EWG-MCDA

EURO Working Group on Multicriteria Decision Aiding

81èmes journées ADMC

81st meeting MCDA

Actes / Proceedings

Annecy le Vieux France

26-28 mars 2015

POLYTECH ANNECY-CHAMBÉRY

LISTIC

iae Savoie Mont-Blanc

Bienvenue, Welcome

Le LISTIC est très heureux d'accueillir les 81èmes journées d'Aide à la Décision MultiCritère dans les locaux de Polytech Annecy Chambéry et de l'IAE Savoie Mont-Blanc. Il s'associe à l'initiative du Groupe de Travail Européen ADMC qui rend hommage au fondateur de ces journées, le professeur Bernard Roy. Que Bernard continue longtemps à y participer aussi activement et contribue à y faire régner cet esprit scientifique et amical qui caractérise ce groupe.

Merci à tous les participants qui ont soumis leurs travaux pour être exposés et discutés autour de la thématique de l'aide à la décision en général et dans le cadre des entreprises en particulier. Un remerciement spécial aux industriels qui accompagnent le LISTIC depuis longtemps autour de l'aide à la décision en milieu de production (ils nous relateront leur expérience et leurs questionnements) et à Didier Dubois pour nous faire part de ses réflexions sur l'attitude du décideur dans un tel contexte.

Au nom de l'équipe d'organisation je vous souhaite des journées scientifiques et conviviales et espère que votre séjour sur Annecy sera des plus agréables.

The LISTIC laboratory is very happy to welcome the 81st meeting of the Euro Working Group on MultiCriteria Decision Aiding at the Polytech Annecy Chambery and IAE Savoie Mont-Blanc campus. It partners with the Euro Working Group on MCDA to honour the meeting founder, Professor Bernard Roy. We hope that Bernard will continue for a long time to actively participate to this meeting, and contribute to this scientific and friendly spirit that characterizes the days.

I thank you all the participants for their submission concerning the general topic of the decision aiding and particularly when applied in the real economic world. I thank you a lot the companies that have been involved for a long time with us on the company decision aiding theme and Didier Dubois who has accepted to share with us his reflexion about the decision-maker behaviour in a such context.

In the name of the organisation team, I wish you scientific and friendly days and I hope that your stay in Annecy will be nice.

Vincent Clivillé

EWG-MCDA
EURO Working Group on Multicriteria Decision Aiding

LISTIC

Programme / Program

Day 1: Jeudi 26 mars 2015 Thursday 26th March 2015	
10:00 – 12:45 **Hall Polytech**	**Enregistrement / Registration of participants**
12:45 – 13:00 **IAE SMB**	**Mot de bienvenue / Welcome address**
13:00 – 14:30 **IAE SMB** **Amphi 108**	**Session 1, Chair: M. Norese**
	V. Ferretti, J. Liu, V. Mousseau, Learning the Parameters of a Ranking Model Using Multiple Reference Points: A Case Study Dealing with Large Datasets
	V. R. Cappelli, S. Cerreia-Vioglio, F. Maccheroni, M. Marinacci, Varying Risk Confidence
	A. Giarlotta, S. Greco, F.Maccheroni, M. Marinacci, Rational preference and rationalizable choice, Necessary and Possible Rankings in Decision Making under Uncertainty
Articles soumis à discussion / Discussion papers *S. Angilella, S. Corrente, S. Greco, R. Słowiński,* Robust Ordinal Regression and SMAA in Multiple Criteria Hierarchy Process for the Choquet Integral *W. K. M. Brauers, E. K. Zavadskas,* The Ordinal Dominance Theory as applied for the most attractive Retail Cities of BENELUX *A. Mendas,* MCDM and GIS to identify land suitability for agriculture *A. De Boni, K.Govindan, G. Ottomano Palmisano, R. Roma,* Bottom-up strategy in the fishing sector: a multicriteria approach for assessing sustainable development of the fisheries local action groups in Apulia region, Italy.	
14:30 – 14:45	**Pause café / Coffee break**
14:45 – 16:30 **IAE SMB** **Amphi 108**	**Session 2, Chair: Y. De Smet**
	J. Branke, S. Corrente, S. Greco, R. Słowiński, P. Zielniewicz, Interactive Evolutionary Multiobjective Optimization with Choquet Integral Preference Model Derived by Robust Ordinal Regression
	M.F. Norese, A.Scarelli, New frontiers for MCDA: from hundreds of indicators to structured models and processes of decision aiding
	Y. Hassane, Modélisation d'un problème de décisions multiniveaux multicritères de gestion de la sureté aéroportuaire
Articles soumis à discussion / Discussion papers *Alberto Graça Lopes Peixoto Neto et Maria Lucia Galves,* Cognitive Map for Improving Integrative Negotiation in Business-to-Business Freight Transportation Services *R. Sarrazin, Y. De Smet, J. Rosenfeld,* An extension of PROMETHEE to interval clustering *Hsu-Shih Shih, Wen-Pu Wu,* A Formulation of DM's Risk Attitude in ELECTRE III *M. Kadzinki, T. Mieszkowski, M. Tomczyk,* Construct your own ELECTRE	
16:30 – 16:45	**Pause café / Coffee break**
16:45 – 18:30 **IAE SMB** **Amphi 108**	**Session 3 – Table ronde en l'honneur de Bernard Roy / Round table in Honor of Bernard Roy** Quelles sont les caractéristiques de l'apport méthodologique des membres du groupe à l'AMCD ? / What are characteristic features of the methodological contribution of group members to MCDA? *Yannis Siskos, Jean-Claude Vansnick, Salvatore Greco, Yves De Smet, Jose Figueira, Constantin Zopounidis, Maria-France Norese, Jean Moscarola.* ***Intervention de clôture par Bernard Roy / Closing address by Bernard Roy*** **Chair: Roman Slowiński**
18:30	**Fin de la 1ère journée / End of day 1**
20:00 – 23:00	***Diner de gala / Official Dinner*** ***Restaurant Le Clocher Annecy le Vieux***

<table>
<tr><td colspan="2">Day 2: Vendredi 27 mars Friday 27th March 2015</td></tr>
<tr><td>9:00 – 10:45</td><td>Session 4, Chair: Y. Siskos</td></tr>
<tr><td rowspan="3">Polytech
Amphi B120</td><td>J. Moscarola, La décision en action. De la réflexion à l'expérience.</td></tr>
<tr><td>S. Ben Amor, M. De Vicente, J. Manera,
A Multicriteria Approach to Patient Classification Systems Evaluation</td></tr>
<tr><td>A. Spyridakos, Y. Siskos, N. Tsotsolas, D. Yannacopoulos, Exploring the robustness of elicited weights in MCDA approaches by using new measures and feedbacks</td></tr>
<tr><td colspan="2"><u>Articles soumis à discussion / Discussion papers</u>
M. Stamenković, I.Anić, M.Petrović, N.Bojković, Sensitivity analysis of ELECTRE-based stepwise benchmarking model
F. Ben Abdelaziz, Optimizing Cost and Quality of International Calls Routing Using Multi-Objective Optimization Techniques Considering Route Availability</td></tr>
<tr><td>10:45 – 11:00</td><td>Pause café / Coffee break</td></tr>
<tr><td>11:00 – 12:30</td><td>Session 5, Chair: K. Govindan</td></tr>
<tr><td rowspan="3">Polytech
Amphi B120</td><td>V. Clivillé, S. Corrente, S. Greco, B. Rizzon, Feasible Optimization</td></tr>
<tr><td>A. Ishizaka, K. Antoniades Are inconsistent decisions better? An interactive experiment with pair comparisons</td></tr>
<tr><td>M. Couceiro, B.Teheux, Median preserving aggregation functions</td></tr>
<tr><td colspan="2"><u>Articles soumis à discussion / Discussion papers</u>
E. Gabla, A. Frini, B. Urli, La sélection de projet dans un contexte de développement durable en présence d'incertitude : choix de l'aménagement forestier du territoire de l'UAF 042-52
O.E. Demesouka, K.P. Anagnostopoulos, Y. Siskos, Spatial ordinal regression for multicriteria land-use decision support in Northeastern Greece
B. Rizzon, S. Galichet, V. Clivillé, Un état de l'art de l'aide à la décision en Génie Industriel</td></tr>
<tr><td>12:30 – 14:00</td><td>Lunch break</td></tr>
<tr><td>14:00 – 14:30</td><td>Vie du groupe ADMC / EWG MCDA events</td></tr>
<tr><td>14:30 – 16:00
Polytech
Amphi B120</td><td>Session 6, Attitude du décideur dans un contexte d'entreprise, Behavioral aspects of decision aiding in real economic context Chair: Jean Moscarola
Christian Farat Société, Témoignage sur la décision dans l'entreprise Fournier (MOBALPA)
Sébastien Jalmain, Témoignage sur la décision dans la démarche d'amélioration continue de la Société ADIXEN Pfeiffer
Didier Dubois, Decision, uncertainty and decision-maker behavior: some new questions</td></tr>
<tr><td colspan="2"><u>Articles soumis à discussion / Discussion papers</u>
L. Berrah, J. Montmain, G. Mauris, L. Foulloy, V. Clivillé,
Attitude du décideur et déclaration des objectifs dans une démarche d'amélioration industrielle
M. A. de Vicente, M. Alvarado, R. Garcia Vegas, J. M.Bassa, A Multicriteria Evaluation of Social Innovation</td></tr>
<tr><td>16:00 – 16:15</td><td>Pause café / Coffee break</td></tr>
<tr><td>16:15 – 17:45</td><td>Session 7, Chair: A. Ishikaza</td></tr>
<tr><td rowspan="3">Polytech
Amphi B120</td><td>A. Oppio, M. Bottero, V. Ferretti, Designing and evaluating alternative adaptative reuses for cultural heritage: a proposal of integration between choice experiments and social multicriteria analysis</td></tr>
<tr><td>M. Ghaderi, F. Javier Ruiz, N. Agell, On the Strategies of Criteria Discretization and Subintervals Design in UTA-like Methods</td></tr>
<tr><td>G. Paschalidou, N. Vesyropoulos, V. Kostoglou, E. Stiakakis and C. K. Georgiadis Evaluation of educational open-source software using multicriteria decision analysis methods</td></tr>
<tr><td colspan="2"><u>Articles soumis à discussion / Discussion papers</u>
M. Doumpos, C. Zopounidis, Data-driven robustness analysis for MCDA preference disaggregation approaches
E. Siskos, J.Psarras, Bipolar robustness control methodology in disaggregation MCDA approaches: Application to European e-government evaluation
N. Matsatsinis, P. Manolitzas, E.Grigoroudis, G-MEDUTA: A Group Decision Making Methodology for improving the health care services of an Emergency department</td></tr>
<tr><td>17:45 – 18:00</td><td>Conclusion</td></tr>
</table>

Day 3: Saturday 28th March 2015	
9:30 – 16:00	**Activité sociale du groupe / Group social activity:** **Excursion à Yvoire / Excursion to Yvoire**

Session 1

Learning the Parameters of a Ranking Model Using Multiple Reference Points: A Case Study Dealing with Large Datasets

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Abstract

Nowadays, decision making processes are more and more complicated by decision problems involving large datasets, which require adapting and improving the algorithms and technics to construct acceptable recommendations. In this study, we propose the use of a newly introduced family of qualitative models for multi-criteria decision aid named Ranking with Multiple reference Points (RMP) (Rolland, 2013). Perticularly, we are more concerned about a Simplified RMP model (Zheng et al., 2012; Bouyssou et al., 2013), namely S-RMP model. This method is based on pairwise comparisons, but instead of directly comparing any pair of alternatives, it compares rather the alternatives to a set of predefined reference points. The idea is to construct the global preference relation between two alternatives on the basis of their relative comparisons with specified reference points.

The contribution aims at investigating the performance of the following three S-RMP preference elicitation approaches in decision problems concerning large datasets: (i) the exact algorithm for inferring S-RMP model without considering inconsistency (Zheng et al., 2012), (ii) the adapted algorithm taking account of the inconsistent data (Liu et al., 2013) and (iii) the metaheuristic algorithm, which is a combination of an Evolutionary Algorithm and a Linear Programming approach to deal efficiently with large datasets (Liu et al., 2014).

The three approaches have been tested by simulating the decision making process for the location of an undesirable facility, by using publicly available data for the problem under analysis and by organising a focus group with different participants for the elicitation of the preference information. The aim of the evaluation is to rank the suitable sites to host a new landfill on the basis of different criteria, such as presence of population, hydrogeological vulnerability, agricultural value, land use capacity, interferences on transport infrastructures and economic costs. This study represents one of the first applications of the RMP approach to a real-world problem and has thus an innovative value.

