$  is  $S_{jk}$  utility value of the action for criterion  $G_k$ . For instance, the proposed

<sup>&</sup>lt;sup>30</sup> Elicitation of weights is beyond the scope of this extended abstract although we recognize the difficulties involved.

utility aggregation function is an additive function for the aggregation of the stakeholders' preference information. Since this type of aggregation function can limit the robustness of the solution, other types of aggregation functions will in the future be taking into consideration.

Thus, each stakeholder  $S_j$  evaluates each action  $A_i$  according to common criteria set **G**, and for each action  $A_i$  we form two disagreeing stakeholder groups  $\mathbf{R}_i^-$  and  $\mathbf{R}_i^+$ , such that the stakeholders of  $\mathbf{R}_i^-$  assign a utility value of  $A_i$  with respect to  $G_k$  lower than the neutrality threshold (lower than zero in the current example) and that the stakeholders of  $\mathbf{R}_i^+$  assign a utility value at the neutrality threshold or greater than it (zero or greater in the current example). Having this information, for each action, we create two utility ranges for  $G_k$ , one range for each of the two groups. These are labeled as the *pro-support* and *con-support* respectively and given from the maximum and minimum stakeholder utility assessment scaled by its weight conditional on group membership (in other words the widths of the sets of weight–utility product points for each group). For instance, given a criterion  $G_k$ , six stakeholders  $S_1$  to  $S_6$  and an action with the following six weight–utility pairs delivered by the stakeholders {(0.1, 1); (0.2, -2); (0.3, -1); (0.1, 2); (0.1, 1), (0.2; 0)}, then  $\mathbf{R}_i^- = \{S_2, S_3\}$  and the con-support is [-0.4, -0.3]. Respectively, the pro-support will be [0, 0.2] and  $\mathbf{R}_i^+ = \{S_1, S_4, S_5, S_6\}$ .

For each action  $A_i \in \mathbf{A}$  and criterion  $G_k \in \mathbf{G}$  we let the *pro-index* and *con-index* be two quantitative measures of the sets of weight–utility pairs in the two groups, these are denoted with p and c respectively. In general, these measures could be any reasonable statistical moment, but for simplicity reasons we restrict the case to the arithmetic mean of the weight–utility products for each of the two groups. Thus, in the above example the pro-index would be 0.1 and the con-index would be -0.35. Then, the sum |c - n| + |p - n|, i.e. the distance between the pro-index and the con-index indicate an additive level of disagreement with respect to the performance of the action  $A_i$  relative to criterion  $G_k$ . This level of disagreement is called the *additive disagreement index* for action  $A_i$  under criterion  $G_k$  and labeled with  $d_{ik}$ . In the current example  $d_{ik} = 0.45$ . Finally, the total disagreement index for action  $A_i$  is denoted with  $T_i$  and is the sum of all criterion specific disagreement indices, such that

$$T_i = \sum_{G_k \in G} d_{ik}$$

The total disagreement for a portfolio of actions P is defined as

$$T_P = \sum_{A_i \in P} T_i$$

(2)

(1)

### Admissibility Concepts from Disagreement Analysis

From the above approach we can now stipulate admissibility concepts for consensus portfolios. The common approach to portfolio generation is to exploit methods from optimization in the form of knapsack problem. A feasible portfolio has a cost lower than some resource constraint. Further, it is possible to partition the set of actions into categories and force inclusion of at least one action per category into a generated portfolio thereby avoiding uninteresting empty solution sets, cf. (Liesiö, Mild, & Salo, 2008). The *maximum consensus portfolio* is the portfolio can thereafter be considered as the most feasible portfolio or used as a reference portfolio for further decision evaluations. The total disagreement index can be exploited as a reference value when performing tradeoffs as a consequence of exchanging actions in a suggested portfolio not being a maximum consensus portfolio and not being accepted by some or more stakeholders.

# **Concluding remarks**

In this extended abstract we suggested an approach to group portfolio decision analysis where information about preferences from diverse stakeholders is present and where identification of a consensus portfolio is of interest. For each action that could be part of the portfolio, the stakeholders are separated into two groups based upon their opinions as regards whether or not they believe that the action contributes or is counterproductive with respect to the decision objective represented by the criterion. Of concern for future work is to incorporate such measures of disagreement in multi-stakeholder decision problems, especially in planning decision situations. Future work include refinements of the disagreement index such that cardinality of the disagreeing stakeholder groups may taken into account in a transparent and feasible manner as well as considering a more elaborated disagreement index than the simple additive one since the level of disagreement could be considered as different although the additive measure provides the same result. Finally, the approach is to be complemented with supportive features enabling for gathering of preference information from stakeholders. The preference information can be gathered by conducing webbased questionnaire, and the interaction among the stakeholders and the decision makers can be fulfilled through a web-based approach. The method can then be implemented in ICT tools for group portfolio decision analysis. The approach can then be applied in case study of public planning, and involve the stakeholders in the decision process. However, this model can also be applied to other kinds of portfolio group decision making, for instance political decisions.

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# Evaluating strategic fit of projects: a fuzzy linguistic approach

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**Abstract**: Strategic fit is a crucial criterion for screening strategically important projects. However, this aspect is vague and unquantifiable to employ with conventional quantitative analysis. This study suggests a method to assess strategic fit as relevance of a project to a set of organisation strategic goals in the context of multi-criteria project evaluation. The assessment is done subjectively by means of linguistic values, which are translated into numerical ones by employing a fuzzy logic.

Keywords: Strategic fit, project evaluation, multi-criteria evaluation, fuzzy linguistic evaluation, multi criteria decision analysis

# Introduction

Implementation of a solid business strategy is required of organizations that operate in a highly competitive market. In order to effectively execute the strategy, organizations must make consistent and highly accurate selection, and thus, evaluation of particular projects, through which the strategy is executed.

Various multi-criteria decision analysis (MCDA) tools have been adopted for project and portfolio evaluation. Multi-criteria scoring models, with underlying utility functions, have gained large spread in business practice, thanks to their simplicity and good performance. This method is even suggested in the American national standard for portfolio management (PMI, 2008) for the purpose of projects evaluation.

While there are certain traditional attributes for project portfolio evaluation, such as costs and income, time frames, quality constraints, risks, etc., "strategic fit" is often named as one of the most important criteria for projects selection (Kaplan and Norton, 2008, Moore, 2010). Moreover, the PMI (2008) suggests the "degree of strategic alignment" as one of the key metric of a project portfolio.

While the traditional metrics mostly have their specific measurement units and tools for assessment, strategic fit is a non-quantifiable criterion. While Kaplan and Norton (2008), along with PMI (2008) suggest to utilize rating scales for the evaluation, neither of them provides any unambiguous definitions of the metric, explicit descriptions of the "degrees" or any other formalized guidelines for its evaluation and quantification.

Moreover, projects' selection as part of a strategic planning process is typically performed under conditions of uncertainty, implicit and incomplete information, lack of time and resources available for a comprehensive analysis, and necessity to deal with multiple stakeholders groups with different views. All of these cause substantial difficulties for managers to make consistent and accurate evaluations.

However, the fuzzy sets theory proposed by Zadeh (1965), allows of representation and evaluation of such imprecise and vague concepts as strategic fit through the use of linguistic values. Additionally, it allows dealing with uncertainties in measurements.

