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CENTRO DE DESENVOLVIMENTO EM SISTEMAS DE INFORMAÇÃO E DECISÃO

Multi-Criteria Group Decision Making

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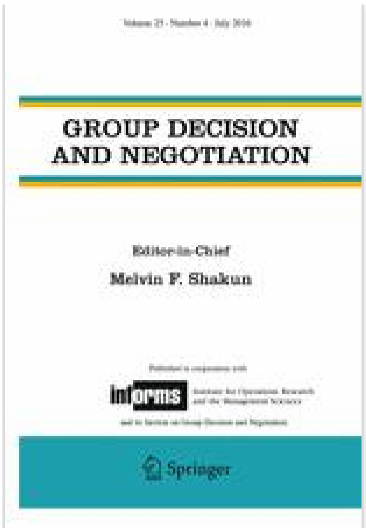
Outline

- Community in GDN (Group Decision and Negotiation)
- Basic concepts on MCGDM (Multi-Criteria Group Decision Making)
- Aggregating approaches to support MCGDM
- Multicriteria Group Decision with partial information
- Voting systems and Choice of a voting procedure

Community on GDN

- Section of INFORMS
- Journal:



https://www.informs.org/Community/GDN

Group Decision and Negotiation

Overview

The Group Decision and Negotiation (GDN) Section of INFORMS emerges from evolving, unifying approaches to group decision and negotiation processes. These processes are complex and self-organizing involving multiplayer, multicriteria, ill-structured, evolving, dynamic problems.

In defining the domain of group decision and negotiation, the term "group" is interpreted to comprise all multiplayer contexts. Thus, organizational decision making support systems providing organization-wide support are included. Group decision and negotiation refers to the whole process or flow of activities relevant to group decision and negotiation, not only to the final choice itself--e.g. scanning, communication and information sharing, problem definition (representation) and evolution, alternative generation and social-emotional interaction. Descriptive, normative and design viewpoints are of interest. Thus, *Group Decision and Negotiation* deals broadly with relation and coordination in group processes.

Approaches include:

- Computer group decision and negotiation support systems (GDNSS),
- Artificial intelligence and management science,
- Applied game theory, experiment and social choice, and
- Cognitive/behavioral sciences in group decision and negotiation.

Areas of application include intraorganizational coordination (as in operations management and integrated design, production, finance, marketing and distribution, e.g., as in new products and global coordination), computer supported collaborative work, labor-management negotiations, interorganizational negotiations (business, government, and nonprofits--e.g., joint ventures), international (intercultural) negotiations, environmental negotiations, etc.

(Note: we are working on resources that would be available for members.)

GDN

GDN Conferences

GDN 2016: The 16th international annual meeting on Group Decision and Negotiation will take place in Bellingham, Washington, USA, in June 20-24, 2016.
more ...

GDN 2015: The 15th international annual meeting on Group Decision and Negotiation Warsaw, Poland. June 23-26, 2015.
more ...

Meetings & Conferences

Conferences

The GDN series of conferences have provided a stimulating environment for the dissemination of state-of-the-art knowledge in the field of group decision and negotiation, allowing for fruitful discussions among participants often leading to new joint research and teaching projects. A number of papers presented at the conferences were published in the Special Issues of the INFORMS "Group Decision and Negotiation Journal" published by Springer as well as in the Journal's regular issues.

Next and Recent Conferences

GDN 2019

The 2019 Joint GDN-BOR Meeting will take place in Loughborough University, Loughborough, England, June 11-15, 2019.

GDN 2018

The 18th International Conference on Group Decision and Negotiation will take place in Nanjing, China, 9th -13th June 2018. more...

GDN 2017

The 17th annual international meeting on Group Decision and Negotiation will take place in Stuttgart, Germany, 14 - 18 August, 2017.

Learn more.

GDN 2016

The 16th international annual meeting on Group Decision and Negotiation will take place in Bellingham, Washington, USA, in June 20-24, 2016. This conference of the INFORMS GDN section provides a forum for researchers from Africa, the Americas, Asia, Europe and Oceania. It is the premier meeting place for researchers, practitioners, teachers and consultants involved in every aspect of group decision and negotiation involving human as well as artificial agents.

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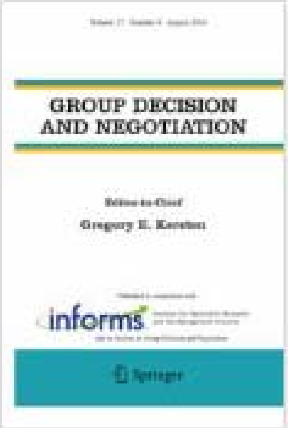

Description

Group Decision and Negotiation is published in cooperation with the Institute for Operations Research and the Management Sciences and its Section on Group Decision and Negotiation. The journal focuses broadly on relation and coordination in group processes by exploring the entire process or flow of activities relevant to group decision and negotiation.

Among the evolving approaches to group decision and negotiation processes, … show all

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GDN - Group Decision and Negotiation

- In many decision processes there is more than one Decision Maker (DM).
- GDN includes the study and development of methods to **support groups** or **individuals within groups** to interact and collaborate in pursuit of a collective decision (Kilgour and Eden, 2010)
- In such situations a group decision (GD) model or a negotiation process has to be applied in order to come to a final solution.
- Negotiation and group decision contain both **unity** and **diversity** (Kilgour and Eden, 2010).