Keywords: preference learning, ranking with multiple reference points, large datasets

References

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[2] Antoine Rolland. Reference-based preferences aggregation procedures in multi-criteria decision making. European Journal of Operational Research, pages 479 – 486, (2013).

[3] Jinyan Liu, Vincent Mousseau, and Wassila Ouerdane, 'Preference elicitation from inconsistent pairwise comparisons for multi-criteria ranking with multiple reference points', ICISO 2013, page 120, (2013).

[4] Jinyan Liu, Wassila Ouerdane, and Vincent Mousseau, 'A metaheuristic approach for preference learning in multi-criteria ranking based on reference points', DA2PL 2014, page 76, (2014).

[5] Jun Zheng, Antoine Rolland, and Vincent Mousseau. 'Preference elicitation for a ranking method based on multiple reference profiles', Technical report, Laboratoire Génie Industriel, École Centrale Paris, August 2012. Cahiers de recherche 2012-05.

Varying Risk Confidence

Veronica Roberta Cappelli, Simone Cerreia-Vioglio, Fabio Maccheroni, Massimo Marinacci

Abstract

There is by now solid empirical evidence on the dependence of the risk attitudes of decision makers on the risk source (or domain, or context, or time-frame) they are facing. In a nutshell, source preference is the assertion that between two prospects yielding the same distribution of outcomes, decision makers may have a strict preference for one over the other. In this paper, source specfic risk taking is modeled through a family of source dependent utility functions over outcomes so that each prospect's certainty equivalent is evaluated by means of a utility function that depends on the family of scenarios that are outcome relevant for that specific prospect (its source of risk) and the certainty equivalents of the different prospects are then compared. The approach is axiomatic, thus allowing to understand the behavioral underpinnings of the proposed model and test it in an experimental lab.

In an MCDA perspective, each risk source can be considered as a different criterion. In fact, the source determines the criterion used to evaluate the prospects depending on it.

The current results focus on prospects depending on a single source. We are investigating the possibility of extending our results to the case of prospects depending on multiple, possibly correlated, sources of uncertainty.

RATIONAL PREFERENCE AND RATIONALIZABLE CHOICE

Necessary and Possible Rankings in Decision Making under Uncertainty

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We consider decision problems under uncertainty. The decision maker is characterized by two binary relations. The first reflects the stable part of her preferences while the second reflects the burden of choice. This two relations are known in the domain of decision making under uncertainty with the names of Bewley and Justifiable preferences and they correspond to the Necessary and Possible preferences arising in robust ordinal regression in multiple criteria decision aiding.

We show that a simple set of axioms allows a joint representation of the two relations by a single set of probabilities and a single utility index. Given two acts f and g, f is necessarily preferred to g if and only if the expected utility of f is at least as high as that of g for each probability in the set, while f is possibly preferred to g if and only if the expected utility of f is at least as high as that of g for at least one probability in the set.

Robust Ordinal Regression and SMAA in Multiple Criteria Hierarchy Process for the Choquet Integral

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Interaction among criteria and hierarchical structure of criteria are two important issues of Multiple Criteria Decision Aiding. Interaction among criteria is often dealt with fuzzy integrals, especially the Choquet integral. To handle the hierarchy of criteria, a recently proposed methodology is the socalled Multiple Criteria Hierarchy Process (MCHP). While Robust Ordinal Regression (ROR) and Stochastic Multiobjective Acceptability Analysis (SMAA) have been already applied to take into account the set of capacities compatible with some preference information provided by the Decision Maker (DM), this paper aims to apply both of them considering the Choquet integral as preference model in case the consideered criteria have a hierarchical structure. To obtain additional insight into the proposed methodology we shall apply it to a real world problem.

The Ordinal Dominance Theory as applied for the most attractive Retail Cities of BENELUX

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Abstract.

An important Estate Broker for Retail in Europe made a statistical research on retail business in BENELUX cities (Belgium, The Netherlands, Luxemburg). The broker choose five characteristics to rate 30 BENELUX cities on their retail business.

1. Potentiality
This characteristic reflects the strength of the considered major retail hub or city center's catchment area.

2. Diversity
This characteristic reflects the degree of diversification of the offer featured by the considered major retail hub or city center.

3. Accessibility
This characteristic reflects the accessibility of the considered major retail hub or city center.

4. Footfall
This characteristic reflects the level of footfall in the considered major retail hub or city center.

5. Specialty
This characteristic reflects the level of specialization of the offer featured in the considered major retail hub or city center.

Is there not a problem when we have to totalize ranks from 5 characteristics? Indeed adding up of ranks, meaning an ordinal scale, returns to a cardinal operation. The method of correlation of ranks consists of totalizing ranks. Rank correlation was introduced first by psychologists such as Spearman (1904, 1906 and 1910) and later taken over by the statistician Kendall, in 1948 followed by Kendall and Gibbons 1990.

This is not allowed (Arrow, 1974).

What is then allowed? Two possibilities exist: the Median Method and the Ordinal Dominance Theory.

A first remark is the huge number of ex aequo's with the Median Method which certainly is a weak point. But there is even more. In order to be significant the Median Method needs a series of at least six figures. The application for the retail business in the BENELUX cities does not correspond to this condition. Indeed, only five characteristics are present.

On the contrary, the Ordinal Dominance Theory only needs at least three characteristics.

In the first five rankings for retail business in the BENELUX three Belgian cities: Brussels, Antwerp and Ghent are present, but in the ten first rankings only the same number is represented. This is the big difference between Belgium and the Netherlands: in Belgium the importance of the three main cities concerning the retail business is dominant, whereas in the Netherlands there is a larger spread of the retail business between cities and towns.

Additionally we made a SWOT-analysis for these cities concerning retail business. Brussels ranking first fears the planned huge shopping center in the nearby Flemish city of Vilvoorde and is more and more threatened by the rise of Antwerp. Ghent from its side fears the competition in retail business of the smaller beach city of Knokke, a city even not mentioned in the research of the brokers.

MCDM and GIS to identify land suitability for agriculture

Dr. A. Mendas
Director of Research (CTS-Arzew).

Abstract

The integration of MultiCriteria Decision Making (MCDM) approaches in a Geographical Information System (GIS) provides a powerful spatial decision support system which offers the opportunity to efficiently produce the land suitability maps for agriculture. Indeed, GIS is a powerful tool for analyzing spatial data and establishing a process for decision support. Because of their spatial aggregation functions, MCDM methods can facilitate decision making in situations where several solutions are available, various criteria have to be taken into account and decision-makers are in conflict. The parameters and the classification system used in this work are inspired from the FAO (Food and Agriculture Organization) approach dedicated to a sustainable agriculture. A spatial decision support system has been developed for establishing the land suitability map for agriculture. It incorporates the multicriteria analysis method ELECTRE Tri (ELimitation Et Choix Traduisant la REalité) in a GIS within the GIS program package environment. The main purpose of this research is to propose a conceptual and methodological framework for the combination of GIS and multicriteria methods in a single coherent system that takes into account the whole process from the acquisition of spatially referenced data to decision-making. In this context, a spatial decision support system for developing land suitability maps for agriculture has been developed. The algorithm of ELECTRE Tri is incorporated into a GIS environment and added to the other analysis functions of GIS. This approach has been tested on an area in Algeria. A land suitability map for durum wheat has been produced. Through the obtained results, it appears that ELECTRE Tri method, integrated into a GIS, is better suited to the problem of land suitability for agriculture. The coherence of the obtained maps confirms the system effectiveness.

Keywords: MultiCriteria Decision Analysis, Decision support system, Geographical Information System, Land suitability for agriculture.

BOTTOM-UP STRATEGY IN THE FISHING SECTOR: A MULTICRITERIA APPROACH FOR ASSESSING SUSTAINABLE DEVELOPMENT OF THE FISHERIES LOCAL ACTION GROUPS IN APULIA REGION, ITALY

Annalisa De Boni[1], Kannan Govindan[2], Giovanni Ottomano Palmisano[1,2], Rocco Roma[1]

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Abstract:

Priority Axis 4 of the European Fisheries Fund (EFF) is a structural aid to the fisheries sector for the sustainable development of fishing areas. The beneficiaries of Priority Axis 4 are the Fisheries Local Action Groups (FLAGs), which are partnerships between the fisheries actors and other local private and public stakeholders. Together, they design and implement a bottom-up strategy (Coastal Fisheries Plan, CFP), based on innovative actions addressing the area's needs to promote sustainable development by improving the quality of life in the fishing areas, and creating new sources of income. Apulia Region (Southern Italy) has implemented six FLAGs: Lagune del Gargano, Gargano mare, Terre di mare, Mare degli Ulivi, Adriatico-Salentino and Jonico-Salentino. They all receive almost the same financial contribution from the EFF, but it has been allocated to different actions in each CFP, according to the needs of each FLAG area due to their environmental aspects, social and economic characteristics, and by considering their individual production fleet structure. Therefore, an ex-ante assessment based on a multi criteria approach is necessary to perform a ranking of the CFPs in terms of sustainability. In this research, the outranking method (PROMETHEE) was applied. The decisional problem was set according to the CFP framework, which made possible the identification of four sustainability criteria (economic, socio-economic, social and environmental) and the weights were obtained through revised SIMOS method. In addition, the thirteen CFP actions were treated as sub criteria, and each sub criteria was weighted by a set of seven indicators.

Session 2

Interactive Evolutionary Multiobjective Optimization with Choquet Integral Preference Model Derived by Robust Ordinal Regression

Juergen Branke[1], Salvatore Corrente[2], Salvatore Greco[2,3],
Roman Słowiński[4,5], Piotr Zielniewicz[4]

Summary

We propose an interactive multiobjective evolutionary algorithm (MOEA) that attempts to discover the most preferred part of the Pareto-optimal set. Preference information is elicited in a holistic way by asking the decision maker (DM) to compare pairwise some solutions from a current population. This information is then used to curb the set of possible value functions, and the MOEA is used to simultaneously search for all solutions that are the most preferred for any of the value functions compatible with the DM's preferences. Compared to previous similar approaches, we implement a much more efficient way of determining potentially preferred solutions. In the testing experiments, we apply as a DM's preference model a value function having the form of the Choquet integral. As there is a trade-off between the flexibility of the value function model and the complexity of learning a faithful model of DM's preferences, we propose to start the interactive process with a simple linear model but then to switch to the Choquet integral when a richer DM's preference information becomes available and it cannot be still represented using the linear model. An experimental analysis demonstrates the effectiveness of the approach.

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New frontiers for MCDA: from hundreds of indicators to structured models and processes of decision aiding

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b University of Tuscia, Department of Environmental and Biological Science, Viale Università, 01100Viterbo, Italy

Abstract

A multicriteria decision aid process can be developed in interaction with decision maker(s) and stakeholders but it may be also oriented to facilitate the Intelligence phase of a decision process, by means of a kind of preliminary study that includes modelling and application of methods, in order to clarify the situation and to propose a new approach for the later phases of the decision process.

These last situations are very frequent as applicative parts of doctoral theses and in some projects of European Programs. They are also present when the decision situation is complex and not well structured, and there is time to develop a "simulative" approach to the problem, to analyze the results and use them to formulate a new treatment for the problem situation.

In these situations a multicriteria model has to be structured and developed without decision makers (DM) and stakeholders and therefore two are the most frequent modeling approaches: the acquisition of the experts' points of view in the literature (also when there are contradictions between their visions or their expertise is relative to contexts that are only apparently similar) and/or the identification of data and indicators that are available and their direct use as criteria and not as dummy variables of the problem.

The number of criteria is often very high, because the data-indicators are available and not expensive and, at the same time, this multiplicity of criteria is consistent with the general belief that only a large amount of data produces information. In general the logical structure of the model is not considered essential because DM and stakeholders are not involved and the "visualization" and validation of the model with them is not possible.

The definition of the parameters (weights, needs of veto and indifference-preference thresholds) is difficult because it is implemented far from the actual decision process. After the application of the method, the visualization of its results, with the identification of their weakness and strength points, is not considered important and the meaning of both the sensibility and the robustness analysis is underestimated.