This research suggests a procedure to assess the strategic fit as relevance of a project to a set of organization strategic goals. By employing fuzzy sets theory, this procedure captures, aggregates and converts managers' judgments expressed with natural language into numerical values.

The rest of the paper is organized as follows. The following section briefly introduces the literature on the notion of strategic fit. The section presenting the key terms of fuzzy sets theory follows. The fourth section presents the method for the strategic fit evaluation in the context of projects evaluation. In the fifth section the method workings are demonstrated on an illustrative case. Finally, conclusions are drawn.

# The Many Faces of Strategic Fit

The concepts of strategic alignment and strategic fit, which are usually used as synonyms, have gained much spread both in theory and practice of management. Neither the theoretical interpretation of the concept or

the fields of business applications are unambiguous. Longman Business English Dictionary (2007) reflects the intuitive understanding of strategic fit as a situation, "when a particular plan, product, etc. is suitable in relation to an organization's strategy". However, in the context of merge & acquisition the strategic fit is understood as "the complimentarily of partner firms" "hard" skills and resources, such as technology, capital, and distribution channels" (Peng, 2009, p. 48).

The notion of strategic fit has its theoretical foundations in contingency theory. The contingency approach suggested that the appropriate form of management depends on the kind of task or environment the organization is dealing with (Ginsberg & Venkatraman, 1985), i. e. strategy is dependent of context. In this sense the concept of fit has been described as a search for a form that is internally or externally consistent (Miles & Snow, 1984).

Venkatraman and Camillus (1984) initiated a discussion on a theoretical issue related to measurement of fit — "whether fit is a static or dynamic phenomenon" (Venkatraman & Camillus, 1984, p. 521). In response to this issue many researchers argued that strategic fit is not an event, but a process of continuous strategic change (Henderson and Venkatraman, 1993) or an ideal stated to continuously strive for, but hard to achieve due to dynamics of environments (Chorn, 1991). The important implication from this is that the fit is not "boolean", thus must be measured in degrees. Miles & Snow (1984) suggested several qualitative degrees of strategic fit, "where better fit should deliver greater value" (Mullaly & Thomas, 2009, p. 126).

One of the six schools in the classification of strategic fit interpretation by Venkatraman and Camillus (1984, p. 516) is "Strategy Implementation School", whose key theme is "Tailoring administrative and organizational mechanisms in line with strategy". From this view Porter (1996) defines strategy itself as "the creating fit among a company's activities". In the same respect, Waterman et al., (1980) identified several interrelated organizational elements, which should be aligned. Those elements are: structure, strategy, systems, skills, style, staff and shared values (also known as "McKinsey 7S Framework"). Thus, the ultimate management task is to create and sustain strategic alignment or strategic fit among several internal aspects of organization.

With this disposition different application areas of strategic fit have been studied, such as organizational culture (Scholz, 1987, p. 78), production and sourcing (Jelinek & Burstein, 1982), human resource management (Aguilera & Dencker, 2004; Boon et al., 2007; Tharenou et al., 2007), research & development (Lyne, 2003). Several attempts to examine project portfolio management in relation to business strategy have been presented as well (Iamratanakul et al., 2009; António & Araújo, 2009; Mullaly and Thomas, 2009), in this literature strategic alignment is emphasized as one of the aims of project portfolio management.

As another representative of this view, Kaplan and Norton (2008) define strategic alignment as "the fit, coordination and harmonization between the strategy and projects to execute it, between soft top-level strategic goals, expressed in vision and mission and certain actions to take". They suggest a term of "strategic initiatives" for these discretionary projects, which are usually outside the organization's day-to-day operational activities and specifically designed to help the organisation fulfil the strategic goals. Further, they present a close-loop management process to ensure strategic alignment, where strategy is executed by means of portfolio of "strategic initiatives". This management approach to strategy execution is supported by PMI (2008), which states that each project in a portfolio "should be aligned to one or more strategic goals".

Hence, the strategic fit of a project can be defined as the degree to which the project is relevant to and consistent with the strategic goals of the organization. This understanding of strategic fit lies at the basis of this research. With this disposition, strategic fit of project portfolio is a crucial aspect, which in a certain extent predefines effectiveness of strategy execution and, thus, viability of an organization itself. Even when omitting the extreme cases, better strategic fit of projects should result in greater efficiency, i. e., achieving the same level of strategic results for less resources, or greater results for fixed amount of resources (Moore, 2010).

# Fuzzy Sets Theory, Its Applications and Key Terms

Zadeh (1975) introduced the concept of linguistic or "fuzzy" variables. Linguistic variables have as values words or sentences in a natural or artificial language. The concept of a linguistic variable plays a central role in fuzzy logic and underlies most of its applications.

Zadeh distinguishes "measurements" and "perceptions". The former are based on numerical values, while the latter — on linguistic ones. The idea to oppose perception to measurement comes from the human capability to understand and operate with obscure and imprecise events, perform a wide variety of physical and mental tasks (e. g., driving a car in city traffic) without any measurements and any computations (Zadeh, 2004, p. 32). Thus, perceptions and linguistic values are inevitable to use in intricate and unstructured decision-making cases, involving vague concepts and phenomena, such as strategic fit of projects. Limitations of conventional "crisp" evaluation of such notions are effectively resolved by the fuzzy logic approach. It allows translating the usually vague meaning of a linguistic term to a specific distribution of values with an associated "degree of truth".

Fuzzy evaluation approach has been applied to managerial decision-making problems, including project evaluation. For instance, it has been used in multi-criteria decision making cases to select new product development and R&D projects (Hsu et al., 2003; Hsu, 2006; Lin and Chen, 2004; Wang, 2009), along with new information systems projects (Machacha & Bhattacharya, 2000; Chen & Gorla, 1998). Fuzzy evaluation approaches have also been applied for other management purposes such as employees' assessment (Zemkova, 2008), government performance (Wu et al., 2010) and suppliers performance (Chang et al., 2007) evaluation.

Further, some basic terms and definitions of fuzzy set theory are reviewed (Zemkova, 2008), (Bansal, 2011).

Non-crisp sets are called *fuzzy sets*, for which a characteristic function can be defined. This function, called a *membership function*  $\mu_A(x)$  of A, assigns a grade of membership  $\mu_A(x_0)$  to each element  $x_0 \in X$ . Therefore, the following notation for the membership function  $\mu_A(x)$  of a fuzzy set A is used:  $A: X \to [0,1]$ . Each fuzzy set is completely and uniquely defined by one particular membership function.

A fuzzy set *A* is called *normal* when the largest membership grade obtained by any element in that set is equal to 1.

The core of a normal fuzzy set A is the crisp set that contains all the elements of X that have the membership grades of 1 in A,  $\operatorname{core}(A) = \{x \in X \mid \mu_A(x) = 1\}$ .

*Fuzzy number* means a fuzzy set A defined on the basis of real numbers R with the following characteristics (Bansal, 2011, pp. 39-40):

- a) A is convex i.e.,  $\mu_A(\lambda x_1 + (1 \lambda)x_2 \ge \min(\mu_A(x_1), \mu_A(x_2)) \forall x_1, x_2 \in R, \forall \lambda \in [0, 1];$
- b) A is normal;
- c)  $\mu_A$  is piecewise continuous.

The following definitions are from Zemkova (2008, pp. 476-477).

Fuzzy numbers  $T_1, ..., T_n$  that are defined on the interval (A, B) make a fuzzy decomposition of the interval (A, B) if:  $\forall x \in (A, B): \sum_{i=1}^{x} T_i(x) = 1$ .