Group Decision and negotiation

- **Group Decision**
  - Decision involving two or more DMs, which will take some responsibility for the choice (Kilgour and Eden, 2010).
  - It involves an **analytical procedure** to aggregate preferences of a group of DMs.
- **Negotiation**
  - Process in which two or more independent individuals can make a collective choice **or no choice** (Kilgour and Eden, 2010)
  - It involves a **process of interaction** among DMs to come to a decision together.

MCGDM
Multi-Criteria Group Decision Making

GD process involves:

- **Analytic procedure**
  - Aggregation of the DMs' preferences.
  - The process for building models pays great attention to following rules of rationality, related to a normative perspective.
  - Also, there are some concerns about dealing with some paradoxes, as shown by the descriptive perspective.
- **Interaction process**
  - The interaction between people invokes other concerns, such as the accuracy of their communication process.

Actors of the GD Process

- Same of MCDM/A
  – Decision maker
    - Power for making decisions
  – Analyst
    - Methodological support
  – Client
    - Intermediary between the DM and the analyst
  – Stakeholders
    - Influencing the DM through some kind of pressure
  – Expert
    - Specialist for factual information

- Add to GDN
  – **facilitator**
  – **mediator**
  – **arbitrator**

Availability and cooperation among decision makers

- GDN could occur in different types of environment:
  - Collaborative or cooperative
  - Competitive, Conflicting

Availability and cooperation among decision makers

- Decision makers may have
  - The **same objectives** (but they do not "clearly" realized it)
  - Different objectives, but **complementary,** in order to achieve a greater goal (from organization)
  - Different and **conflicting objectives**
  - **Opposite** objectives

Availability and cooperation among decision makers

Decision makers may

- Have available time to interact among them (the communication process could be simultaneous or not)
- Not have available time (or their time availability could not be synchronized) to develop interactions within the needed time window.

GDN and some areas of knowledge

GDN involves synergy among several areas of knowledge, such as:

- Operational Research
  - Game theory
  - MCDM/A
  - Problem Structuring
- Social Choice Theory
- Social Psychology
- Political science
- Systems engineering
- Information systems
- Computer science

Preference Aggregation or Knowledge Aggregation

- **Preference** aggregation
  - **Decision makers**
- **Knowledge** aggregation
  - **Experts**

Preference aggregation

- Get the preference structures of decision-makers
  - Do not seek the same result
  - It may involve different or conflicting objectives among decision makers
- Aggregating preferences
  - Bargain may occur
  - Several manipulations in the process may occur and should be worked on

Knowledge aggregation

- Involves a **description** of behavior of one or more system's variables
- It is **NOT a decision process** in the sense of using a preference structure
  - It could consider sensorial decision.
- **Different perceptions** of the same phenomenon
  - They seek the same answer
  - It does not involve different or conflicting objectives among experts
  - Hopefully, experts do not act as decision makers trying to distort the process of seeking knowledge
- Experts have different backgrounds

Knowledge aggregation

- It does not involve negotiation, but it may involve disputes under the imposing of their perceptions
  - A **learning process** about a ‘system behavior’ is expected from the interaction
- Processes for obtaining consensus
  - about the **perception** of the problem’s variables
- A variety of type of knowledge and processes
  - Subjective probabilities aggregation

Organizational context

Decision-maker within the organizational context

Regards the role of the actor in the organization representing the **organization's preferences**

What is a Decision-maker?

- DM should not be mistaken by experts
  - regarding to the organizational context
- Characteristics of Decision Maker
  - **Power** for making decisions
  - **Responsibility** over the **consequences**
    - Rewarded or
    - pay damages
- Pseudo-DMs (do not have power)
  - But, may have influence
  - Power is classified in many ways, such as the power of making influence on other people.

Interrelation among DMs

Group of DMs with a Supra-Decision Maker

- Also called ‘benevolent dictator’ (Keeney, 1976)
- Supra-DM usualy has a hierarchical position in the organization’s structure above the other DMs.
- Imposes the aggregation rule
- Defines the weights for each DM, if that is the case

Group Decision with Participatory process

- The group acts jointly in the GD process, with the same power
- Develop their own aggregation rule
- Decide about the DMs’ weights (Same weights or use of a method to obtain different weights)

Weights for DMs

- Degree of importance of decision-makers
  - weighting decision-makers
- Some methods assume
  - **same weights** for DMs
  - **different weights** for DMs
  - **no weights** are assigned for DMs

Degree of importance or Weighting the DMs

- In non-compensatory models the degree of importance of decision-makers can be represented by weights.
- However, in compensatory models, as in the additive model, one question might appear: what you want to compensate?
  - Is there tradeoff among results or among DMs?
- The aggregation rule must combine the different assessments of the consequences or the different decision-makers?
  - The idea of compensation among DMs may seem strange or may not be exactly what you want.