The decision aid processes can be improved, in these situations, by means of some precautions and a clear and whole attention to all the activities of the modeling-validation process. These elements will be presented in relation to a general problem today, the problem of a territory agency who has to allocate resources, subsidies or costs in relation to the different characteristics or performances of some territorial units. Their behavior (also in terms of intangible assets) can be easily evaluated by means of a multicriteria model that includes technological, economic, environmental, political and social facets. Different multicriteria methods can be used, individually or in an integrated way, to facilitate a collective analysis of the situation. They may be used in different phases of the decision process, consistently with their specific problem statements.

A case study, related to the disaster resilience of the communalities near the Italian Ombrone river, has been solved using γ problematic, that means giving a ranking from the most virtuous communality to the less one. This and other cases will be analysed adopting also β and δ problematics and proposing new modeling and visualization logics.

Modélisation d'un problème de décisions Multi-niveaux et multicritères de gestion de la sureté aéroportuaire

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La problématique de la sureté aéroportuaire est devenue cruciale ces derniers temps avec la multiplication des actes et des interventions illicites. En effet, le transport aérien de part sa vulnérabilité et son importance économique présente des caractéristiques et des spécificités qui en font une cible privilégiée pour les terroristes et déséquilibrés de toute sorte, la mise en jeu de l'intégrité des personnes et des biens, l'assurance de la sécurité du transport aérien est un enjeu essentiel de l'activité de transport aérien.
Ainsi se pose aujourd'hui, de manière saillante, le problème du coût de la sûreté aéroportuaire et de son management. L'objectif principal de cette communication consiste à apporter une contribution méthodologique à cette question. Il s'agit d'une formulation de problème de décisions multi-niveaux et multicritères permettant d'améliorer les performances du système de gestion de la sureté aéroportuaire.

Cognitive Map for Improving Integrative Negotiation in Business-to-Business Freight Transportation Services

Alberto Graça Lopes Peixoto Neto and Maria Lucia Galves
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Abstract

Negotiation is the popular collaborative decision-making behavior in inter-organization systems, especially in the B2B freight transportation services. However, negotiation has long been recognized as a critical but time and energy consuming process. The lack of an effective framework to improve the performance of negotiation is a major problem for those seeking to enhance the efficiency and effectiveness of collaborative working in freight projects. We propose to discuss business-to-business freight transportation services negotiation practices, from the conventional approaches using primary negotiation terms such as price and/or lead-time in contrast with problem structuring from multi-criteria decision aid. The aim of structuring the negotiation process is to identify key areas of concern (not only primary negotiation terms) to organize ideas in a way which clarifies goals and actions. The selected method for representing and structuring ideas was the cognitive map, which was a useful way of capturing ideas in a dynamic form – needed at business environment – that permitted further analysis. To build the map from ideas generated, different meetings were held with both sides of negotiation (the carrier and the shipping company). Therefore, this paper aims to develop a cognitive mapping based application framework for improving collaborative working in freight project from negotiation perspective. The research was conducted during a process of annual negotiation to review contract of cargo transportation between two stakeholders: a shipper (with factory in Campinas, state of São Paulo) and a carrier (with warehouse and distribution in southern Brazil). This paper includes three steps: (1) describing a complex and unstructured freight transportation project; (2) mapping negotiation process in freight projects using the cognitive map method (representing and structuring ideas); (3) discussing results. This research will benefit the partners (shipper and carrier) in freight projects to improve negotiation performance. This research also suggests that the emphasis must move from the problem structuring to model building to evaluation negotiation alternatives, which contribute to good negotiation decisions.

Keywords: negotiation, MCDA, cognitive mapping, freight transportation project, collaborative working.

An extension of PROMETHEE to interval clustering

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Abstract

Multicriteria clustering techniques aim to detect groups of alternatives evaluated on multiple criteria with similar profiles. The preferential partitioning of the dataset allows the decision maker to get a better understanding of the structure of his problem. In this paper, we focus on the particular case of interval clustering. This approach allows us to assign alternatives either in individual or interval clusters. For this purpose, we develop a model based on the PROMETHEE I outranking method and the FlowSort sorting procedure. We evaluate its performances on real-world datasets regarding the convergence, the stability and the quality of the clustering. In particular, we analyze the impact of three update functions and two initialization strategies. This analysis has pointed out some promising results that we underline by comparing the performances of the proposed

A Formulation of DM's Risk Attitude in ELECTRE III

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Abstract

This study aims to formulate a decision maker's (DM's) risk attitude to modify ELECTRE (ELimination Et Choix Traduisant la REalité, or ELimination and Choice Expressing REality) III model. We apply both the traditional and modified models to evaluate WEEE (Waste Electrical and Electronic Equipment) recycling plants in Taiwan for the purpose of improving their operation quality in the future. The results show that both models are stable and suitable for the applications of environment evaluation.

The evaluation criteria include environmental, managerial, social, financial, and technological aspects on 15 recycling plants. Taiwan's Environmental Protection Administration (EPA) looks to provide higher differentiated subsidies as a bonus to those plants with better performances and offers some directives to the underachieving plants for further improvement. We employ concave and convex utility functions to modify the concordance and discordance indices in order to represent the DM's risk attitude, mimicking the gain and the loss in the DM's mind. We also execute sensitivity analyses on different weights and thresholds so as to demonstrate the stability of our proposed model.

Keywords: ELECTRE III, Utility function, Concordance, Discordance, Sensitivity analysis.

1. Introduction

The resource recovery rate of the WEEE (Waste Electrical and Electronic Equipment) recycling plants is reaching 80% in Taiwan, and is higher than the EU's standard. The capacity of the plants not only can process the current domestic wastes but also deal with the demand for the future growth. At the next stage Taiwan's Environmental Protection Administration (EPA) aims to enhance the quality of recycling process so that there is less damage to the environment. Hence, EPA attempts to evaluate these recycling plants and looks to provide higher differentiated subsidies as a bonus to those plants with better performances and offers some directives to the underachieving plants for further improvement.

Performance evaluation is one of the important managerial works, and many multi-criteria decision making (MCDM) techniques have been developed, such as ELECTRE, TOPSIS, AHP/ANP and others, and these techniques have been applied to many evaluation problems in practice. ELECTRE (ELimination Et Choix Traduisant la REalité - ELimination and Choice Expressing the REality) was introduced by Benayoun, Roy and Sussmann (1966) as a main stream of French School (Lootsma, 1990). The technique models decision maker's (DM's) preference by an outranking relation on a set of actions (Figueira et al., 2013), and its preference modeling has an edge over other MCDM techniques. The ELECTRE has been demonstrated in various environmental applications, e.g., water resources planning, alternative energy, and waste management (Hokkanen & Salminen, 1997; Norese, 2006).

ELECTRE III (Roy, 1978) is an extension in dealing with fuzziness and uncertainty in making a decision. It can provide a relative ranking on alternatives, and is popular around the world. However, it seems that no work involves DM's risk attitude in ELECTREs. Inspiring by the work of Almeida (2007) on the performance evaluation by utility functions, this study employs concave and convex utility function to modify the concordance and discordance indices in order to represent the DM's risk attitude, mimicking the gain and the loss in DM's mind. In the following sections, we will propose a modified procedure of ELECTRE III, illustrate the evaluation of Taiwan's recycling plants, execute sensitivity analyses, and provide discussions and conclusions.

2. Proposed model

To tackle DM's risk attitude, we use utility functions to modify the core of the concordance and discordance indices in ELECTRE III. The original linear shape of the function is replaced by the concave and convex shapes of the utility functions to represent the DM's risk attitude, i.e., risk aversion or risk seeking (Hillier and Lieberman, 2010). Both shapes can mimic the gain and the loss in DM's mind which proposed by prospect theory (Kahneman & Tversky, 1979). Based on the concept, we illustrate the concordance and discordance indices as follows.

The formula of partial concordance matrices can be defined as:

$$c_j(aSb) = \begin{cases} 1 & , \ g_j(a) \geq g_j(b) - (q_j(g_j(a)) \\ 0 & , \ g_j(a) < g_j(b) - (p_j(g_j(a)) \\ R\left(1 - e^{-\frac{\frac{g_j(a)-g_j(b)-p_j(g_j(a))}{v_j(g_j(a))-p_j(g_j(a))}}{R}}\right) & , \ else \end{cases} \quad (1)$$

The formula of partial discordance matrices can be defined as:

$$d_j(aSb) = \begin{cases} 1 & , \ g_j(b) > g_j(a) + (v_j(g_j(a)) \\ 0 & , \ g_j(b) \leq g_j(a) - (p_j(g_j(a)) \\ R\left(1 - e^{-\frac{\frac{g_j(b)-g_j(a)-p_j(g_j(a))}{v_j(g_j(a))-p_j(g_j(a))}}{R}}\right) & , \ else \end{cases} \quad (2)$$

We can see that the third part of the above two equations are utility functions.

3. Analysis results

There are 15 recycling plants to be evaluated in Taiwan. The performance values of the plants are illustrated by five aspects: environment protection, management system, financial performance, technology achievement, and social responsibility. Table 1 presents the detailed data of the plants which are marked by the letters A to O.

3.1 Selections of weights and parameters

Before the analysis, we need to setup the weights and the parameters for ELECTRE III. This study considers equal and Rank Order Centroid (ROC) weights in the evaluation. Equals weights are used to represent these five aspects being equally important in DM's mind, and ROC weights are utilized while the importance of the aspects can be ordered. Both are common in the evaluation. In addition, ELECTRE III needs three types of parameters for the analysis, i.e., indifference, preference, and veto thresholds. In general, ELECTRE III sets the preference threshold is larger than the indifference threshold, while the veto threshold is the largest, and these parameters depend on the preference of DM (Hedel & Vance, 2005). In our evaluation, the preference thresholds of all aspects are set by the DM. Indifference and veto thresholds are considered as the same value, which means the DM feels the cases of the indifference and the rejection are the same. Table 2 lists the values of the weights and the parameters on each aspect.

Table 1

The performance of 15 recycling plants in Taiwan

Plant	Aspect				
	Environment Protection	Management System	Financial Performances	Technology Achievement	Social Responsibility
A	3.75	5.5	7.5	6.3	2
B	3.75	5.1	7.5	6.3	3
C	4.25	4.75	8.5	7.6	3.5
D	3.25	5	5.25	2.2	1
E	3.25	5.5	6	4.6	1
F	4.25	5.1	7	6.1	2.8
G	2.75	1.3	6.6	3.9	1.3
H	3.95	3.8	7.35	2.6	1.5
I	2.8	4.55	7.1	4.1	2.5
J	3.85	6.75	7	5.3	4.3
K	4.1	4	5.6	8.6	2
L	3.25	2.75	6.8	4.1	1
M	4.25	5.5	5.05	5.9	2
N	3.25	4.75	6.6	3.6	4
O	2.8	3.5	6.6	4.6	3

Table 2

The chosen values of weights and parameters in this study

		Environment Protection	Management System	Financial Performances	Technology Achievement	Social Responsibility
Criteria Weight	Equal Weights	0.2	0.2	0.2	0.2	0.2
	ROC Weights	0.4567	0.2567	0.1567	0.09	0.04
Indifference threshold q		0.0949	0.0949	0.0949	0.0949	0.0949
Preference threshold p		0.5	0.45	0.4	0.3	0.3
Veto threshold v		0.8	0.8	0.8	0.8	0.8

3.2 Comparison results

Table 3 shows the ranks of 15 plants by score sum, traditional and modified ELECTRE III. Score sum is to sum up the performance values on all five aspects of any plant, which is taken by the EPA original evaluation. However, EPA worried about the ranks because a simple method might not be suitable for the purpose. Thus, we adopt ELECTRE III and modified ELECTRE III to make the evaluation. Table 3 illustrates the comparison results of three methods. The second, the third, and the fourth columns of Table 3 are the ranks of the 15 plants by score sum, ELECTRE III, and modify ELECTRE III, respectively. We can see that the upper half ranks of the group have no significant difference. EPA should have a confident on the decision for subsidy and supervision.

Table 3

The final ranks of 15 plants by three methods

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Score sum	5	3	1	14	11	4	15	12	9	2	6	13	7	8	10
ELECTRE III	5	3	1	14	11	3	15	9	10	2	6	11	7	7	11
Modified ELECTRE III	5	2	1	14	9	4	15	12	8	3	7	13	9	6	11

3.3 Sensitivity analysis

Sensitivity analysis is to investigate the effect on the solution if the parameters take other possible values (Hillier & Lieberman, 2010). WE can think about the model being stable if the effect is minor. Here we conduct a sensitivity analysis on the weights of the evaluation aspects in which the weight of environment protection is chosen due to its big value. We change its values to the plus and the minus 30% of its original value. The analyses on equal and ROC weights are executed, and find that there is no significant difference on the ranks of the plants. Figure 1 shows the results of the sensitivity analysis on equal weights.