A fuzzy scale is a set of fuzzy numbers  $T_1, ..., T_n$  defined on the interval (A, B) and make a fuzzy decomposition of this interval that are numbered according to their order.

A linguistic variable is characterized by a quintuple (v, T(v), X, G, M) in which v is the name of the variable, T(v) is the set of linguistic values,  $X \subseteq R$  is a universe based on which the fuzzy numbers, representing the meaning of the linguistic values, are defined, G is a syntactic rule for generating the elements of linguistic values and M is a semantic rule for associating meaning with the linguistic values of a fuzzy number in X (Zemkova, 2008, pp. 476-477).

If (v, T(v), (A, B), G, M) is the linguistic variable, the value meanings of which form a fuzzy scale in (A, B), then the values of the linguistic variable v make a fuzzy linguistic scale in (A, B) (Zemkova, 2008, pp. 476-477).

As expected from a scale, linguistic values pertaining to a linguistic scale are linearly ordered. Meanings of linguistic values are translated by fuzzy numbers with associated membership function.

# Strategic Fit Evaluation Method

This study generalizes some past studies and presents a method for projects' strategic fit evaluation. The method consists of 7 consecutive steps, which are grouped into three distinct phases. The first phase is Preparation, where all necessary input and background information on the project selection is collected. Furthermore, the group of evaluators is formed. At the second phase, Evaluation, the evaluators perform assessment of the strategic fit of the projects by means of linguistic values. At the final phase, Processing, the linguistic values are aggregated and transformed into a crisp numeric value for the strategic fit of each evaluated project. The method outline is presented in the Table 1. The detailed description and discussion of each step follow.

Phase	Step
	Step 1. Form a group of evaluators
Preparation	Step 2. List top-level strategic goals
	Step 3. List identified projects
Evaluation	Step 4. Evaluate projects' strategic fit
	Step 5. Transform linguistic values into fuzzy numbers
	Step 6. Aggregation:
Processing	6.1 Aggregate individual evaluations for each goal-project pair
	6.2 Aggregate goals' values on a project level
	Step 7. Defuzzification

### Table 1. Method outline

### Step 1. Form a Group of Evaluators

Strategy execution is typically a prerogative of a top-management team. Solving associated issues, such as evaluation of projects' strategic fit, often requires from managers specific knowledge, experience and such vague skills as intuition. This knowledge is typically tacit, i.e. rarely formalized and explicitly communicated. Additionally, several different "views" on the strategic issues are common in such conditions. Hence, collective decision-making and expert evaluation is a typical practice in strategy development, project and portfolio evaluation.

At the first step of the suggested method, the organization should define a limited group of evaluators. While the method hypothetically has no limit on the number of evaluators, typically this is defined by practical considerations. It is worth noting that the method effectively works with a single evaluator as well, however, the benefits of collective decision-making won't be exploited then. Moreover, PMI (2008) defines a need of a "portfolio management board" (PMI, 2008, p. 25) as a collective body to screen and decide on project portfolio content. This body seems a natural group for the strategic fit evaluation.

### Step 2. List Top-Level Strategic Goals

A goal is a textual statement about a desired state or condition of the organization. Assuming a certain hierarchy in the set of strategic goals, only top-level goals should be listed. These top-level goals are typically so-called "soft" goals, which are general, not formalized and non-quantifiable. "Hard" goals, on the other hand, have some measurable and achievable targets in their statements, but, since more specific, they usually present sub-goals to the "soft" ones.

In this study we assume that a set of strategic goals are already present in the organization, that is, defining strategic goals is not a step required to perform at the time of projects evaluation. So, this step outputs a list of strategic goals, which are, hereafter, used as natural criteria for strategic fit evaluation.

## Step 3. List Identified Projects

PMI (2008, pp. 51-54) establishes the "Identify components" process, which should output the "List of Components". Also, this process should result with "Key descriptors for each component", which represent projects' documentation presented on proper templates. The description might include a project's title, brief description of the project, key outputs and objectives of the project, etc. Such information can be useful for the evaluators to make informed and more accurate judgments. Thus, the three steps above comprise the Preparation phase of the method.

### Step 4. Evaluate Projects' Strategic Fit

At this step each evaluator expresses his/her perceptions on a strategic fit value of each identified project. Assuming the specified definition of strategic fit of a project presented in the Introduction section, the following question is suggested to guide the assessment: "In what extent the project is relevant to and consistent with the strategic goal?". The assessment is performed on a goal-by goal basis, that is, each project's strategic fit is assessed against each strategic goal separately.

The strategic fit is assessed by means of a linguistic scale. For the purposes of this research we adopted the linguistic scale with the corresponding membership function suggested by Chang et al., (2007). They proposed a 7-level scale, which suits this study with good balance of precision and usability. In order to incorporate specifics of the research, the original boundary values, namely, "None" and "Perfect", were replaced with "No Fit" and "Perfect Fit" respectively. The linguistic scale along with the matrix of corresponding distinctive values (points) to construct the membership function is presented in the Table 2. Further details on the membership function are discussed in the following subsection.

Linguistic value	Distinctive points			
No Fit	0	0	0	0,1
Very Low	0,1	0,15	0,25	0,3
Low	0,25	0,3	0,4	0,45
Medium	0,4	0,45	0,55	0,6
High	0,55	0,6	0,7	0,75
Very High	0,7	0,75	0,85	0,9
Perfect Fit	0,9	1	1	1

Table 2. Linguistic scale and distinctive points

# Step 5. Translate Linguistic Values into Fuzzy Numbers

While some authors suggest experts to derive their own scales with respective membership functions (Zeng et al., 2007; Hsu et al., 2003), we find this approach damaging its accessibility, since this requires the decisionmakers to be familiar with fuzzy sets theory application. Moreover, as the case-study by Lin & Chen (2004) has revealed, it might be problematic for a group of managers to find a compromise on linguistic values and membership functions. Meanwhile, custom scales' potential benefit in better accuracy of assessment is not substantial for most cases.

For some applications the modelling requires continuously differentiable curves and therefore smooth transitions (e.g., the generalised bell function). However, the benefit in accuracy the smoothness of a shape provides is often negligible. Therefore, for evaluation purposes piecewise linear functions are often employed, such as triangular and trapezoidal functions, since they are simpler and efficient calculation-wise. Moreover, they can take asymmetric shapes, which is crucial for some applications.

The membership function employed in this research is trapezoidal, which in general is defined as follows (1).

$$\mu(x, a, b, c, d) = \begin{cases} 0, x < a, x > d \\ \frac{x - a}{b - a}, a \le x \le b \\ 1, b < x < c \\ \frac{d - x}{d - c}, c \le x \le d \end{cases}$$
(1)

The parameters a, b, c and d define the shape of a trapezoid, thus, can be used for adjusting to a particular case. By means of distinctive points (Table 2) the employed membership function is constructed (see Figure 1).

The extreme linguistic values, i.e. "No fit" and "Perfect fit", are distinguished in a way to deal with a bias, when humans tend to select middle values when uncertain. Therefore, undoubted perceptions, i.e. the extreme linguistic values, are assigned to a narrower range of numeric values and generally higher membership for most of the values.



Fig. 1. Membership function for linguistic values of Strategic Fit

Thus, at this step the previously collected values of linguistic assessment are translated into fuzzy numbers with accordance to this membership function. The Table 2 basically represents the respective fuzzy numbers for the linguistic values.