Aggregation approaches to support group decision

Involve the reduction of different individual preferences to a set of **collective** preferences

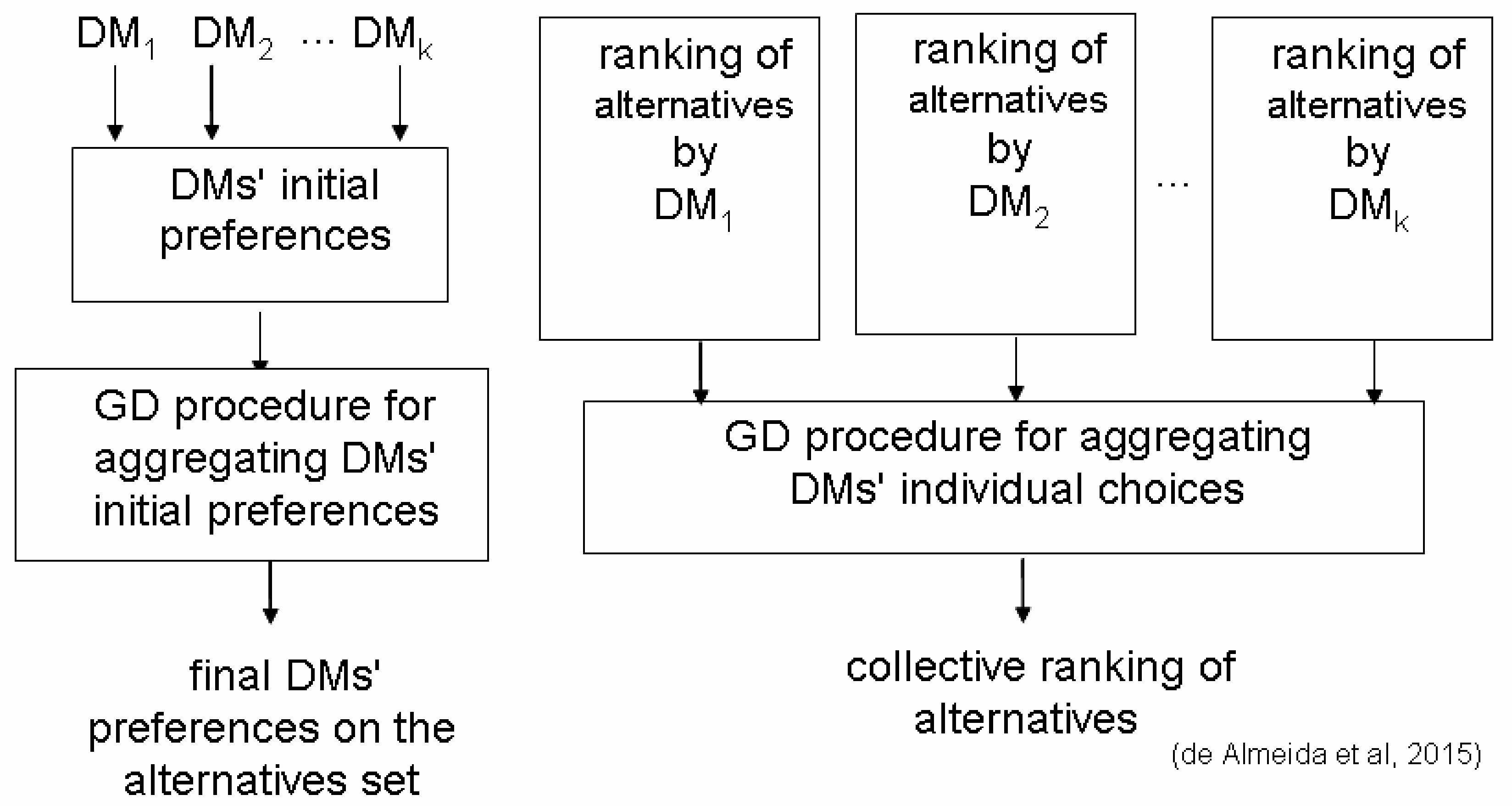
Procedures for group decision

– Whether or not a supra-DM is present in the process, two kinds of GD aggregation general procedures may be considered (Kim and Ahn 1999; Leyva-López and Fernández-González 2003; Dias and Clímaco 2005; de Almeida et al, 2015):

Procedure #1: Aggregation of DMs' **initial preferences**

Procedure #2: Aggregation of DMs' **individual choices**, which means the ranking of alternatives by each DM's

Procedures for group decision



- Procedure #1: Aggregation of DMs’ **initial preferences**

- Procedure #2: Aggregation of DMs’ **individual choices**

How choosing between the two procedures?

- It depends on the organizational context and how DMs are related and available
- For **expert aggregation** (knowledge),
  - Procedure #1 (the process applied to Aggregation of DMs' initial Preferences)
  - would be more appropriate

Procedures for group decision

With regard to the first steps of preparation for the GD process,

- In the Procedure 1,
  - there is an integration
  - The final result of each DM is not viewed directly,
  - because the aggregation among DMs is developed from the initial preference data.
- whereas in the Procedure 2, the process is completely separate for each DM.

Procedure #1: Aggregation of DMs' **initial Preferences**

- The DMs provide their initial preferences in an integrated way,
  - in which the aggregation process is considered from the very beginning.
- Then, the process produces the final choices for the set of alternatives.
- This may be given as a
  - simple ordinal ranking of the alternatives or
  - may include a cardinal score for each alternative,
  - depending on the method applied, which is the same for all DMs.
- The same criteria are considered for all DMs,
  - but the intra-criterion and inter-criteria evaluations may be different.
    - In most models intra-criterion are the same; so, the main difference is in the analysis of the criteria weights.