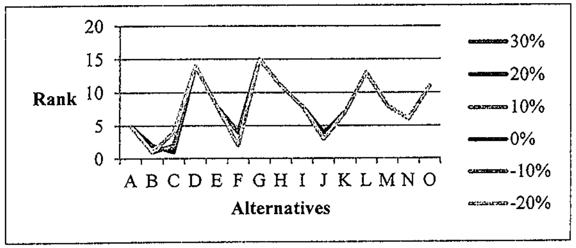

Figure 1 A sensitivity analysis on the weight of environment protection, equal weights

4. Conclusions and remarks

We propose the modified ELECTRE III to model DM's risk attitude in evaluating 15 recycling plants in Taiwan. Compared to the traditional ELECTRE III, the upper half of the group in the analysis is almost the same. Through the sensitivity analysis, we ensure that these two models are stable, and think both models are suitable for the environment applications.

The thresholds are the important parameters for decision making in using ELECTRE III. We will check the effect of the changes of the values of three thresholds on the final ranks. In addition, ranking tests and the simulation on the range of performance values of the plants will be executed in order to verify the difference between the two models of ELECTRE III.

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Construct you own ELECTRE

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All ELECTRE methods are based on the same rule: they first construct an outranking relation for all ordered pairs of compared objects, and then exploit this relation to deliver recommendation in function of the specific problem to solve. Several approaches have been designed for the three main types of multiple criteria problems: choice (e.g., ELECTRE I, Iv, and Is), ranking (e.g., ELECTRE II, III, and IV) and sorting (ELECTRE TRI-B, TRI-C, and TRI-rC). In fact, these methods are sequences of the elementary well-defined steps which contribute to some particular implementation of the construction and exploitation phases. When it comes to formalizing the general concepts of concordance and discordance, none of these approaches tolerates the freedom in their interpretation. As a result, each ELECTRE method is distinguished not only by its unique exploitation procedure, but also by the way it constructs an outranking relation. While these two phases are independent, paradoxically, a new approach can be obtained each time when coupling together the existing construction and exploitation procedures that have not been yet considered within a common methodological framework. Such developments are still considered valuable, because they are mainly application-driven, thus, allowing to deal with a specific multiple criteria problem at hand.

The contribution of this paper is of both methodological and software nature. It consists in postulating flexibility in constructing ELECTRE methods so that they are well suited for dealing with the specific real-world decision problems, and implementing this paradigm in practice. For this reason, we have designed a wide spectrum of elementary ELECTRE-based components that are able to interoperate, and make them available via the diviz platform. The proposed methodological bricks are useful for designing advanced approaches, supporting the analysts in both problem structuring and preference elicitation process.

At the stage of construction of an outranking relation, we consider a variety of procedures for carrying out the concordance and (non-)discordance tests, computing the credibility of an outranking relation, and checking the validity of a crisp relation. These are derived, e.g., from Electre Is, Tri-B, III, IV, and MR-Sort. We also account for the concepts which are not linked to any specific approach, such as modeling interactions between criteria, the effects of reinforced preference and counter veto, using pre-veto (discordance) thresholds, or numerous procedures for aggregating concordance and discordance degrees into a valued or crisp outranking relation. We ensure universality of the implemented modules so that they admit comparison of alternatives either with each other or with class profiles (boundary or characteristic ones). In this way, we provide means for constructing an outranking relation that may be subsequently exploited to derive choice, ranking, or sorting recommendation.

At the stage of exploitation of an outranking relation, we consider the following approaches: algorithms for finding the graph kernel as in the ELECTRE I methods, distillation and ranking procedures of ELECTRE III/IV, Net Flow Score rules for exploiting valued and crisp outranking relation, and class assignment rules of ELECTRE Tri-B, ELECTRE Tri-C, and ELECTRE Tri-rC. Taking advantage of such components, the user may ``construct her/his own ELECTRE" in a few minutes without any mathematical or programming skills. This construction process boils down to combining the modules in one of several hundred ways that are possible with our proposal and discussed in the paper.

Session 3

Table ronde en l'honneur de Bernard Roy

Round table in Honor of Bernard Roy

Exploring the robustness of elicited weights in MCDA approaches by using new measures and feedbacks

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Abstract: The assessment of criteria weights expressing the Decision Maker's (DM) value system in multicriteria methods using incomplete information, given either as pairwise comparison of the weights themselves (e.g. SIMOS cards method) or indirect through the comparison of reference alternatives using a disaggregation – aggregation (D-A) approach (e.g. UTA methods), often leads to the elicitation of preference models with low degree of robustness. Namely, several weight vectors, which are compatible with the DM's preference structure, are estimated. In many cases, wide range of the weight of each criterion is observed, as well as, several rank reversals of the criteria importance in the different weight vectors. Given the fact that the DM shall be aware of such phenomena of low robustness, so that (s)he can be protected when applying the estimated preference model, the key point of this research is the development of a methodological approach which will provide the framework to measure the level of robustness of the estimated preference model and facilitate the exploration of its nature. This research work presents a methodological frame which focus on three main issues: a) the evaluation of the degree of robustness of the elicited weights, b) the provision of support to the DM towards the exploration of the nature of the probable low robustness and the deeper understanding of his/her preferential structures and c) the estimation of more robust preference models by applying a set of feedbacks.

Key words: Multiple Criteria Decision Aid (MCDA), Robustness Analysis, Decision Support Systems

1. Introduction

The assessment of criteria weights in multicriteria methods of value systems, such as disaggregation - aggregation approach (Jacquet-Lagreze and Siskos 1982, Siskos and Yannacopoulos 1985) or SIMOS method (Simos 1990a,1990b, Figueira and Roy 2002) often leads to preferential models with low robustness. Infinite number of criteria weights vectors is assessed bounded into an n-dimensional hyper-polyhedron. The beaten track to face the low robustness in these cases is:

a) the calculation of the n-dimensional hyper-polyhedron of the weights can lead to the estimation of ranges of criteria weights and finally to the identification of a barycentre vector, which constitute the working preferential model (Siskos and Yannacopoulos 1985) for the next steps and interactions.

b) the utilisation, at the initial steps of preference elicitation stage, of guided questions and special treatments, so as to lead to preferential models with higher robustness, by limiting the degree of freedom during the expression of preferences by the DM (Kadzinski et al. 2012)

c) the utilisation of special treatment processes on preferential data oriented to ensure higher robustness.

One primary question, in cases of low robustness, is to identify its existence and explore its nature into the estimated preferences models. A frequently observed reason of such unwanted unstable solutions is the nature of the methodological approaches used for the weights' estimation related to the relatively poor preference information given by the DM. Methods of disaggregation-disaggregation approaches require global preferences of the DM, expressed through a pre-order on a limited subset of alternative actions (reference set) by which (utilising linear programming techniques) the vector of criteria weights and marginal value functions are estimated. On the other hand, SIMOS method based on a pair wise comparison of the criteria importance, leads to the estimation of criteria weights' vector, either by using simple quantitative technique (Simos 1990a, 1990b) or by applying linear programming modelling.

These methods aim to elicit the criteria weights based on the preference information provided by the DM, in order to activate interactive dialogues with him/her, having multiple purposes. On the one hand, it is desired to uncover the preference structure of the DM, and on the other to support the DM towards a better understanding of the nature of the decision problem, to recognise the strengths and weakness of the examined case and to increase his/her knowledge about the problem status.

Another factor that affects the robustness of preferences models is related with the initial stages of the preferences' elicitation. The steps of criteria modelling and alternatives evaluation on the criteria involve subjectivity and frequently are based on assumptions derived from rational but subjective points. These points are not always well documented and confirmed, as far as their accuracy is concerned. Methods of disaggregation - aggregation approach can support the investigation of the reasonableness of the assumptions and support their clarification through interactive features.

Furthermore, low estimated robustness may express a possible vagueness of DM preference structure. In many cases, the ranges of the criteria' weights estimated by post optimality analysis can reflect the real preferences of DMs. DMs usually has an order of magnitude for the importance of the criteria or a classification of the criteria importance and not the precise value of their weights. Low robustness is not something to be always avoided. Instead, an estimated preference model of low robustness ought to be considered and investigated for its causes, while it could be the result of more than one of the above reasons. Consequently, the challenge is not to estimate perfectly robust preference model, but models with possible higher robustness, reflecting the real structure of DM's preferences.

All aforementioned issues triggered the implementation of this research work. The key point of this research is the development of a methodological framework providing the capability to analyse and explain the low robustness of the estimated preference model and support the systematic investigation processes for its nature and causes. The proposed framework aims to: a) estimate the degree of robustness of the elicited weights, b) support the DM to explore the nature of the probable low robustness and to understand deeper his/her preferential structures, and c) estimate more robust preference models by applying a set of feedbacks.

The first issue is tackled through the estimation of the n-dimensional hyper-polyhedron, which bounds the vectors of the n criteria weights, using analytical or heuristic approaches for the calculation of its vertices and its volume. Based on the hyper-polyhedron, a representative barycentric weight vector is calculated, as well as robustness measures, such as the ranges of the criteria weights, the ASI index representing the normalized standard deviation of the solutions, the PRI index representing the rank reversals of the weights importance (only in D-A approaches), etc. The second issue concerns the idea that low estimated robustness may be consistent with the actual DM's preference structure. The estimated preference model of low robustness shall be explored by providing to the DM visualisation tools concerning the 3-D mapping of the hyper-polyhedron and graphical representations of the ranges of the weights using a parallel graph system. Furthermore, towards the deeper understanding of the nature of the low robustness, a tomographical approach is proposed through which a discretisation of the hyper-polyhedron is implemented by using n-1 dimensional cutting hyper-polyhedra based on specific values of each criterion weight. The measures of robustness are re-calculated and presented graphically to the DM for each tomographical level.

Finally, a dialogue is initiated with the DM which is triggered by the results of the robustness analysis in order to ask for additional preference information. The acquired additional information may support the estimation of an updated preferential model with higher robustness, reflecting the real preferential structures of the DM in a more precise manner. The complexity of the proposed framework imposed the development of special software in order to support the efficient implementation of the various steps.

The paper includes the introduction and five more sections. The characteristics of low robustness in D-A approach is presented into the second section. Following, the three stages of the proposed methodological frame for robustness analysis is presented in details in the next three sections. Finally, the last section includes the outline of the conclusions and further developments.

2. Preference Models Robustness Issues.

The UTA Methods of Multicriteria disaggregation - aggregation approach (Lagreze and Siskos, 1982, Siskos 1980) for discrete alternative actions lead to the estimation of DMs' additive value preference model described in the following formulae:

$$U(\mathbf{g}) = \sum_{i=1}^{n} p_i u_i(g_i) \quad \text{subject to normalization constraints:}$$

$$u(g_{i*}) = 0, \quad u(g_i^*) = 1, \ \forall i = 1,2,...,n \quad \text{and} \quad \sum_{i=1}^{n} p_i = 1, \quad \forall i = 1,2,...,n$$

where: $\mathbf{g} = (g_1, g_2, ..., g_n)$ is the evaluation vector of an alternative action on the n criteria, g_{i*} and g_i^* are the least and most preferable levels of the criterion g_i respectively and $u_i(g_i)$, p_i are the value function and the relative weight of the i-th criterion respectively.