### Step 6. Aggregation

It is necessary to aggregate plural values of strategic fit gained at the previous steps. Li et al. (2004) argue that the choice of aggregation method depends on decision maker attitude: pessimistic, optimistic or neutral. For instance, Fuzzy intersections (T-norms), where basically, the minimal value is selected, Fuzzy unions (T-conforms), where the highest value is selected, or Fuzzy Averaging Operators (Mean type operators), can be used to represent respective attitude.

Since the method is not bound with any specific case, the neutral attitude is reflected, and thus, the mean type operator is employed in this research. As for the particular averaging technique, a *Simple mean operator* (2) is chosen for its simplicity and familiarity for potential business users.

$$A(a_1, a_2, \dots, a_n) = \frac{1}{n} \sum_{i=1}^n a_i$$
(2).

So, at this step the multitude of fuzzy numbers resulted from two dimensions, namely the set of strategic goals and the number of evaluators, have to be aggregated. The aggregation is to be done through two substeps for each such dimension.

### Step 6.1 Aggregate Individual Evaluations for Each Goal-Project Pair

First, the different expert's assessments for each pair of project-goal are aggregated with use of simple mean operator (2). The resulting output is a set of fuzzy numbers, each of which represents the averaged "opinion" for each project-goal pair.

### Step 6.2 Aggregate Goals' Values on a Project Level

Secondly, we need to aggregate final values for all the strategic goals. For this purpose, we use the simple mean operator (1) as well. This step outputs one trapezoidal fuzzy number for each evaluated project.

### Step 7. Defuzzification

At the previous step we have aggregated all the partial evaluations values into one for each project. However, the value is still a fuzzy number, which has to be transformed into a crisp number. This transformation is called defuzzification. While there are several defuzzification methods, for the purposes of this research the "Mean of Maxima" (MoM) method (3) is suggested.

$$MoM(A) = \frac{\sum_{x \in core(A)} x}{|core(A)|}$$
(3).

MoM belongs to a so-called "most plausible result" category, in opposition to a "best compromise" category. MoM is derived from the "centre of gravity" (CoG) method and calculates the mean of all elements of the core (values with the highest membership) of a fuzzy set. Thus, MoM selects the typical value of the most valid output.

This defuzzification method is especially efficient with the trapezoidal function, since the core is easily distinguishable. It is worth noting, that for the symmetric membership functions CoG and MoM have equal defuzzified value. Finally, MoM is computationally very efficient.

Thus, the output of this step and the presented method itself is a crisp number within [0; 1] interval, representing a numeric value for strategic fit of a project.

### **Illustrative Case**

To illustrate the method application, we have invented a case. A general context of the case is based on the "Business and Payroll services" unit of Aurenav, a Sweden-based international company offering solutions for Enterprise Architecture, ICT Security, Web Services and Business Services. Aurenav is an example of a so-called "umbrella" organisation, where the "Business and Payroll services" unit is one of several businesses, which share common administrative and support services, and the general management. In terms of strategy it operates almost as independent business, i.e., the unit has unrelated separated goals and projects.

Further in this section we are demonstrating the method application to determine values of strategic fit for the real current projects of Aurenav "Business and Payroll services" unit with respect to their strategic goals.

### Step 1. Form a Group of Evaluators

For the demonstration purposes we assume two evaluators, they are further denoted as the "Evaluator 1" and the "Evaluator 2".

### Step 2. List Top-Level Strategic Goals

A set of original strategic goals for the "Business services and payroll" unit was articulated by the CFO and the CEO of Aurenav. The top-level strategic goals are presented in the Table 3.

Table 3. Strategic goals of Aurenav's "Business services and payroll" unit.

Goal	Description
G1	Maximize our profit per client

G2	Maintain high customer satisfaction
G3	Become a single point of contact for the customer
G4	Enhance effectiveness of our operations
G5	Improve quality of our operations
G6	Become experts in the fields of payroll and labour law
G7	Improve our professionalism in management

# Step 3. List Identified Projects

A set of potential internal projects specified by the CFO of Aurenav are presented in the Table 4.

Project	Description
P1	Implement a tool for risk assessment
P2	Publish a guideline for external users on legal and tax aspects of doing business in Sweden
P3	Implement new payroll software
Р4	Implement a timesheet software for internal use
P5	Internship programme
Р6	Implement "Customer data collection" process
Р7	Develop an internal guideline for customers' frequently asked questions
P8	Introduce service package offers

Table 4. Projects of Aurenav's "Business services and payroll" unit

### Step 4. Evaluate Projects' Strategic Fit

The evaluations were made up subjectively assuming how they might be in a real-life scenario. The evaluations for the Evaluator 1 and the Evaluator 2 are presented in the Tables 5 and 6 respectively.
	Goals						
Project	G1	G2	G3	G4	G5	G6	G7
P1	Low	No Fit	No Fit	Very High	High	Very Low	Very Low
P2	No Fit	High	Very Low	No Fit	No Fit	Very High	No Fit
P3	Medium	High	Very High	Medium	No Fit	High	No Fit
P4	No Fit	High	High	Very High	Perfect Fit	No Fit	Very High
P5	No Fit	No Fit	Very Low	Medium	Low	High	High
P6	Very High	Perfect Fit	Very High	No Fit	Medium	Low	Very Low
Ρ7	Low	Very High	High	High	Medium	No Fit	No Fit
P8	Very High	High	Perfect Fit	No Fit	No Fit	No Fit	No Fit

Table 5. Evaluation of strategic fit in terms of linguistic values assigned by Evaluator 1

Table 6. Evaluation of strategic fit in terms of linguistic values assigned by Evaluator 2

	Goals						
Project	G1	G2	G3	G4	G5	G6	G7
P1	Medium	High	No Fit	High	Perfect Fit	No Fit	Medium
P2	Very Low	Very High	Perfect Fit	No Fit	No Fit	Perfect Fit	Low
Р3	Perfect Fit	Very High	Very High	Very Low	High	Low	No Fit
P4	Low	High	Medium	Perfect Fit	High	No Fit	Perfect Fit
Р5	Medium	Low	Low	Medium	Medium	Low	Low
P6	Medium	Perfect Fit	Medium	No Fit	No Fit	Very High	Very Low
P7	No Fit	Perfect Fit	Medium	Very High	Perfect Fit	Low	No Fit
P8	Perfect Fit	Medium	Perfect Fit	Low	No Fit	No Fit	No Fit

### Step 5. Translate Linguistic Values into Fuzzy Numbers

The linguistic values are transformed into fuzzy numbers in accordance to Table 2. The results are presented in the Table 7. The values for the Evaluator 1 and the Evaluator 2 are combined in one cell for each project and goal respectively.