Procedure #2:
Aggregation of DMs' **individual choices**

- Each DM provides his/her individual ranking of alternatives.
- That is, the individual DMs' choices produce the final ranking of alternatives
  - or other results if another problematic, such as choice or sorting, is applied,
  - although in many cases, information on scores of the alternatives is not expected to be produced, in general.
- These **may be** produced by **completely different methods**, with **different criteria** for each DM.

Procedure #2: Aggregation of DMs' **individual choices**

- With regard to the procedure, It does **not matter which objective each DM** considers.
- The **only information** that matters is the **final individual evaluation** of each alternative by each DM.
- With regard to the GD process,
  - if a ranking of alternatives is produced by each DM, then the GD procedure may be conducted by using:
    - a voting procedure, which is based on the foundations of Social Choice Theory (Nurmi 1987; Nurmi 2002); or
    - An MCDM method in which ordinal input may be applied.

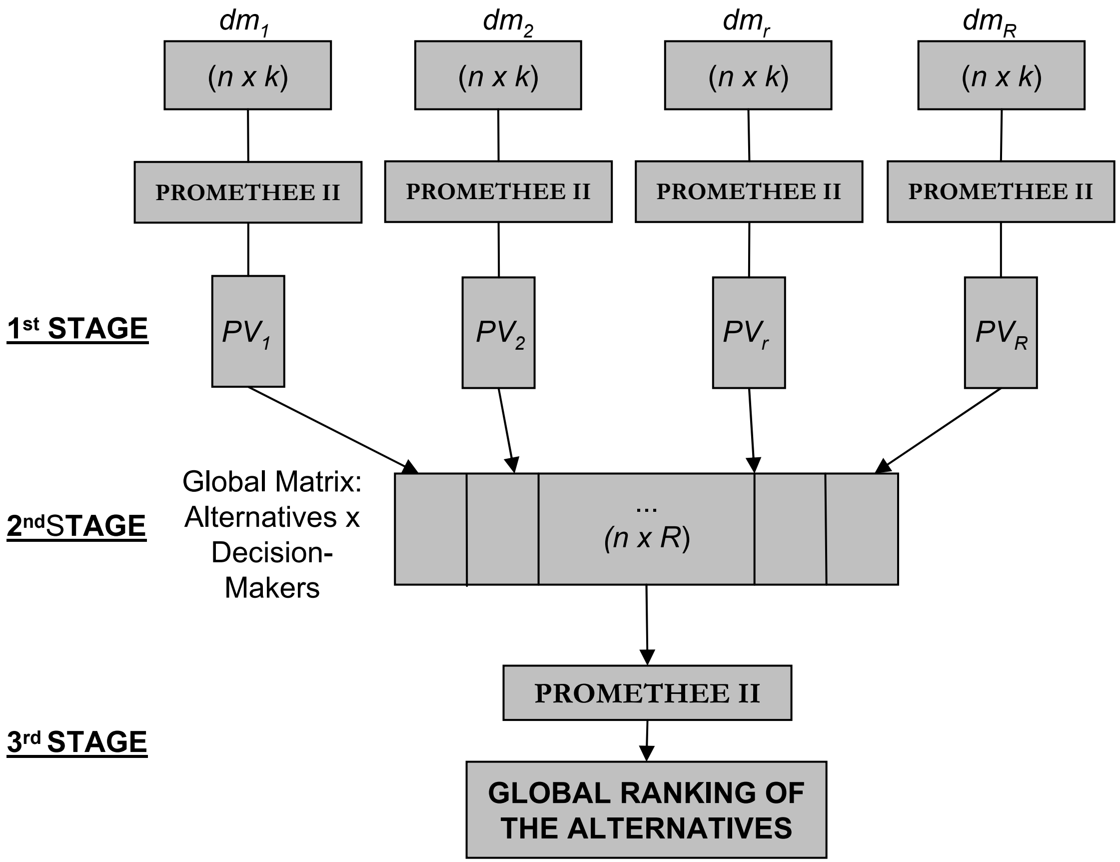
Multicriteria Methods for aggregating DMs' preference

- Multicriteria Methods may be applied for aggregating DMs' preference in both procedures:
  - Procedure #1 - Aggregation of DMs' Initial Preferences;
  - Procedure #2 - Aggregation of DMs' Individual Choices
- The difference is made in the process of integrating the DMs and their preferential information.
- On the other hand, voting procedures are applied in general for procedure #2.