The assessment of the preference models in UTA methods is achieved through interactive procedures, where preference information is derived from the DM. Also, the process utilises a representative subset of the alternative actions, which are evaluated into a consistent family of criteria (Roy, 1985). DM's global preferences are expressed by rank-ordering (pre-ranking) of a representative and familiar to the DMs subset of the alternative actions, called reference set. Special Linear Programming (LP) techniques are utilised in order to estimate an additive value model, which produces a ranking of the reference actions as consistent as possible with the pre-ranking given by the DM. The alternative actions of the reference set are rearranged in such a way that a_1 is the head and a_k is the tail of the ranking and for every pair of consecutive actions (α_m, a_{m+1}) holds, either $\alpha_m \mathbf{P} \alpha_{m+1}$ (preference) either $\alpha_m \mathbf{I} \alpha_{m+1}$ (indifference). Special linear programmes are solved through which the parameters of the value systems are estimated, so as to minimise the over and under estimation errors function. The following formulas provide the structures of the linear programmes:

$$[\min] F = \sum_{m=1}^{k} \left(\sigma^+(a_m) + \sigma^-(a_m) \right) \quad \text{subject to:}$$

$$HP1 \begin{cases} \left.\begin{array}{l} \sum_{i=1}^{n} p_i u_i\left[g_i(a_m)\right] - \sigma^+(a_m) + \sigma^-(a_m) - \sum_{i=1}^{n} p_i u_i\left[g_i(a_{m+1})\right] - \sigma^+(a_{m+1}) + \sigma^-(a_{m+1}) \geq \delta \text{ if } a_m \mathrm{P} a_{m+1} \\ \sum_{i=1}^{n} p_i u_i\left[g_i(a_m)\right] - \sigma^+(a_m) + \sigma^-(a_m) - \sum_{i=1}^{n} p_i u_i\left[g_i(a_{m+1})\right] - \sigma^+(a_{m+1}) + \sigma^-(a_{m+1}) = 0 \text{ if } a_m \mathrm{I} a_{m+1} \end{array}\right\} \forall m \\ \sum_{i=1}^{n} p_i = 1, \text{ for } i = 1,2,...,n, \quad p_i \geq 0, \ \sigma^+(a_m) \geq 0, \ \sigma^-(a_m) \geq 0 \ \forall i \text{ and } m \end{cases}$$

where δ being a small positive number; $g_i(\alpha_m)$ the evaluation of the α_m action on the i-th criterion and $u_i[g_i(\alpha_m)]$ the corresponding marginal value; and σ^+, σ^- the overestimation and the underestimation error, respectively.

The solution of the linear program results in the following distinct cases:

- Total reconstitution of the DM's pre-ranking with zero or negligible sum of over(under) estimation errors.
- A new ranking of the alternative actions (reference set), as close as possible to the pre-ranking with non-zero over(under) estimation errors.

Also, the estimation of the parameters of the value system can lead to:

1. A unique optimal solution indicating a perfectly robust preference model.
2. No solution, where the DM's preferences cannot lead to an estimation of a convex hyper-polyhedron
3. Infinite multiple optimal solutions, which are bordered into a hyper-polyhedron (possible low robustness). In this case, the beaten track is to move to post-optimality analysis in order to estimate a mean solution of the LP's optimal solutions, corresponding to the vertices of the hyper-polyhedron (Figure 1). The most familiar approach for post-optimality analysis, used in MINORA [Siskos et al, 1993] and MIIDAS [Siskos et al, 1999] systems, is oriented to the heuristic approximation of a barycentre solution by maximizing and minimising of the weight of every one of the criteria [Siskos 1984]. This barycentre solution is used as the working preferences model for the next steps of D-A approach. The (2 x n) LPs of the post optimality analysis have the following form:

$$[\min] \ or \ [\max] F_i = p_i, \ i = 1,2,...,n$$

subject to:

$HP1$

$$\sum_{m=1}^{k} \left(\sigma^+(a_m) + \sigma^-(a_m) \right) = f^*$$

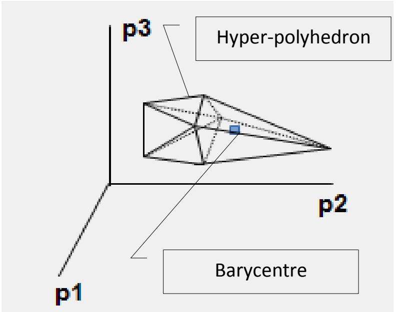

Figure 1: Example of Hyper-Polyhedron of LP Solution for low robustness preference models and Barycenter for 3 criteria weights (p1, p2, p3)

Another approach for post optimality analysis is to find and record all the vertices of the polyhedron, by using the Manas-Nedoma (1968) analytical algorithm, which traverses all the vertices of the Hamiltonian graph, and calculate a new average weighting vector which represents the barycentre of the polyhedron. This later approach constitutes a more precise way to estimate the barycentre of the polyhedron and to provide a more accurate image.

Similar approach is applied when the Simos cards method is used, under which the DM ranks subsets of ex aequo criteria according to their importance. The provided ranking is expressed using a system of linear relations, which are satisfied by a hyper-polyhedron. The information extracted by the DM, within the original, as well as the revised Simos method, is not sufficient to ensure a single or robust criteria weighting. On the contrary, there exists an infinite number of weighting vectors that are consistent with the DM's ranking and form the hyper-polyhedron.

The case of low robustness stimulates a set of inquiries to be investigated, so as to be able to continue the decision support process in an efficient way. First of all, there is a need to examine issues concerning the acceptance level of the weight vector deduced from the barycentre solution.

a) Can a preference model with low robustness be accepted, while the criteria weights are falling into a wide range of values?

b) Can a preference model be accepted, which presents reversal of criteria importance into the estimated hyper-polyhedron?

c) Which is the degree of robustness that could be accepted for continuing the decision support process?

3. Robustness Measures

The first step in the proposed framework is the calculation of robustness measures, which are able to provide an initial evaluation of the robustness level of the set of compatible value functions. A set of indices and special data handling features are proposed for this purpose.

The first type of indices used is the range between the maximum and minimum values of the criteria weights for every criterion, as these values are estimated at each vertex of the hyper-polyhedron during post optimality analysis. For the i-th criterion the index is estimated as:

$$\mu_i = \left(\max\left(p_{ij}\right) - \min\left(p_{ij}\right)\right), \qquad p_{ij} \text{ the weight of the } i \text{ criterion in the } j \text{ vertice,}$$

$$i = 1,2,..,n, j = 1,2,..,m, \qquad n\text{: number of criteria and } m\text{: number of vertices of hyper} - \text{polyhedron}$$

An initial indication of the measure of stability of solutions is the standard deviation of the solutions resulting from the square root of the mean square deviation for each criterion i:

$$S_i = \sqrt{\frac{1}{m-1}\left(\sum_{j=1}^{m}\left(p_i^j\right)^2 - \frac{\left(\sum_{j=1}^{m} p_i^j\right)^2}{m}\right)} \quad \text{for} \quad i = 1,2,\dots,n$$

This simple index can be normalized, where the value 1 corresponds to total robustness and 0 to complete un-robustness of the preference models (Hurson and Siskos 2014). This normalized index is called Average Stability Index (ASI):

$$ASI = 1 - \frac{1}{n}\sum_{i=1}^{n}\frac{S_i}{Norm}, \quad \text{where } Norm \text{ is a normalization factor}$$

The final form of ASI is the following:

$$ASI = 1 - \frac{\sum_{i=1}^{n}\sqrt{m\left(\sum_{j=1}^{m}\left(p_i^j\right)^2\right) - \left(\sum_{j=1}^{m} p_i^j\right)^2}}{m\sqrt{(n-1)}} \qquad n\text{: number of criteria and}$$

m: number of vertices of hyper-polyhedron

The infinitive set of solutions (hyper-polyhedron) resulting from the post optimality analysis in aggregation-disaggregation approach provides a lot of cases where we may observe rank reversal of the criteria weights. There might be a set of solutions where criterion g_i has equal or higher weight than criterion g_j and other set of solutions (complementary) vice versa. This produces a conflict with the real preferences of the DM while he/she can consider on of the two criteria to be more important than the other. A new index is introduced to describe this situation, which is called Priorities Reversal Index (PRI). This new index provides a mean to measure the reversal of the criteria weights into the hyper-polyhedron. The estimation of all the vertices is recorded for the calculation of the PRI index. For each vertex the weights vector is estimated.

A set of indices, Criterion Priorities Index (CPI_{ij}), is calculated for every pair of criteria, representing the degree of criterion weights rank reversals among the vertices of the hyper-polyhedron. CPI_{ij} is estimated with the following formulae:

$$CPI_{ij} = \frac{\#\left\{p_i^j > p_k^m, \, for \; j = 1,\dots,m\right\}}{m}, \quad for \; i,k = 1,2,..,n, i \neq k$$

where $(p_1, p_2, .. p_n)$ the vector at each vertex , n: number of criteria, m:number of vertices

For CPI_{ij} the following relations hold:

$CPI_{ij} + CPI_{ji} = 1$ and $CPI_{ij} \leq 1$

Also,

- $CPI_{ij} = 1$, when the criterion i has higher weight of criterion j for all the vertices of the hyper-polyhedron.
- $CPI_{ij} = 0.5$, when the number of vertices with $p_i > p_j$ equals to the ones with $p_i \leq p_j$

The Index Priorities Reversal Index (PRI) is the normalized mean value of the CPI_{ij} indices and it is calculated with the formulae:

$$PRI = \frac{\sum_{i=1,\, j=i+1}^{n-1} \left| CPI_{ij} - 0.50 \right|}{\frac{n(n-1)}{2} 0.50}$$

PRI =0 when $CPI_{ij} = 0.5$ for all i, j=1,2,..n and i≠j, corresponding to the higher rank reversals of criteria priorities.

PRI=1 when $R_{ij} = 1$ or $R_{ij} = 0$ for all $i. j = 1,2,..,n$ and i≠j, corresponding to the absence of criteria priorities rank reversals on the vertices of the hyper-polyhedron.

4. Robustness Exploration

The exploration of the robustness of the elicited preference models in the proposed methodological frame is achieved through the following steps:

a) Visualisation of the hyper-polyhedron in 3-D graphical interface so as to provide the picture of the solution' hyper-space by selecting 3 dimensions every time. A key point in the robustness analysis of the preference models is the visualization and measurement of the level of robustness. The estimated weights of criteria are bordered in an n-dimensional hyper-polyhedron. Visualisations in paper and computers are also restricted in 2-dimantional space representation. Several software systems provide visualisation capabilities by using various graphs for the calculated results. In multicriteria decision aid systems, due to the need of interaction between DM and system there is a need for visualizations and presentation to be adopted in a simple and understandable manner. Furthermore, robustness shall be expressed using measures which are understandable by the analyst and the DMs. In this view it is suggested that visual tools may serve this need in a better way. Siskos and Grigoroudis (2010), Haasnoot et al. (2013), Montibeller and Franco (2010) propose the use of specific visualisation techniques that provide to the DMs a very clear picture of the performance, variations and the level of robustness.

The system that we are building provides the necessary interface, so as the DM in collaboration with the analyst to select criteria (3 criteria every time) and values of the polar coordinates (elevation and azimuth) in order to view part of the hyper-polyhedron corresponding to the selected 3 criteria-dimensions. The interactivity of the software provides animation features (Figure 1).

b) Exploitation of a parallel graph system, where the weights of the criteria are presented in bars in the scale of [0, 1] (Figure 2). The parallel graph systems considered appropriate for our purposes because of the need for interactions between DM and system. This need for user friendly presentation and visualisation ought to be satisfied with a simple and understandable manner for the DM, so as to be able to provide efficiently the required additional preference information.

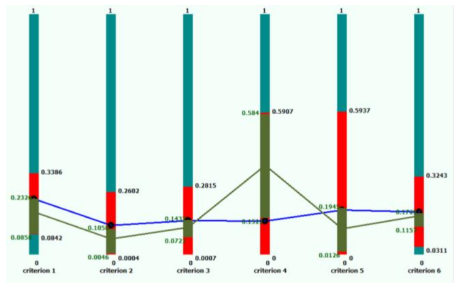

Figure 2: Visualisation of weights' ranges using parallel graph system

c) Tomographical Approach.

Tomographical approach constitutes a way to picture the degree of robustness into the hyper-polyhedron. The idea is to discretize the n-dimensional estimated hyper-polyhedron of the criteria weights by using n-1 dimensional cutting hyper-polyhedra. For the presentation of the cutting tomographies the parallel coordination system is used (Figure 3). By this way, with a simple and comprehensive way we can visualise the levels of criteria weights' robustness. For the estimation of these n-1 dimensional cutting hyper-polyhedra the Linear Programme of post optimality analysis of UTA methods is enriched with the following conditions:

$p_i = q, q = \min(p_i) + rt,$ where t is a predetermine step,

$r = 0,1, \ldots l,$ where l is the total number of steps and $q \leq \max(p_i)$

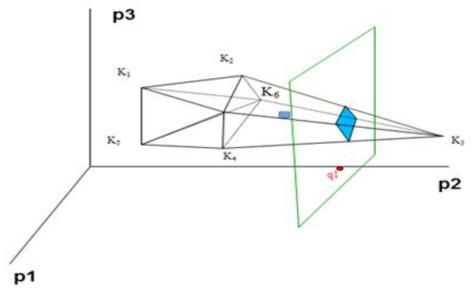

Figure 3: Visual example of Tomography of Hyper-polyhedron for three criteria

This process of tomography has a double target:

1. Picturing the structure of low robustness into the hyper-polyhedron in a way that is easily understandable by the DM and also supporting the identification of areas in the hyper-polyhedron with low or high robustness.