	Goals						
Project	G1	G2	G3	G4	G5	G6	G7
P1	(0.25, 0.30, 0.40, 0.45)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.70, 0.75, 0.85, 0.90)	(0.55, 0.60, 0.70, 0.75)	(0.10, 0.15, 0.25, 0.30)	(0.10, 0.15, 0.25, 0.30)
	(0.40, 0.45, 0.55, 0.60)	(0.55, 0.60, 0.70, 0.75)	(0.00, 0.00, 0.00, 0.10)	(0.55, 0.60, 0.70, 0.75)	(0.90, 1.00, 1.00, 1.00)	(0.00, 0.00, 0.00, 0.10)	(0.40, 0.45, 0.55, 0.60)
P2	(0.00, 0.00, 0.00, 0.10)	(0.55, 0.60, 0.70, 0.75)	(0.10, 0.15, 0.25, 0.30)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.70, 0.75, 0.85, 0.90)	(0.00, 0.00, 0.00, 0.10)
	(0.10, 0.15, 0.25, 0.30)	(0.70, 0.75, 0.85, 0.90)	(0.90, 1.00, 1.00, 1.00)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.90, 1.00, 1.00, 1.00)	(0.25, 0.30, 0.40, 0.45)
D2	(0.40, 0.45, 0.55, 0.60)	(0.55, 0.60, 0.70, 0.75)	(0.70, 0.75, 0.85, 0.90)	(0.40, 0.45, 0.55, 0.60)	(0.00, 0.00, 0.00, 0.10)	(0.55, 0.60, 0.70, 0.75)	(0.00, 0.00, 0.00, 0.10)
P5	(0.90, 1.00, 1.00, 1.00)	(0.70, 0.75, 0.85, 0.90)	(0.70, 0.75, 0.85, 0.90)	(0.10, 0.15, 0.25, 0.30)	(0.55, 0.60, 0.70, 0.75)	(0.25, 0.30, 0.40, 0.45)	(0.00, 0.00, 0.00, 0.10)
P4	(0.00, 0.00, 0.00, 0.10)	(0.55, 0.60, 0.70, 0.75)	(0.55, 0.60, 0.70, 0.75)	(0.70, 0.75, 0.85, 0.90)	(0.90, 1.00, 1.00, 1.00)	(0.00, 0.00, 0.00, 0.10)	(0.70, 0.75, 0.85, 0.90)
	(0.25, 0.30, 0.40, 0.45)	(0.55, 0.60, 0.70, 0.75)	(0.40, 0.45, 0.55, 0.60)	(0.90, 1.00, 1.00, 1.00)	(0.55, 0.60, 0.70, 0.75)	(0.00, 0.00, 0.00, 0.10)	(0.90, 1.00, 1.00, 1.00)
D5	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.10, 0.15, 0.25, 0.30)	(0.40, 0.45, 0.55, 0.60)	(0.25, 0.30, 0.40, 0.45)	(0.55, 0.60, 0.70, 0.75)	(0.55, 0.60, 0.70, 0.75)
FS	(0.40, 0.45, 0.55, 0.60)	(0.25, 0.30, 0.40, 0.45)	(0.25, 0.30, 0.40, 0.45)	(0.40, 0.45, 0.55, 0.60)	(0.40, 0.45, 0.55, 0.60)	(0.25, 0.30, 0.40, 0.45)	(0.25, 0.30, 0.40, 0.45)
P6	(0.70, 0.75, 0.85, 0.90)	(0.90, 1.00, 1.00, 1.00)	(0.70, 0.75, 0.85, 0.90)	(0.00, 0.00, 0.00, 0.10)	(0.40, 0.45, 0.55, 0.60)	(0.25, 0.30, 0.40, 0.45)	(0.10, 0.15, 0.25, 0.30)
	(0.40, 0.45, 0.55, 0.60)	(0.90, 1.00, 1.00, 1.00)	(0.40, 0.45, 0.55, 0.60)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.70, 0.75, 0.85, 0.90)	(0.10, 0.15, 0.25, 0.30)
P7	(0.25, 0.30, 0.40, 0.45)	(0.70, 0.75, 0.85, 0.90)	(0.55, 0.60, 0.70, 0.75)	(0.55, 0.60, 0.70, 0.75)	(0.40, 0.45, 0.55, 0.60)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)
	(0.00, 0.00, 0.00, 0.10)	(0.90, 1.00, 1.00, 1.00)	(0.40, 0.45, 0.55, 0.60)	(0.70, 0.75, 0.85, 0.90)	(0.90, 1.00, 1.00, 1.00)	(0.25, 0.30, 0.40, 0.45)	(0.00, 0.00, 0.00, 0.10)
100	(0.70, 0.75, 0.85, 0.90)	(0.55, 0.60, 0.70, 0.75)	(0.90, 1.00, 1.00, 1.00)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)
P8	(0.90, 1.00, 1.00, 1.00)	(0.40, 0.45, 0.55, 0.60)	(0.90, 1.00, 1.00, 1.00)	(0.25, 0.30, 0.40, 0.45)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)	(0.00, 0.00, 0.00, 0.10)

#### Table 7. Strategic fit values transformed into fuzzy numbers

## Step 6. Aggregation

#### Step 6.1 Aggregate Partial Evaluations for Each Goal-Project Pair

The values in the form of the fuzzy numbers are aggregated with the simple mean operator (2). Since the trapezoidal membership function is linear, to simplify calculations only average values for the respective points (i.e. distinctive values) can be calculated. The results are presented in the Table 8.

Table 8. Aggregation of Strategic Fit values for goal-project pairs	

	Goals						
Project	G1	G2	G3	G4	G5	G6	G7
P1	(0.325, 0.375, 0.475, 0.525)	(0.275, 0.3, 0.35, 0.425)	(0, 0, 0, 0.1)	(0.625, 0.675, 0.775, 0.825)	(0.725, 0.8, 0.85, 0.875)	(0.05, 0.075, 0.125, 0.2)	(0.25, 0.3, 0.4, 0.45)
Р2	(0.05, 0.075, 0.125, 0.2)	(0.625, 0.675, 0.775, 0.825)	(0.5, 0.575, 0.625, 0.65)	(0, 0, 0, 0.1)	(0, 0, 0, 0.1)	(0.8, 0.875, 0.925, 0.95)	(0.125, 0.15, 0.2, 0.275)
P3	(0.65, 0.725, 0.775, 0.8)	(0.625, 0.675, 0.775, 0.825)	(0.7, 0.75, 0.85, 0.9)	(0.25, 0.3, 0.4, 0.45)	(0.275, 0.3, 0.35, 0.425)	(0.4, 0.45, 0.55, 0.6)	(0, 0, 0, 0.1)
P4	(0.125, 0.15, 0.2, 0.275)	(0.55, 0.6, 0.7, 0.75)	(0.475, 0.525, 0.625, 0.675)	(0.8, 0.875, 0.925, 0.95)	(0.725, 0.8, 0.85, 0.875)	(0, 0, 0, 0.1)	(0.8, 0.875, 0.925, 0.95)
P5	(0.2, 0.225, 0.275, 0.35)	(0.125, 0.15, 0.2, 0.275)	(0.175, 0.225, 0.325, 0.375)	(0.4, 0.45, 0.55, 0.6)	(0.325, 0.375, 0.475, 0.525)	(0.4, 0.45, 0.55, 0.6)	(0.4, 0.45, 0.55, 0.6)
P6	(0.55, 0.6, 0.7, 0.75)	(0.9, 1, 1, 1)	(0.55, 0.6, 0.7, 0.75)	(0, 0, 0, 0.1)	(0.2, 0.225, 0.275, 0.35)	(0.475, 0.525, 0.625, 0.675)	(0.1, 0.15, 0.25, 0.3)
<b>P</b> 7	(0.125, 0.15, 0.2, 0.275)	(0.8, 0.875, 0.925, 0.95)	(0.475, 0.525, 0.625, 0.675)	(0.625, 0.675, 0.775, 0.825)	(0.65, 0.725, 0.775, 0.8)	(0.125, 0.15, 0.2, 0.275)	(0, 0, 0, 0.1)
P8	(0.8, 0.875, 0.925, 0.95)	(0.475, 0.525, 0.625, 0.675)	(0.9, 1, 1, 1)	(0.125, 0.15, 0.2, 0.275)	(0, 0, 0, 0.1)	(0, 0, 0, 0.1)	(0, 0, 0, 0.1)

#### Step 6.2 Aggregate on a Project Level

To aggregate the values for the goals for each of the projects a mean of the goals' values is calculated. The resulting output is a fuzzy number for each project (see Table 9).