Outranking Models

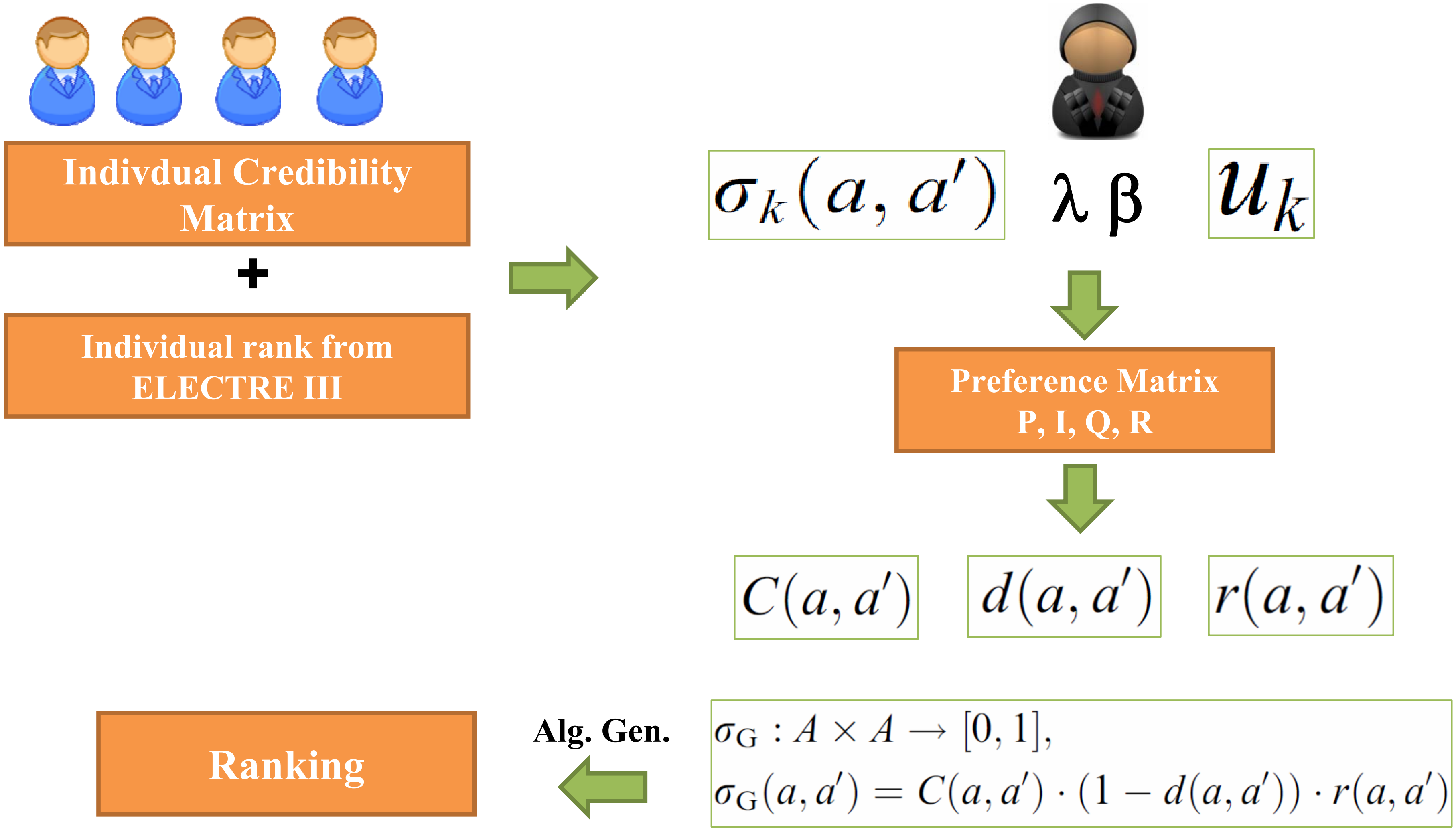
Procedure #2:
Aggregation of DMs' individual choices

PROMETHEE - GDSS



The GDSS PROMETHEE Procedure (Macharis, Brans, Mareschal, 1998)

ELECTRE - GD



(Leyva-López, et al, 2003)