II. Triggering dialogues with the DM in order to refine the information concerning his/her preferences for focused areas of the decision space

Tomographies constitute a tool to explore robustness in the estimated hyper-polyhedron. The study of the robustness of the estimated hyper-polyhedron is transferred to the tomographies and the relative indices. This cannot be achieved without the support of software, special developed for the needs of the research. The software module developed for the tomography support two discrete approaches:

a) The manual inspection of the robustness of the hyper-polyhedron by selecting a criterion and a specific step. The tomographies are estimated for each value of the weight of the examined criterion, starting from the minimum value of the criterion weight and increasing by the selected step at each iteration.

b) The automatic running for every criterion with a selected step for the estimation of tomographies and calculation of the indices of the robustness evaluation and presentation the results into a graph. The automatic tomographies provide an overall inspection of the estimated hyper-polyhedron. The ASI index is calculated in each step of the process and it is presented using parallel graph system. The minimum and maximum ASI index is estimated for all the topographies as well as for the tomographies of each criterion. PRI index is also calculated for the different tomographies (Figure 4).

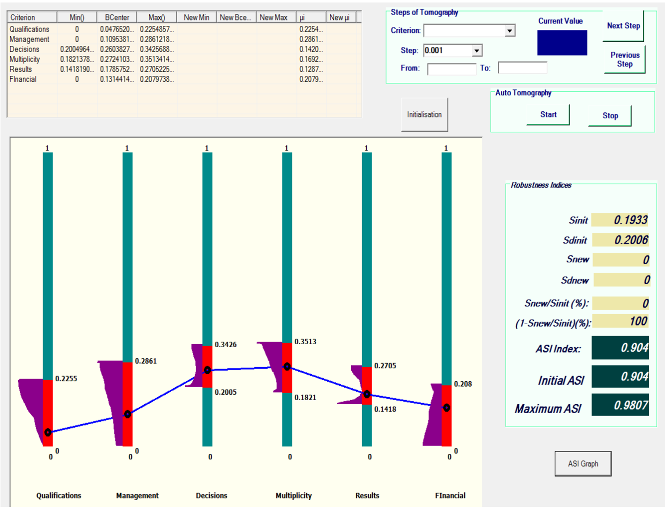

Figure 4: Calculation of ASI indices for different tomographies

5. Feedbacks to increase Robustness

The estimation of preference models with low robustness is something frequently observed and probably undesired. Nevertheless, it can be considered as the starting point for new dialogues with the DM in order to receive additional preference information, which may lead to the revision of the preference model towards an acceptable one. This process is triggered by an analysis of the structure and nature of low robustness and includes dialogues, steps and feedbacks in a directed way for the estimation of preference models with higher robustness.

The procedures of MINORA and MIIDAS systems (Siskos et al, 1993, Siskos et al, 1999) includes steps covering and supporting the decision making process starting from the initial steps, such as the criteria modelling and the alternatives evaluation on the criteria, and it continues in the subsequent steps of the selection of the reference set, the expression of DM' preference through the provision of the pre-order on the reference set and the assessment of the additive value preference model. All these steps are implemented in a waterfall manner. If the initial estimated preference model is acceptable by the DM then we can accept it and use it to rank order the total set of alternative actions and finally to make the decision. The acceptance of the preference model is the result of a multifactor process in which many conditions have to be satisfied.

- The preference model (criteria weights, marginal value functions, global and marginal values) must express the actual preference structure of the DM has really in his mind and are rational to the Decision Making
- There are no inconsistencies into the estimated preference model
- There are no objections from the DM, as far as the results of the estimated preference model are concerned.
- The estimated preference model can be considered robust at a satisfactory level.

In the case where one of the above conditions is not satisfied, this could be considered as a starting point of a circle of interactive processes and feedbacks utilising focused dialogues with the DM. Actually, the outcomes of the current preference model are explained to the DM in a comprehensive way and new preference data are collected. This process can lead to a set of interactive feedbacks, which mainly concern adaptation of the parameters at previous steps (criteria modelling, etc) or ad hoc modifications of the estimated preference model. The aims of these processes are: a) to eliminate inconsistencies between the DM actual preference structure and the estimated preference model, b) to include the arguments and the persisting opinions and preferences of the DMs, and c) to estimate a consistent to the DMs' preferences revised additive value model.

The new features that are presented in this research work concern the cases where the low robustness doesn't allow considering satisfactory the estimated additive value model. So, new approaches and tools were designed to be embedded into the UTA methods process for the measurement and visualisation of the level of robustness and new feedbacks were developed, which on the one hand aim to estimate a preference model consistent to the real preferences of DM, while on the other aim to increase the level of robustness. The proposed Robustness Analysis process and the relative feedbacks were realised in a software system, which could constitute a module of MINORA and MIIDAS systems. Actually, MINORA and MIIDAS systems could be enriched with the new interactive feedbacks, in addition to the existing ones, so as to: a) provide an integrated framework for the analysis of the estimated preference model, b) support the dialogues with the DM in the process of inquiring the preference model, and c) conclude to a higher robustness preference model harmonised with the DM's preferences.

The new feedback tools include two main processes, shrinking the hyper-polyhedron and giving criteria priorities. These processes are used in order to extract focused preference information by the DM towards the estimation of a consistent to DM preference additive value model with higher robustness. Information, which has been provided during the previous stages of robustness analysis, either by the calculated robustness measures or the robustness exploration procedures, such as tomographies, may trigger a set of questions for the DM as an effort to collect additional preferential information concerning the criteria weights. In each case we can identify smaller areas in the hyper-polyhedron, which match better with DM's preferences and therefore lead to a higher robustness.

(a) Shrinking the hyper-polyhedron:

Post optimality analysis results, in many cases, to maximum and minimum values of criteria weights, which can be considered extreme and unacceptable. For example, the weight of a criterion with zero value can be characterized by the DM unacceptable, as well as the case where the maximum weight of the criterion is greater than a given value, 0.5 for example. The purpose of this feedback is to determine minimum and maximum values of the criteria weights which are not acceptable by the DM and to identify lower and upper limits of the weights that meet the actual preferences of the DM (Figure 5). These extreme points can trigger a dialogue between Decision Analyst and DM in order to investigate the capability to determine new limits of the criteria weights or to support a trade-off process where new conditions can be identified concerning the preferences of the DMs.

The identification of new lower and upper limits of the criteria weights inserts new conditions and constraints in the LP programmes at the post optimality analysis process. The estimation of the new preference model may lead to a new hyper-polyhedron, which, in reality, constitutes a shrinking of the initial one. The new conditions embedded into the linear problems have the following form:

$p_i \geq r_{imin,}\ p_i \leq r_{imax}\ \ where\ \ r_{imin,}\ r_{imax}$ the lower and upper limits of criteria weights

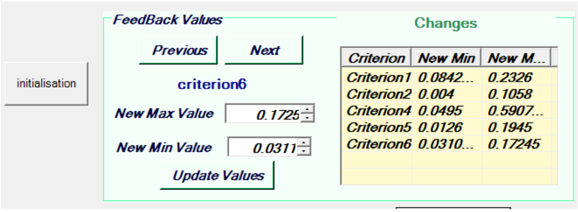

Figure 5: Set lower and upper limits for criteria weights

(b) Giving criteria priorities:

As already mentioned, one important issue is the fact that there are areas in the hyper-polyhedron where rank reversals of criteria weights are appeared. DMs usually have a clear picture of the priorities of the criteria, either for all of them or in a pairwise manner. Obviously, weights vectors which are not harmonised with the actual preference structure of of the DM cannot be accepted. Therefore, one of the subjects raised during the robustness analysis process is to determine the attitudes of the DM, as far as the criteria priorities are concerned. This can be achieved either directly or indirectly. We can ask the DM to give priorities for some of the criteria in cases where the DM has a clear picture of the criteria importance and so he/she is in the position to express it directly with conviction (Figure 6).

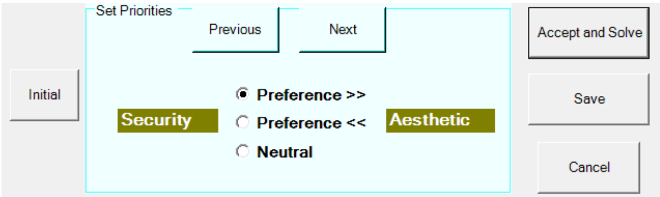

Figure 6: Set priorities between criteria weights

6. Conclusions – Further development

The exploration and analysis of low robustness of the estimated preference models in disaggregation-disaggregation and in other approaches, such as SIMOS' cards method, may reveal useful information about the structure of DM's preferences and it may also trigger a series of useful feedbacks, so as to estimate preference models of higher robustness and more consistent to his/her preferences.

The interactivity of the MINORA and MIIDAS systems could be enriched though these new feedbacks triggered by the robustness analysis results. This interactivity and effectiveness of the proposed approaches shall be extensively tested in real world case studies. The proposed methodological tools are now developed in a new system, called RAVI system, which will be a special software module ready to be included as a subsystem in MINORA and MIIDAS systems, for supporting robustness analysis of elicited preference models. This research will continue through the application of the proposed framework in real world case studies through MINORA and MIIDAS systems and its proper adaptation based on the actual needs of Decision Analysts and DMs.

Acknowledgement

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Cognitive Map for Improving Integrative Negotiation in Business-to-Business Freight Transportation Services

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Abstract

Negotiation is the popular collaborative decision-making behavior in inter-organization systems, especially in the B2B freight transportation services. However, negotiation has long been recognized as a critical but time and energy consuming process. The lack of an effective framework to improve the performance of negotiation is a major problem for those seeking to enhance the efficiency and effectiveness of collaborative working in freight projects. We propose to discuss business-to-business freight transportation services negotiation practices, from the conventional approaches using primary negotiation terms such as price and/or lead-time in contrast with problem structuring from multi-criteria decision aid. The aim of structuring the negotiation process is to identify key areas of concern (not only primary negotiation terms) to organize ideas in a way which clarifies goals and actions. The selected method for representing and structuring ideas was the cognitive map, which was a useful way of capturing ideas in a dynamic form – needed at business environment – that permitted further analysis. To build the map from ideas generated, different meetings were held with both sides of negotiation (the carrier and the shipping company). Therefore, this paper aims to develop a cognitive mapping based application framework for improving collaborative working in freight project from negotiation perspective. The research was conducted during a process of annual negotiation to review contract of cargo transportation between two stakeholders: a shipper (with factory in Campinas, state of São Paulo) and a carrier (with warehouse and distribution in southern Brazil). This paper includes three steps: (1) describing a complex and unstructured freight transportation project; (2) mapping negotiation process in freight projects using the cognitive map method (representing and structuring ideas); (3) discussing results. This research will benefit the partners (shipper and carrier) in freight projects to improve negotiation performance. This research also suggests that the emphasis must move from the problem structuring to model building to evaluation of negotiation alternatives, which contribute to improve negotiation decisions.

Keywords: negotiation, MCDA, cognitive mapping, freight transportation project, collaborative working.

Introduction

The process of negotiation is the primary method of managing conflict in trading relationships between buyers and suppliers within chains. There are two major approaches to negotiation. In pure integrative negotiation, parties assume that their various interests are not fundamentally opposed and that it is possible to benefit from co-operation between their organizations and, as a result, seek to maximise their join benefit or value. In contrast, parties involved in pure distributive negotiations tend to have, or assume that they have, sharply opposed interests; in this case, co-operation is unlike to be effective (Raiffa, 1982).

Negotiation processes in the freight transportation services - mainly between carrier and shipper - have conflicts of interest, expressing the existence of different perceptions, preferences and value judgments between the parties.

Thus arose the need for a process that allows managing the conflict of interests and reaching an agreement that is satisfactory to the parties involved. In this context, uncertainty and risks are present. Tools that address the decision support and the negotiation can, and should be used, to facilitate the achievement of results that create win-win opportunities.

Given this scenario, the multi-criteria decision aid (AMCD) methodology emerged, which allows the prioritization of alternatives in a situation of conflicting criteria, seeking to satisfy the constraints with conflicting goals, i.e., a compromise. Therefore, the AMCD can provide mechanisms to support the negotiation and group decision (Buchanan and Gardiner, 2003).