Project	Aggregated fuzzy number	Crisp value
P1	(0.3214, 0.3607, 0.4250, 0.4857)	0,393
P2	(0.3000, 0.3357, 0.3786, 0.4429)	0,357
P3	(0.4143, 0.4571, 0.5286, 0.5857)	0,493
P4	(0.4964, 0.5464, 0.6036, 0.6536)	0,575
Р5	(0.2893, 0.3321, 0.4179, 0.4750)	0,375
P6	(0.3964, 0.4429, 0.5071, 0.5607)	0,475
P7	(0.4000, 0.4429, 0.5000, 0.5571)	0,471
P8	(0.3286, 0.3643, 0.3929, 0.4571)	0,379

Table 9. Aggregation and Defuzzification of Strategic fit values for each project

#### Step 7. Defuzzification

Finally, the aggregated fuzzy numbers are defuzzified with the MoM method (3). This means, that for further processing we need to take the values with the highest membership. In cases of trapezoidal membership functions these are all the values lying on the top horizontal line of the trapezoids with the membership equal to 1. Then, the MoM corresponds to a midpoint of that line. The Table 9 comprises the rounded up values of strategic fit for each of the projects.

## **Concluding Discussion**

This research is motivated by the importance of strategic fit as one of the criteria for strategic projects evaluation and selection. In response to the obstacles of strategic fit assessment, such as uncertainty and impreciseness of information, complexity and vagueness of the strategic fit notion itself, and finally lack of formalized approaches, a method based on fuzzy logic has been developed.

The method treats strategic fit as a certain relation between a project and strategic goals. This relation is assessed by evaluators in natural language, while the method employs a fuzzy set theory to aggregate and transform the linguistic values into numeric output.

The study suggests a way to include the strategic fit aspect in common and standardized practices of project portfolio evaluation and selection, namely quantitative MCDA methods. Thus, this study should be valuable for practitioners in strategic and project portfolio management, and related fields of MCDA. Additionally the research highlights another field of application for the fuzzy linguistic evaluation.

One of the key features of the suggested method is "reuse" of strategic goals for project screening purposes. Not only are strategic goals natural criteria for the strategic fit evaluation, but this solution results in high generality and universality of the method as well. The method can be adopted for virtually any business case (industry, business line, etc.), as long as the practice of strategic goals setting is employed.

This is different to a typical MCDA approach, where the goals as criteria are specifically defined for the decision-making case, as in Hsu (2003). While more suitable for a given case, particular criteria are less applicable in other cases. In opposite, direct employment of strategic goals ensures instant adaptation of the method, for instance, in the case of a strategy change. Finally, the approach itself reinforces such a view on strategic alignment, as consistent, interdependent and goal-oriented decision-making.

While underlying fuzzy set theory is not quite common and thus, overall might be difficult to comprehend for managers, the selected mathematical operators are quite straight-forward and light calculation-wise. All the calculations are gathered in one phase and have been fully automated with a tabular processor. Finally, the assessment of strategic fit in natural language should further improve usability and accessibility of the method.

While being promising, the research has some limitations. The suggested method is mostly based on theoretical considerations, and thus, should be further tried on real-life cases to draw any conclusions on its feasibility and effectiveness. Future research should therefore concentrate on the investigation of actual human assessment and judgement making when applying the method. Also, the method is designed to be incorporated with a MCDA tool for project portfolio evaluation. Thus, possible interpretations of the method output, as well as actual specification how the method could be integrated in the project selection process, are required. Another direction for future research is taking into account interrelations both among the strategic goals and among the projects. The effect of alternative aggregation techniques warrants investigation, for instance aggregation that allows for weighing of evaluators assessments according to credibility.

Acknowledgments. The authors would like to thank the Aurenav company's managers for their cooperation.

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# An Inconsistency-rectifying Approach to Group Decision Making with Intuitionistic Preference Relations

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**Abstract**: A framework is proposed to investigate group decision making (GDM) problems where decision-makers' (DMs') preferences are expressed as intuitionistic preference relations and priority weights of DMs are completely unknown. An inconsistency rectification approach is first introduced to obtain consistent intuitionistic preference relations based on inconsistent input. An induced intuitionistic ordered weighted averaging (IIOWA) operator is developed to aggregate intuitionistic fuzzy numbers. A paradigm is then put forward to solve GDM problems with intuitionistic preference relations.

**Keywords**: Group decision making (GDM); Intuitionistic preference relation; Consistency; Aggregation; Induced intuitionistic ordered weighted averaging (IIOWA) operator.

## Introduction

Based on the notion of intuitionistic fuzzy sets (IFSs) (Atanassov, 1986), intuitionistic preference relations were proposed as a useful tool for expressing DMs' judgment with hesitancy or indeterminacy in decision analysis (Xu, 2007a). As a key issue in intuitionistic preference relations, consistency has been investigated by many researchers (Xu, 2007b; Xu et al., 2011; Gong et al., 2011; Xu, 2012; Wang, 2013). Various definitions have been discussed, and different approaches have been developed to derive priority weights of intuitionistic preference relations.

In the process of group decision making (GDM), a critical challenge is to aggregate individual preference information into a consistent group preference. This is further complicated by the fact that individual preference relations furnished by DMs are often inconsistent. To effectively tackle these issues, this research first develops a practical method to rectify inconsistency of intuitionistic preference relations. Subsequently, an induced intuitionistic ordered weighted averaging (IIOWA) operator is proposed to aggregate intuitionistic preference relations is employed as an order inducing variable of the IIOWA operator to aggregate the rectified intuitionistic preference relations. Finally, a paradigm is put forward to solve GDM problems with intuitionistic preference relations.

## Preliminaries

Definition 1 (Atanassov, 1986) Let a nonempty set Z be fixed, an IFS A in Z can be defined as

$$A = \{ \langle z, \mu_A(z), \nu_A(z) \rangle | z \in Z \}$$
(1)

where the functions  $\mu_A(z)$  and  $\nu_A(z)$  satisfy  $0 \le \mu_A(z) \le 1, 0 \le \nu_A(z) \le 1, \mu_A(z) + \nu_A(z) \le 1, \forall z \in \mathbb{Z}$ .

 $\mu_A(z)$  and  $\nu_A(z)$  denote the membership and non-membership degree of element z to set A, respectively. In addition,  $\pi_A(z) = 1 - \mu_A(z) - \nu_A(z)$  measures the hesitancy of z to A. Obviously,  $0 \le \pi_A(z) \le 1$  for every  $z \in Z$ .

For a given z and IFS A, the pair  $(\mu_A(z), \nu_A(z))$  is referred to as an IFN (Xu and Yager, 2006). For convenience, an IFN is often denoted by  $\tilde{\alpha} = (\mu, \nu)$ , where  $0 \le \mu, \nu \le 1$  and  $\mu + \nu \le 1$ .