Voting Procedures

Procedure #2:
Aggregation of DMs' individual choices

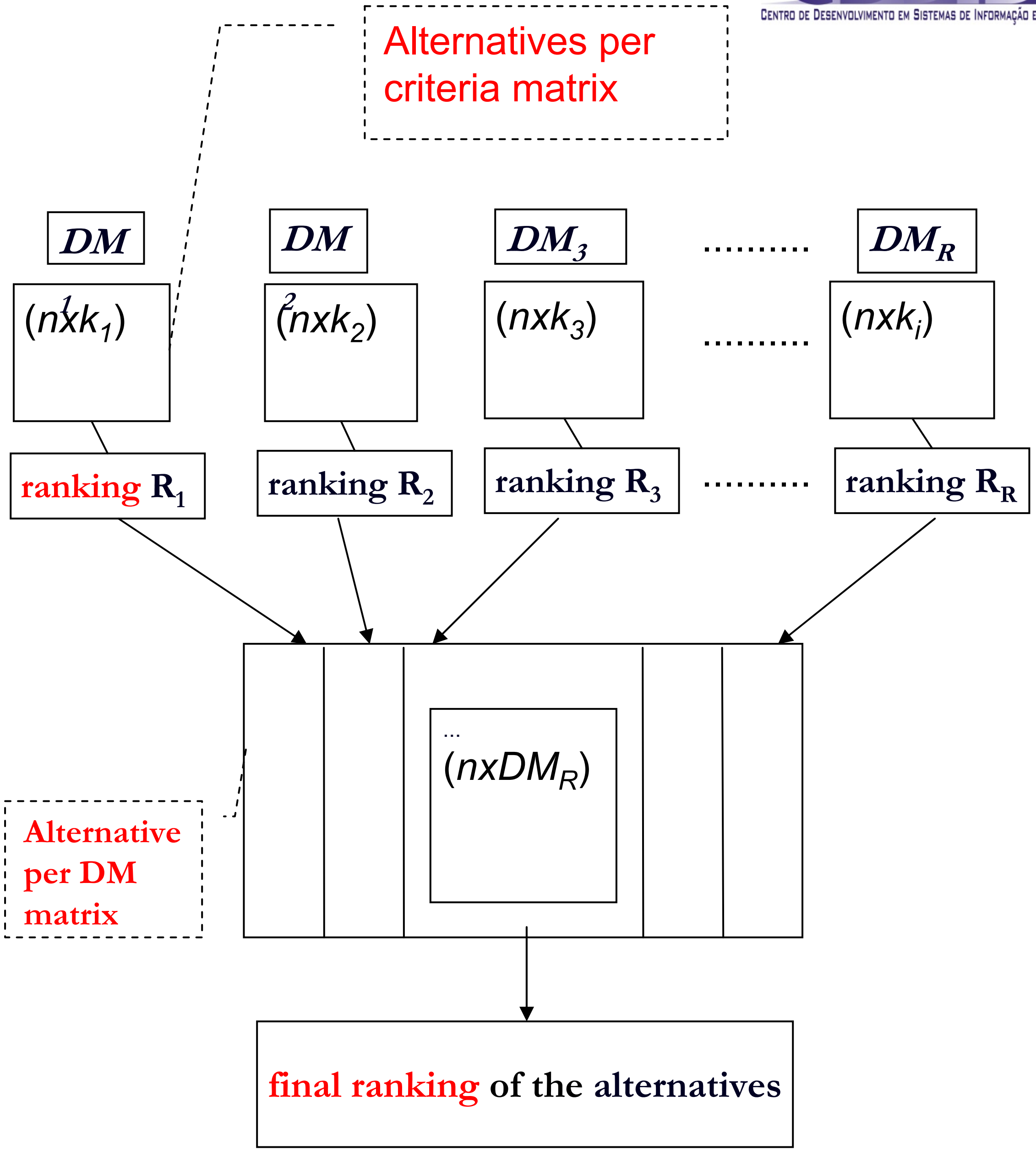
Voting Systems

- The voting systems can be used for other purposes than election.

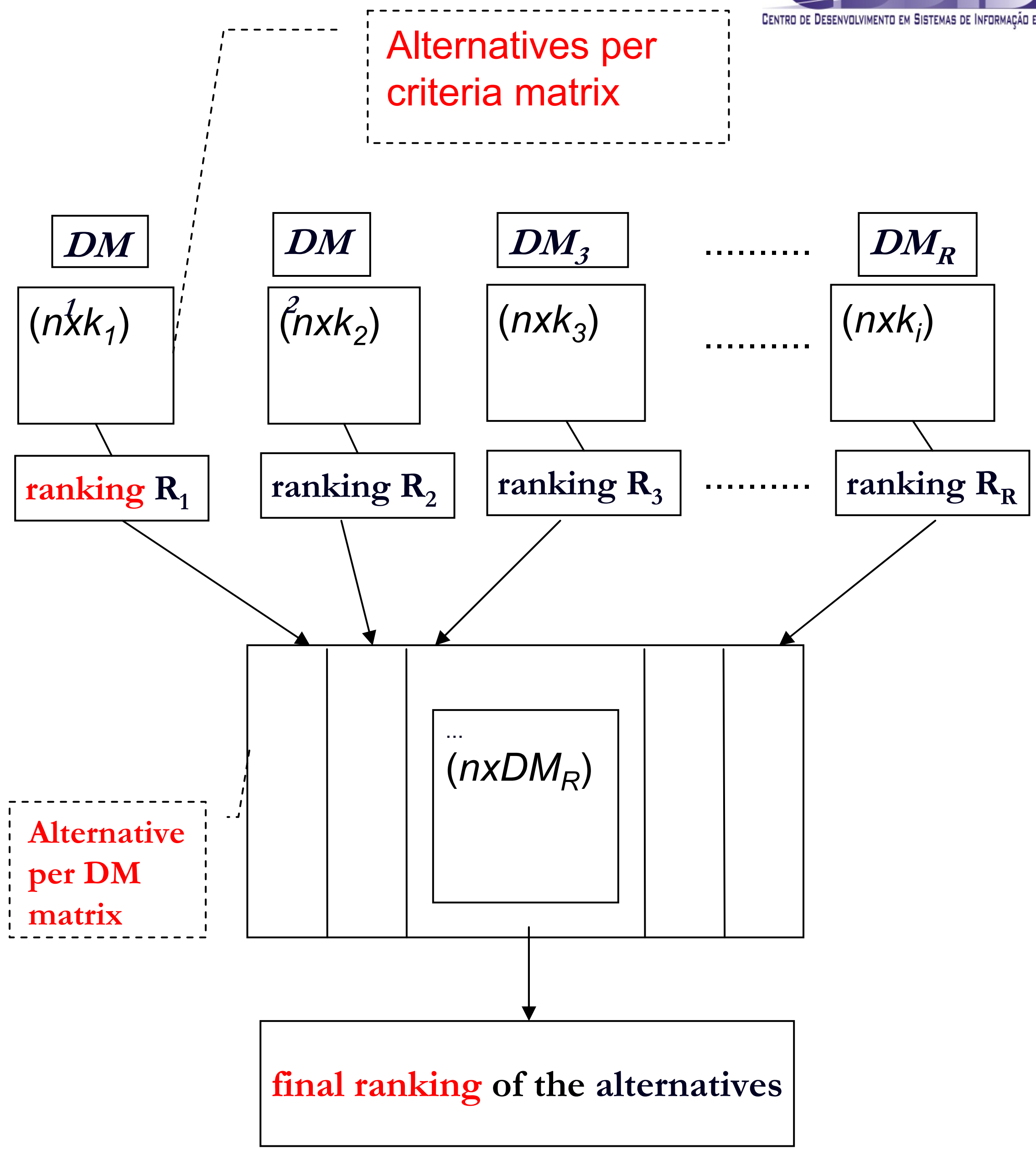
- A particularly interesting purpose is
  - supporting a multicriteria decision-making process of a group of DMs.