Considering the entire context presented, the problem addressed in this research can be formulated by the following question: How to improve the negotiation process in the freight transportation services, considering the interests of the parties involved, so win-win opportunities are generated?

The basic problem of a negotiation is not in conflicting positions, but in the conflict between the interests of each side. However, a careful analysis of the interests can reveal the existence of a much larger amount of common or compatible interests than antagonistic interests.

Nevertheless, we must not confuse positions with interests. Positions are the concrete things that the negotiator says it wants to, as long as the interests are the intangibles that justify that position. To reach an agreement that satisfies both sides, the negotiator should, therefore, attempt to the interests of the parties involved (Ury, 2000).

The reflection on possible options tries to develop paths which satisfy these interests. Although it may not be possible to obtain the initial position desired, it may be possible to meet the initial interests with a different position than initially imagined.

The idea that there is a single point to be negotiated leads managers (negotiators) to interpret the most competitive situations as gain and loss, which tends to inhibit the creativity need to find solutions that meet the interests of all those involved in the negotiation (Fisher et al., 1994).

There are agreements or parts of agreements that can creatively satisfy both sides. Fischer et al. (1994) suggest four obstacles that inhibit the creation of a multiplicity of options: (1) the premature judgment; (2) the search for a single answer; (3) the assumption of a fixed cake; and (4) think that "solve their problem is their problem".

The development of alternatives is considered a crucial step of preparation for negotiation (Bazerman and Neale, 2008), because it is common, in negotiations, the parties enter into discussions looking for an agreement, without having to worry about thinking of other options if no agreement is reached. An agreement is only the means to an end, which is to satisfy the interests of the parties, and the purpose of a negotiation is to know in what way these interests can be satisfied.

The obtaining of agreements - that generate opportunities for mutual gain - in a negotiation is therefore a complex problem that involves multiple agents, criteria, interests and conflicting points of view.

It is assumed that group decisions of business, government and labour natures are usually taken in complex environments. Therefore, the scientific study of conflict analysis and facilitating consensus are highly relevant from a practical point of view (Gomes, 1991).

The reasons that make this a relevant research are:

- Originality: during the literature review, few publications related to the theme proposed by the current search were found;
- Specification and clarification of cognitive map as a support to the process of B2B integrative negotiation.
- Even though the word negotiation is known and commonly used, we can say that the subject negotiation is undeveloped in academia.

Methods

This work considers the multi-criteria decision aid methodology as an appropriate tool to model the negotiation process in the freight transportation services, due to the presence of the following:

- The criteria and the alternatives are both not clearly defined;
- The solution of the problems depends on many actors, each one with his points of view, in general conflicting.

Considering the conceptual characteristics of the multi-criteria decision aid and integrative negotiation, we propose the following methodological framework for this work (Figure 1).

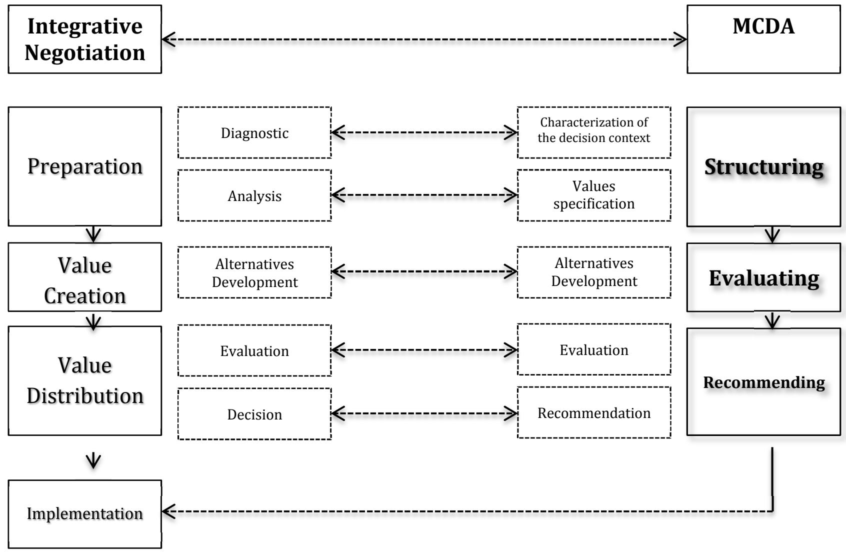

Figure 1. Proposed methodology.

In this work we use the model of integrative negotiation for creation of mutual gains proposed by Duzert et al. (2007), which consists of four steps, namely:

- Preparation: the initial step in the negotiation process, led by the facilitator, in which participants are selected and the provision of each one to negotiate on the basis of the search for the best deal is evaluated. The interests and alternative proposals for negotiation are also assessed; the regions of indecision and the points that need additional information are identified; the circulation of information is facilitated; an agenda is established. It refers, therefore, to what is before the process of negotiation starts.
- Value Creation: this step assumes that the dialog between the parties involved is open. Therefore, it refers to what is being done to explore (understand) the interests of the parties, create options for agreements and suspend the critical to enrich the possibilities.
- Distribution of Value: it refers to what is being done to reach an agreement from the distribution of the options defined in the stage of creation of value.
- Implementation: it refers to what is being done to implement and monitor the enforcement of agreements.

The agreement is the product of a decision-making process and, as such, goes through the stages characteristics as described above.

According to the model proposed in Table 1, in multi-criteria decision aid the steps of structuring, evaluation and recommendation are integrated with the steps of integrative negotiation.

Table 1: Correlation between the integrative negotiation and MCDA

Integrative Negotiation	Multi-criteria Decision Aid
Diagnostic	Characterization of the decision-making context
Analysis	Value specification
Alternatives creation	Alternatives creation
Evaluation	Evaluation
Decision	Recommendation

Application of the proposed methodology

For the application of the proposed methodology, the main activities are:

- Initial Activities:
  1) Choice of the unit for the methodology application, that is, to define the negotiation situation and the location where the methodology will be applied;
  2) Selection of the research group;
  3) Initial meeting: project presentation; selection of negotiation problems (opportunities); preparation of the schedule of activities.

- Activities related to Diagnostics: meeting with the research group for characterization of the decision context.

- Activities related to the Analysis:
  Meetings with actors to:
  a. Identification of the actors' objectives;
  b. Identification of the fundamental objectives;
  c. Construction of a hierarchy of fundamental objectives;
  d. Choice of attributes that will be used in the alternatives evaluation;
  e. Definition and description of the alternatives to be evaluated

- Activities related to Evaluation (not included in this research scope)
  Meetings with actors to:
  a. Construction of value functions;
  b. Determination of value scale;
  c. Partial assessment of alternatives;
  d. Overall assessment.

- Activities related to Decision (not included in this research scope)
  Meetings with actors to choose the more appropriate alternative.

Techniques and procedures of data collection used in this research

1. Characterization of the decision-making context

At the beginning of the decision aid process, the decision-making context is characterized by the following items: type of situation, level of decision, limits of time and space, actors and decision-makers.

2. Identification of the actors' objectives

The main purpose of this step is to make the identification of the objectives to be as complete as possible. In this research study, we chose to use the method known as cognitive mapping (Eden, 1988) to identify the objectives of the actors.

The cognitive map has proved to be of particular value when it comes to structuring complex decision-making problems (Belton et al, 1997). This method allows portray (describe) ideas, feelings, values, attitudes, and their inter-relationships, by means of a graphical representation.

According to Peixoto Neto et al. (2007), the cognitive map is used to identify the objectives, as follows:

a. The construction of the map starts with the definition of a label for the problem;
b. Decision-makers and the actors establish the problem label as a result of issues that are raised and considered important;
c. Primary Elements of Evaluation (PEE) are defined, which represent the goals, objectives and values, as well as options and alternatives; the PEEs are the basis for the construction of the cognitive map;
d. The PEEs are obtained by means of brainstorming; the PEEs are keywords of an idea, that is to say, they are important or desirable aspects about the problem;
e. Then a concept is associated with each PEE. A concept is represented by a phrase and a contrasting phrase to clarify its meaning. The phrases are separated by dots which are read as "rather than";
f. Hierarchies of concepts are constructed, starting from any one of the concepts. The facilitator will help the decision-maker to relate ideas with questions like: "why is this concept important to you?" or "how can you obtain this?"

3. Cognitive map analysis

The analysis of the cognitive map starts with the identification of paths of argumentation (Ensslin et al., 2001). Each path of argumentation is composed of a sequence of concepts. Once defined the paths of argumentation, the branches of the map have to be defined. They are formed by one or more paths of argumentation that demonstrate similar concerns on the issue.

An important analysis in relation to the complexity of cognitive maps is the determination of clusters, which are sets of concepts strongly interconnected, with a minimum of external links. According to Eden et al. (1983), the set of concepts, which makes a cluster, defines an area of interest related to the problem.

4. Hierarchy of fundamental objectives

Following the procedure for construction of a multi-criteria model to aid negotiation, a hierarchy of fundamental objectives has to be built. Keeney (1992) differentiates fundamental objectives, that represent the values of the actors, and means objectives, that help to achieve the fundamental objectives.

According to Bana e Costa (1992), a fundamental point of view is an end in itself, that is, when the decision-maker says that the point of view is important in itself, it reflects a fundamental value. It is observed that Keeney (1992) uses the term fundamental objective to refer to what Bana e Costa (1992) calls the fundamental point of view.

A fundamental objective should be essential and controllable, i.e. it must be an important aspect and is influenced only by the characteristics of the decision-making context. In order to obtain the fundamental objectives, a concept being essential and controllable at the same time is identified in each branch of the cognitive map. This concept is the fundamental objective in that branch. Then, the fundamental objectives are structured in a hierarchy.

Results

The research work was carried out as follows:

- Initially a group of companies was selected for initial screening of an integrative negotiation situation;

- After that, the companies selected were contacted to schedule an initial meeting with the purpose of presenting the research proposal and identifying an integrative negotiation situation that is interesting both for research and for the parties involved;

- Finally, only after selection and acceptance of the negotiation situation for all involved, we initiated a meeting schedule for the methodological application as described in the previous item.

Some companies that were participating in the research gave up during the negotiation process, due to the purely distributive nature that negotiation took. The companies that remained in the research project considered that, even with the negotiation constantly tending to the distributive side (win-lose), there was a need - at least one of the parties - to return to integrative negotiation (win-win).

1. Characterization of the decision-making and negotiation context

This research was settled in Campinas (state of São Paulo, Brazil), during the annual negotiation process to renewal contract of warehousing and distribution services between the carrier and the shipper.

The carrier is a medium-size Brazilian company with reasonable operations (overland transportation and warehousing) only in the south and southeast of Brazil, acting with distribution and warehousing in 93 different cities of those two regions.

The shipper is a medium-size Brazilian manufacturing, localized in Campinas, which produces farmer equipment for small agribusiness. Its product flow is mainly for those two regions, which are the highest agribusiness areas in Brazil.

Both companies have been partners for almost 5 years, but in the contract renewal period, the relationship usually is not favourable for an integrative negotiation, due to the opposite demands from both managers. The shipper focuses are mainly based on cost reduction and service improvement. The carrier focuses are to increase price and reduce operation complexity (reduce cost).

In the months preceding the negotiation to contract renewal, the shipper company begins the process of bargaining (commercial game), making some complaints about the delivery time and failures of goods. The issues usually are not confirmed and accepted by the carrier.

On the other hand, the shipper complains about the cost due to the equipment used by the carrier that is not able to read the barcode printed in the shipper, forcing the carrier to relabel all the boxes. According to the carrier, this issue should be solved if the shipper changed the barcode software. All those complaints are generally present in the negotiation table just to force the other part to accept the arguments and proposals.

However, there is declared interest of both parties (shipper and carrier) to continue the partnership for another year, even recognizing that there are some different points that are still under negotiation, such as: freight cost, quality acceptance level, delivery time, labeling of boxes and implementation of performance indicators.

2. Cognitive maps

There are many types of cognitive maps. Here we will present a causal (or influence) map, because it seems to be the most helpful in structuring an objective hierarchy.

The cognitive maps enabled the negotiators (decision-makers) clarify their values related to the negotiation opportunities and provided a number of means in order to reach the desired ends.

The two organizations (shipper and carrier) were represented by their respective managers. Due to the dynamics of the negotiation process, it was not possible to construct the cognitive map in group. The sessions were held in separate meetings and the maps were built individually with each manager.

Figures 1 and 2 show, consecutively, the carrier and the shipper managers final version of cognitive maps. Each map is a hierarchy of concepts related by means-ends and influence links.