**Definition 2** (Wang, 2013) An intuitionistic preference relation  $\tilde{R} = (\tilde{r}_{ij})_{n \times n}$  with  $\tilde{r}_{ij} = (\mu_{ij}, v_{ij})$  is additive consistent if the following additive transitivity is satisfied

$$\mu_{ij} + \mu_{jk} + \mu_{ki} = \mu_{kj} + \mu_{ji} + \mu_{ik} \quad \text{for all } i, j, k = 1, 2, ..., n$$
(2)

Since  $\mu_{ij} = v_{ji}, v_{ij} = \mu_{ji}$  for all i, j = 1, 2, ..., n, it follows from (2) that

$$v_{ij} + v_{jk} + v_{ki} = v_{kj} + v_{ji} + v_{ik}$$
 for all  $i, j, k = 1, 2, ..., n$  (3)

**Lemma 1** (Wang, 2013) An intuitionistic preference relation  $\tilde{R} = (\tilde{r}_{ij})_{n \times n}$  is additive consistent if and only if

$$S(\tilde{r}_{ij}) = S(\tilde{r}_{ik}) - S(\tilde{r}_{jk}) \quad \text{for all } i, j, k = 1, 2, ..., n.$$
(4)

where  $S(\tilde{r}_{ij}) = \mu_{ij} - v_{ij}$ .

# **Rectification of Inconsistent Intuitionistic Preference Relations**

**Theorem 1** Let  $\tilde{R} = (\tilde{r}_{ij})_{n \times n}$  with  $\tilde{r}_{ij} = (\mu_{ij}, v_{ij})$  be an intuitionistic preference relation, and  $\hat{\mu}_{ij}$  and  $\hat{v}_{ij}$  (i, j = 1, 2, ..., n) be defined by

$$\hat{\mu}_{ij} = \frac{1}{2n} \left( \sum_{l=1}^{n} S(\tilde{r}_{il}) - \sum_{l=1}^{n} S(\tilde{r}_{jl}) \right) + 0.5 \left( 1 - \pi(\tilde{r}_{ij}) \right) \quad i, j = 1, 2, ..., n$$
(5)

and

$$\hat{v}_{ij} = \frac{1}{2n} \left( \sum_{l=1}^{n} S(\tilde{r}_{jl}) - \sum_{l=1}^{n} S(\tilde{r}_{il}) \right) + 0.5 \left( 1 - \pi(\tilde{r}_{ij}) \right) \quad i, j = 1, 2, ..., n$$
(6)

respectively, then

$$\begin{array}{ll} (i) \quad \hat{\mu}_{ii} = \hat{v}_{ii} = 0.5 \quad \forall i = 1, 2, ..., n \,. \\ (ii) \quad 0 \leq \hat{\mu}_{ij} + \hat{v}_{ij} \leq 1 \quad \forall i, j = 1, 2, ..., n \,. \\ (iii) \quad \hat{\mu}_{ij} = \hat{v}_{ji} \quad \text{and} \quad \hat{v}_{ij} = \hat{\mu}_{ji} \quad \forall i, j = 1, 2, ..., n \,. \\ (iv) \quad \hat{\mu}_{ij} + \hat{v}_{ij} = \mu_{ij} + v_{ij} \quad \forall i, j = 1, 2, ..., n \,. \\ (v) \quad \hat{\mu}_{ij} + \hat{\mu}_{jk} + \hat{\mu}_{ki} = \hat{\mu}_{kj} + \hat{\mu}_{ji} + \hat{\mu}_{ik} \quad \forall i, j, k = 1, 2, ..., n \\ (vi) \quad \hat{v}_{ij} + \hat{v}_{jk} + \hat{v}_{ki} = \hat{v}_{kj} + \hat{v}_{ji} + \hat{v}_{ik} \quad \forall i, j, k = 1, 2, ..., n \end{array}$$

**Corollary 1** If  $\hat{\mu}_{ij} \ge 0$  and  $\hat{v}_{ij} \ge 0$  for all i, j = 1, 2, ..., n, then  $\hat{\tilde{R}} = (\hat{\tilde{r}}_{ij})_{n \times n}$  is a consistent intuitionistic preference relation and  $\pi(\hat{\tilde{r}}_{ij}) = \pi(\tilde{r}_{ij})$ .

**Theorem 2** If  $\tilde{R} = (\tilde{r}_{ij})_{n \times n}$  is a consistent intuitionistic preference relation, then  $\hat{\tilde{R}} = \tilde{R}$ .

Let

$$d = \begin{cases} 0, & \text{if } \hat{\mu}_{ij} \ge 0, \forall i, j = 1, 2, ..., n \\ \max\{ \left| \hat{\mu}_{ij} \right| \mid \hat{\mu}_{ij} < 0, i, j = 1, 2, ..., n \}, & \text{Otherwise} \end{cases}$$
(7)

It is obvious that  $d \ge 0$ , and  $\hat{\mu}_{ij} \ge -d$ ,  $\forall i, j = 1, 2, ..., n$ . As per Theorem 1, one obtains  $\hat{\nu}_{ij} = \hat{\mu}_{ji} \ge -d, 0 \le \hat{\mu}_{ij} + \hat{\nu}_{ij} \le 1$ ,  $\forall i, j = 1, 2, ..., n$ . Thus, we have  $\hat{\mu}_{ij} \in [-d, 1+d], \hat{\nu}_{ij} \in [-d, 1+d]$  $\forall i, j = 1, 2, ..., n$ .

**Theorem 3** Let  $\tilde{R} = (\tilde{r}_{ij})_{n \times n}$  be an intuitionistic preference relation, and  $\hat{\tilde{R}} = f_0(\hat{\tilde{R}}) = (\hat{\tilde{r}}_{ij})_{n \times n}$  be defined by

$$\hat{\vec{r}}_{ij} = (\hat{\mu}_{ij}, \hat{v}_{ij}) = f_0(\hat{\vec{r}}_{ij}) = \left(\frac{\hat{\mu}_{ij} + d}{1 + 2d}, \frac{\hat{v}_{ij} + d}{1 + 2d}\right),$$
(8)

then  $\hat{\tilde{R}}'$  is a consistent intuitionistic preference relation and  $\pi(\hat{\tilde{r}}_{ij}) = \frac{1}{1+2d} \pi(\tilde{r}_{ij})$ .

The aforesaid rectification process can be conveniently applied to rectify any inconsistent intuitionistic preference relation  $\tilde{R}$  to derive a consistent relation.

# Group Decision Making with Intuitionistic Preference Relations IIOWA Operator

**Definition 3** (Yager and Filev, 1999) An IOWA operator is a function  $IOWA: (\Re \times \Re)^m \to \Re$  defined by an associated weighting vector  $\omega = (\omega_1, \omega_2, ..., \omega_m)^T$  of dimension *m* satisfying the normalization conditions  $\sum_{i=1}^{m} \omega_i = 1$  and  $\omega_i \in [0,1]$  (i = 1, 2, ..., m), and a set of pairs  $\{< I_1, a_1 >, < I_2, a_2 >, ..., < I_m, a_m >\}$ , according to the following expression:

$$IOWA_{\omega}(, , ..., ) = \sum_{i=1}^m \omega_i a_{\sigma(i)}$$
(9)

where  $\sigma$  is a permutation of  $\{1, 2, ..., m\}$  such that  $I_{\sigma(i)} \ge I_{\sigma(i+1)}$  for each i = 1, 2, ..., m-1, i.e.,  $(a_{\sigma(1)}, a_{\sigma(2)}, ..., a_{\sigma(m)})$  is the reordering of  $(a_1, a_2, ..., a_m)$  as per a decreasing order of  $I_i$  (i = 1, 2, ..., m).