- Consider a situation where several DMs must choose one of several alternatives or rank these alternatives
  - these DMs has several objectives (multicriteria), which may be common for all or not.

- In this model:
  - Each DM can consider different criteria k_i to evaluate the alternatives
  - The information given by each DM is the rank of *n* alternatives.
  - No matter which criteria each DM will consider
  - The ranking of the alternatives is obtained by each DM, using the same method or different method (according the preference structure of each DM).



- In this model:
  - From the intermediary result generated by the DMs (ranking 1, ranking 2, ..., ranking r)
  - It can be used an approach that applies ordinal information about the alternatives, aggregating in order to reach a group decision process.
  - In this case, **a voting system** can be applied.



Voting Systems

- Voting systems are associated with Procedure 2 of the types of procedures for GD aggregation:
  - Aggregation of DMs' **individual choices**

- The study of the voting systems is related to the Social Choice Theory.

- There are several voting systems proposed in the literature.

Voting Systems

- It is important to highlight the role of the Social Choice Theory in voting systems, when the purpose of these systems is related to support a group decision and the preferences of DMs should be considered.
- So, these systems do not just deal with the analysis of data on the preferences of various DMs.
  - There are approaches like this related to computer science area
- Aspects of preferential characteristics and social behavior should be considered.
- A voting procedure can be understood as
  - A method for reaching social choices from individuals preferences (Arrow, 1950).
- There are many voting procedures available.
  - Only a few are following presented.

Voting Systems

- **Plurality method**
  - One of the simplest ways to assess the collective preference.
  - The option which receives more votes wins.
  - Some drawbacks: For example, in a dispute among six alternatives if one gets 20% of votes and five others get 16% of votes each, the former wins despite having achieved only 20% of the preference, against 80% divided among the other contrary to its victory (Smith, 1973).

A1	A2	A3	A4	A5	A6
20%	16%	16%	16%	16%	16%

80%

  - Widely used in political elections
    - The second round system is adopted to mitigate inconveniences
    - It is only indicated in cases where voters only vote in one alternative
  - For ranking, another type of aggregation is required.

A paradox of voting

Example:

- 3 decision makers and 3 alternatives (A, B, C)
- *P* is a preference relation

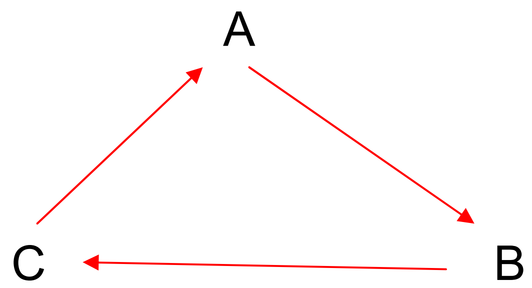
- Individual preferences:
  - DM 1: A *P* B *P* C
  - DM 2: B *P* C *P* A
  - DM 3: C *P* A *P* B

- For the majority A*P*B and also B*P*C
  - So assuming rationality of decision makers (transitivity) then A*P*C

- However,... another majority says that C*P*A !!!

Paradox of voting

- The transitive property – required for rationality- is not attended



- In a problem with several alternatives, when making a pairwise comparison, may arises several cycles, demanding more attention.

Social choice

- Kenneth J. Arrow (1950) “A Difficulty in the concept of social welfare”, The Journal of Political Economy, vol. 58, n. 4, 328-346.
- Question:
  - “*Is it formally possible to build a procedure for passing from a set of individual preferences to a pattern of social decision-making, satisfying certain natural conditions?*”
- Arrow’s theorem (1950)

Social Choice conditions – Arrow

- **Condition I:** The social welfare function is defined for every admissible pair of individual orderings, *R1, R2*
- **Condition 2:** If an alternative social state *x* rises or does not fall in the ordering of each individual without any other change in those orderings and if *x* was preferred to another alternative *y* before the change in individual orderings, then *x* is still preferred to *y*. (Positive association of social and individual values)
- **Condition 3**: Let R1, R2, and R1', R2' be two sets of individual orderings. If, for both individuals *i* and for all *x* and *y* in a given set of alternatives S, xR_jy if and only if $xR_j'y$, then the social choice made from S is the same whether the individual orderings are R1, R2, or R1', R2'. (Independence of irrelevant alternatives.)

Social Choice conditions – Arrow

- **Condition 4**: The social welfare function is not to be imposed.

- **Condition 5**: The social welfare function is not to be dictatorial (nondictatorship).

Social Choice Axioms - Arrow

- x*R*y, means that x is preferable or indiferente to y:

- Axiom I: For all x and y, either xRy or yRx.

- Axiom II: For all x, y, and z, xRy and yRz imply xRz.