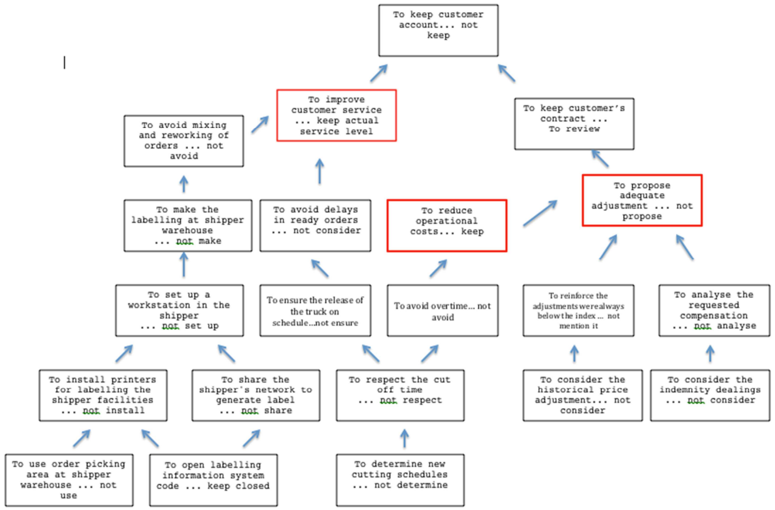

Figure 2: Carrier's cognitive map.

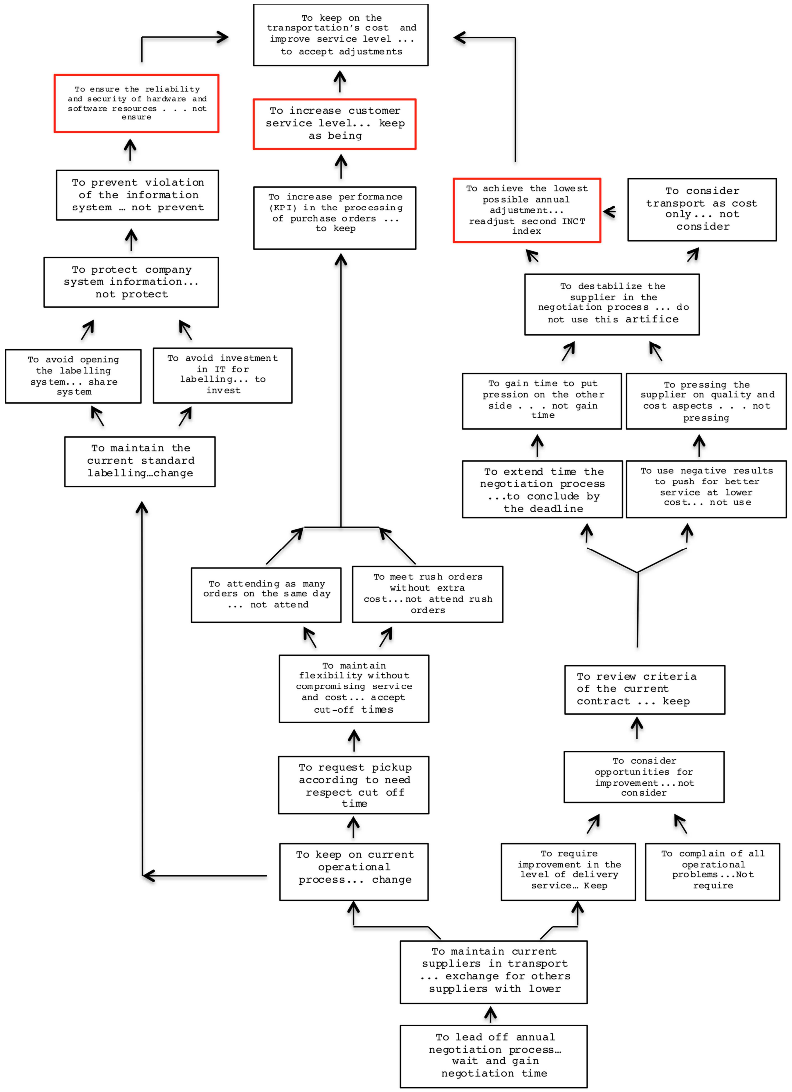

Figure 3: Shipper's Cognitive Map.

3. Identification of fundamental objectives

To identify the objectives, they were categorized into two types:

- Fundamental objectives: the ends objectives that essentially define the essential reasons for being interested in the decision;
- Means objectives: objectives that are important only for their influence on the achievement of the fundamental objectives.

It is important to separate objectives into fundamental objectives (which reflect the ends we are trying to achieve) and means objectives (which are important ways of achieving them), in summary:

- A fundamental objective is an end that the negotiators are trying to achieve.
- A means objective is a way of achieving an end or fundamental objective.
- Focusing on ends rather than means helps find creative solutions to problems.
- Objectives only need to state the thing that matters, and what direction you'd like it to move.

The objectives of the carrier and shipper are illustrated in Figures 4 and 5 separately.

Means objectives:	Fundamental objective:
➢ To open shipper's labelling system information code; ➢ To share the shipper's network to generate label; ➢ To install printers for labelling in the shipper facilities; ➢ To use picking are at shipper warehouse; ➢ To set up a workstation in the shipper warehouse; ➢ To labelling orders at shipper warehouse; ➢ To avoid mixing and reworking of orders.	To improve customer service

Means objectives:	Fundamental objective:
➢ To determine a new cut-off collect schedules; ➢ To respect the cut off time; ➢ To avoid over time; ➢ To avoid delays in ready orders.	To reduce operational costs

Means objectives:	Fundamental objective:
➢ To consider the historical price adjustment; ➢ To reinforce the adjustments were always below the index; ➢ To consider the indemnity dealings; ➢ To analyse the requested compensation.	To propose adequate price adjustment

Figure 4: Fundamental and means objectives of the carrier.

Means objectives:	Fundamental objective:
➢ To lead off annual negotiation process; ➢ To maintain actual transportation suppliers; ➢ To keep on current operational process; ➢ To request pickup according to need; ➢ To maintain flexibility without compromising service and cost; ➢ To attending as many orders on the same day; ➢ To meet rush orders without extra cost; ➢ To increase performance (KPIs).	To increase customer service level

Means objectives:	Fundamental objective:
➢ To keep on current operational process; ➢ To maintain the current standard labelling; ➢ To avoid opening the labelling system; ➢ To avoid investment in IT for labelling; ➢ To protect company system information; ➢ To prevent violation of the information system;	To ensure the reliability and security of hardware and software resources

Means objectives:	Fundamental objective:
➢ To require improvement in the level of delivery service; ➢ To complain of all operational issues; ➢ To consider the opportunities for improvement; ➢ To review criteria of the current contract; ➢ To extend time the negotiation process; ➢ To use negative results to push form better service at lower cost; ➢ To gain time to put pressure on the other side; ➢ To pressing the supplier on quality and cost aspects; ➢ To destabilize the other side (supplier) in the negotiation process.	To achieve the lowest possible annual adjustment

Figure 5: Fundamental and means objectives of the shipper.

The process of identifying objectives resulted in a more accurate understanding of what each party should care about in the negotiation process and helped to clarify the negotiation context.

The fundamental objectives seem to be common, however, they would be referred to different point of views. For instance, when the shipper refers "To increase customer service level", he is referring to his customers (retail); however, for the carrier, the customer is the shipper. As both are parts of the same supply chain, we can say that the other side directly influences the service level of one side.

The same can be concluded about the objectives related to the price/cost. For the carrier, the fundamental objective is to have a fair price for the desired service level; on the other hand, to the shipper, the fundamental objective is to pay as little as possible for a better service. Therefore, so long as the price is right for the desired service level, the two sides are met in their objectives.

Therefore, after the construction of the cognitive maps, the negotiation process has tended to a more integrative posture, thereby facilitating achievement of mutual gains.

4. Remarks

The negotiation process stood at intermediate points, ranging between two extremes: purely distributive bargaining (when discussing only price and cost) and the highly integrative bargaining (when using the cognitive map as a facilitador tool). However, in certain moments, it was also found a distributive negotiation for non-monetary criteria, such as when discussing delivery time and quality indices.

Integrative negotiation is important because it usually produces more satisfactory outcomes for the parties involved than does distributive negotiation. Distributive negotiation is based on fixed, opposing viewpoints (positions) and tends to result in compromise or no agreement at all. Oftentimes, compromises do not efficiently satisfy the true interests of the disputants.

Instead, compromises simply split the difference between the two positions, giving each side half of what they want. Creative, integrative solutions, on the other hand, can potentially give everyone all of what they want.

In distributive negotiations where there is only one issue to negotiate, for example, the price of a good, what one party wins is equivalent to what the other party looses. Conversely, if a negotiation contains more than one issue, there is room to exploit the differences on preferences, beliefs and capacities, and this way achieve an outcome that is better off for both parties (Raiffa, 1982).

The following are key features established for negotiation between carriers and shippers:

- Reliability: ability to fulfill what was agreed as the delivery and collection, security, price and availability.
- Price / Cost: the shipper selects his best option basically evaluating cost, more specifically the freight price established for the load to be transported, even if he considers a variety of factors, such as transport time, multimodality, contracts, distance, security integrity, agility, urgency, among others.
- Flexibility: both commercial and operational, it has become an increasingly important criterion by the dynamics of the business world; necessary to adapt the operation and renegotiate prices and contracts.
- Financial health: it is a requirement for long-term relationships in basis for cooperation and permanent technological upgrading.
- Quality of operational staff: formal educational need, technical training and behavioral and operational ability through qualification and training programs.
- Continuous improvement: structured activity aimed at the continuous improvement of service quality and cost reduction; the need to develop partnerships with service providers based on trust and exchange of information.
- Cargo consolidation policy: in order to work with large volumes and making use of full capacity of large vehicles, allowing reduction of transport costs; should pay attention to standardization of service and deadlines; useful both to the carrier - directly - as the shipper.

Conclusions

This paper presented the cognitive map as a tool that allows a problem definition, in a context of multiple actors involved in a negotiation, showing that the cooperation between the parties, particularly with regard to information sharing, is essential to enable the expansion of value. This conclusion comes from the observation during the application of the proposed methodology in a context that, sometimes, tended more to a dispute (distributive negotiation) than for cooperation (integrative negotiation).

If the negociation process, as we have presented, is a set of multiple objectives about each dead-lock, the definition of which negotiation problem (impasse negotiation) the facilitator is aiding to solve is extremely important to structuring a multi-criteria model.

Knowing that negotiation is the search for agreements in the presence of common interests and divergent points of view, the use of cognitive maps can encourage members to think of common points that otherwise would not be thought.

It was also found that the negotiation has combined distributive and integrative dimensions: sought to "expand the pie", but each party bothered to secure for himself a good share of it.

What makes a negotiation more integrative is a series of combined factors such as: (Ramsay, 2005)

- Existence of a prior relationship;
- Prospects for future relationship;
- Possibility of other related business (immediate or future)
- Common interests (the same desirable outcome for both sides);
- Complementary interests between the parties (the positive outcome of a party does not prevent the additional gain of another);
- Interests with degrees of importance distinct between the parties.

Therefore, it seems that when the occurrence of the above factors increases, the negotiation is closer to the integrative type.

It is important to note here the difference between negotiation and group decision. Although sometimes used interchangeably, these terms represent different ideas. The main differences are presented in Table 2.

Table 2: Differences between negotiation and group decision.

Aspects	Group Decision	Negotiation
1. Fundamental objectives	Common	Contrary
2. Alternatives	Established	Interactively generated
3. Restriction, values and beliefs	Discussed and shared	Suppressed
4. Resolution of disagreements	Can occur by vote	Mediation or arbitration may be required
5. Nature of the process	Deliberative process	Competition
6. Abandoning the process	Unusual	Usual

Source: Dias e Clímaco, 2005

These differences indicate that the negotiation process is very complex and therefore require tools to facilitate decision-making.

People are not alike in their values and beliefs; there are huge differences among people within a single organization, and even greater differences between people in different organizations.

Strategic leaders must know how to operate across such boundaries that mark differences in expectations and perspectives, and competing values and goals. It is one thing to influence a group essentially in agreement; it is quite a different thing to influence a group with goals in conflict with those you want to pursue.

In conclusion, co-operation is still perceived as desirable, companies will need to understand the slower maturing benefits that are achievable through the application of the integrative approach.

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