In Definition 3,  $I_i$  in the pair  $\langle I_i, a_i \rangle$  is referred to as the value of an order inducing variable and  $a_i$  as the value of an argument variable. The direction of the reordering may be generalized as an ascending order.

**Definition 4** Let  $\alpha_i = (\mu_i, v_i)$  (*i* = 1, 2, ..., *m*) be *m* IFNs, then an induced intuitionistic ordered weighted averaging (IIOWA) operator is defined as:

$$IIOWA_{\omega}(,,...,) = (IOWA_{\omega}(,,...,), IOWA_{\omega}(,,...,))$$
(10)  
$$= \left(\sum_{i=1}^{m} \omega_{i}\mu_{\sigma(i)},\sum_{i=1}^{m} \omega_{i}\nu_{\sigma(i)}\right)$$

where  $\omega = (\omega_1, \omega_2, ..., \omega_m)^T$  is an associated weighting vector with  $\sum_{i=1}^m \omega_i = 1$  and  $\omega_i \in [0,1]$  (i = 1, 2, ..., m),

 $I_i$  is the value of an order inducing variable (*i* = 1, 2, ..., *m*), and  $\sigma$  is a permutation of {1, 2, ..., *m*} such that  $I_{\sigma(i)} \leq I_{\sigma(i+1)}$  for *i* = 1, 2, ..., *m*-1.

**Theorem 4** The IIOWA operator defined in (10) is idempotent, commutative, bounded and monotonic with respect to the order based on score and accuracy functions.

#### **IIOWA Based Aggregation of Intuitionistic Preference Relations**

The IIOWA operator allows us to develop many aggregation approaches for different decision problems under an intuitionistic fuzzy environment. By applying the IIOWA operator to aggregate intuitionistic preference relations, the following results are obtained.

**Theorem 5** Let  $\tilde{R}^k = (\tilde{r}_{ij}^k)_{n \times n}$  with  $\tilde{r}_{ij}^k = (\mu_{ij}^k, v_{ij}^k)$  (k = 1, 2, ..., m) be *m* intuitionistic preference relations, and  $I_k$  (k = 1, 2, ..., m) be *m* values of the order inducing variables, then the aggregation  $\tilde{R}^G = (\tilde{r}_{ij}^G)_{n \times n} = ((\mu_{ij}^G, v_{ij}^G))_{n \times n} = (IIOWA_{\omega}(< I_1, \tilde{r}_{ij}^1 >, < I_2, \tilde{r}_{ij}^2 >, ..., < I_m, \tilde{r}_{ij}^m >))_{n \times n}$  is also an intuitionistic preference relation.

**Theorem 6** If  $\tilde{R}^k = (\tilde{r}^{\kappa}_{ij})_{n \times n} = \left( (\mu^k_{ij}, v^k_{ij}) \right)_{n \times n}$  (k = 1, 2, ..., m) is a consistent intuitionistic preference relation, then  $\tilde{R}^G = (\tilde{r}^G_{ij})_{n \times n} = \left( (\mu^G_{ij}, v^G_{ij}) \right)_{n \times n} = \left( IIOWA_{\omega}(< I_1, \tilde{r}^1_{ij} >, < I_2, \tilde{r}^2_{ij} >, ..., < I_m, \tilde{r}^m_{ij} >) \right)_{n \times n}$  is consistent.

#### A Paradigm for GDM with Intuitionistic Preference Relations

**Definition 5** Let  $\tilde{R} = (\tilde{r}_{ij})_{n \times n} = ((\mu_{ij}, v_{ij}))_{n \times n}$  and  $\tilde{R}' = (\tilde{r}'_{ij})_{n \times n} = ((\mu'_{ij}, v'_{ij}))_{n \times n}$  be any two intuitionistic preference relations, the mean absolute deviation (MAD) between  $\tilde{R}$  and  $\tilde{R}'$  is defined as:

$$MAD(\tilde{R}, \tilde{R}') = \frac{1}{2n(n-1)} \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} \left( \left| \mu_{ij} - \mu'_{ij} \right| + \left| v_{ij} - v'_{ij} \right| \right)$$
(11)

By applying (11) in  $\hat{R}^{'k}$  and  $\tilde{R}^{k}$  for each k = 1, 2, ..., m, we have a set of m MAD values  $\{MAD(\hat{R}^{'k}, \tilde{R}^{k}) | k = 1, 2, ..., m\}$ . The smaller the value of  $MAD(\hat{R}^{'k}, \tilde{R}^{k})$ , the higher the importance level for  $\hat{R}^{'k}$  is assigned in the aggregation process. Thus,  $MAD(\hat{R}^{'k}, \tilde{R}^{k})$  can be used to define an order inducing variable in the aggregation of  $\hat{R}^{'k}$  (k = 1, 2, ..., m). For the order inducing variable  $MAD(\tilde{R}^{k}, \hat{R}^{'k})$ , its associated weight is defined as follows:

$$\omega_{k} = \frac{\left(1 - MAD(\hat{\vec{R}}^{'\sigma(k)}, \tilde{\vec{R}}^{\sigma(k)})\right)^{\lambda}}{\sum_{k=1}^{m} \left(1 - MAD(\hat{\vec{R}}^{'\sigma(k)}, \tilde{\vec{R}}^{\sigma(k)})\right)^{\lambda}} \qquad k = 1, 2, ..., m$$
(12)

where  $\lambda \in (0, +\infty)$ .

Based on the associated weights determined by (12), a group intuitionistic preference relation  $\tilde{R}^{'G} = (\tilde{r}_{ij}^{'G})_{n \times n}$  with  $\tilde{r}_{ij}^{'G} = (\mu_{ij}^{'G}, v_{ij}^{'G})$  can be derived from  $\hat{R}^{'k}$  (k = 1, 2, ..., m) by employing the IIOWA operator. According to Theorem 6, we know that  $\tilde{R}^{'G}$  is consistent.

**Theorem 7** Let  $S_i$  (i = 1, 2, ..., n) be defined by

$$s_i = \frac{1}{n} \sum_{j=1}^n S(\tilde{r}_{ij}^{G}) \qquad i = 1, 2, ..., n$$
(13)

If  $S(\tilde{r}_{i_0,j_0}^{'G}) \ge 0$   $(i_0, j_0 \in \{1, 2, ..., n\})$ , then  $s_{i_0} \ge s_{j_0}$ .

Based on the aforesaid analyses allow for the development of a solution algorithm for solving GDM with intuitionistic preference relations.

## Conclusion

Consistency and aggregation of intuitionistic preference information play important roles in deriving a rational decision result for GDM with intuitionistic preference relations. Based on inconsistency rectification and a new aggregation operation, this article develops a useful framework to handle GDM problems with intuitionistic preference relations. Further research is needed to deal with cases when some preference values are missing or the rectified consistency requirement is relaxed to an acceptable consistency level.

Acknowledgements. Zhou-Jing Wang would like to acknowledge the financial support by the National Natural Science Foundation of China (NSFC) (Grant #: 71271188). Kevin W. Li is grateful for the financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC) under its Discovery Grant program and the National Natural Science Foundation of China (Grant #: 71272129).

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