The Possibility Theorem For Social Welfare Functions

- “If there are at least three alternatives among which the members of the society are free to order in any way, then every social welfare function satisfying:
  - Conditions 2 (a positive association between the social choice and the individual) and 3 (Independence of irrelevant alternatives), and yielding a social ordering satisfying Axioms I and II must be imposed or dictatorial”

Some Voting Systems

- Borda (1781)
- Condorcet (1785)
- Copeland (1951)
- Approval voting (Brams and Fisburn, 1978)
- Weighting voting procedure based on the quartil classification

Borda

- Proposed by Jean-Charles de Borda in **1781** as a procedure to aggregate individual judgement of members of a jury (Borda, 1781; Nurmi, 1983).

- There are some variations of this method.
  - This is a **method of weighted position.**
  - The method involves ranking all the alternatives for each criterion, **assigning k1 points to the first position, k2 points for the second position**, and so on.
  - Considering *m* alternatives of set A, then exist kj which is named Borda Coefficient and k1> k2> k3> ...> km ≥ 0.

Borda

- Aggregation is the sum of the points that each alternative gets for each decision maker.
- So the **first alternative** of the ranking, called "**Borda winner**" is the one with more points, and so on, until the last alternative (fewer points).
- Initially the alternatives are ordered per each DM i in a complete pre-order.
- The alternative *j* receives the ranking $r_i(a_j)$ related to the DM *i*. Then, $r_i(a_j)$ is the function associated *kj* with *aj*. Then: *ri(a1) = k1, ri(a2) = k2, ri(a3) = k3, ri(a4) = k4*, etc.

Borda

- To determine Borda coefficient:
  – Consider that the worst alternative km = a, and for the following alternative (second worst) k_{m-1}= a + b, for the third worst k_{m-2}= a + 2b, and so on.

- Aggregation function b(aj):

$$b(a_j) = \sum_{i=1}^{n} r_i(a_j)$$

Example (Borda)

- 4 alternatives and 3 decision makers
- Suppose the following sequences for each DM
  - DM 1: *A1 P A2 P A3 P A4*
  - DM 2: *A1 P A2 P A4 P A3*
  - DM 3: *A2 P A3 P A4 P A1*
  - Considering a = 1 e b =1 for the Borda Coefficient:

	D1	D2	D3	b (aj)
A1	4	4	1	9
A2	3	3	4	10
A3	2	1	3	6
A4	1	2	2	5

Collective Result: *A2 P A1 P A3 P A4*.

Borda

- A problem of this method is the dependence of irrelevant alternatives, question raised by Arrow (1950).

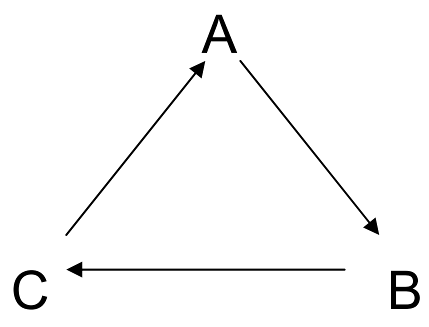
- a problem of order reversal among alternatives may arise if removed or added any alternative to the set.

Condorcet

- This method was proposed by the Marquis de Condorcet (Condorcet, 1785), who had its motivation in a vote aggregation context in a jury.
  - The procedure consists of an assessment based on **pairwise comparison**.
  - Comparing two alternatives, *Ai* and *Aj*, the winning alternative is the one that gets advantage over the other by **most of decision makers**.
  - If two alternatives have the same number of DMs in favor, an indifference is considered. The alternative that has the best performance among all is called "**Condorcet winner**".

Condorcet

- Paradox of Condorcet:
  - **Do not assure the property of transitivity**.
  - This paradox may occur in a comparison among 3 alternatives *A, B* and *C* in which **a circle could be formed.**
- *A P B; B P C; C P A*



Condorcet

- A feature of Condorcet method is that it is **a non-compensatory procedure**.
- It can be observed easily that **the final position of the alternative does not consider**, for each decision maker, **its position or value**.
- The only information considered is **which alternative has better performance** for each decision maker, **without taking into account how much it is.**

Condorcet - example

- 3 alternatives and 5 decision makers
- DM1: *A P C P B* DM3: *B P A P C*
- DM2: *B P C P A* DM4: *C P A P B* DM5: *C P B P A*

Alternatives	A	B	C
A	--	2	2
B	3	--	2
C	3	3	--

(*C P B; B P A; C P A*); transitivity

- 3 alternatives and 13 decision makers

Alternativas	A	B	C
A	--	8	6
B	5	--	11
C	7	2	--

- (*A P B; B P C; C P A*) – cycle!

Voting in agenda

Alternatives presented in a sequence of pairs for evaluation.

- **For each pair compared**, one alternative is eliminated and **the winner goes to next pair**.

The **one organizing the agenda** can **make the decision**.

- In previous example: (*A P B; B P C; C P A*) – intransitivity!
  - 1st pair: A and C; following pair with B.
  - Alternative **B is the winner**!
- However, changing the order:
  - 1st pair: A and B; following pair with C.
  - Alternative **C is the winner**!
- Again
  - 1st pair: B and C; following pair with A.
  - Alternative **A is the winner**!

Approval Voting Procedure

- This method was introduced in the field of politic sciences by Brams and Fishburn (1978).
- The method Approval Voting (AV) is a procedure in which each DM can indicate as many alternatives as wish to be considered to win the first position.
- A simple procedure can be considered.
  - Each decision-maker gives a value of 1 or 0 for each alternative.
    - Value 1 indicates that the alternative has approval and
    - value 0 indicates that does not have approval.
  - The chosen alternative is the one that has the major number of votes.

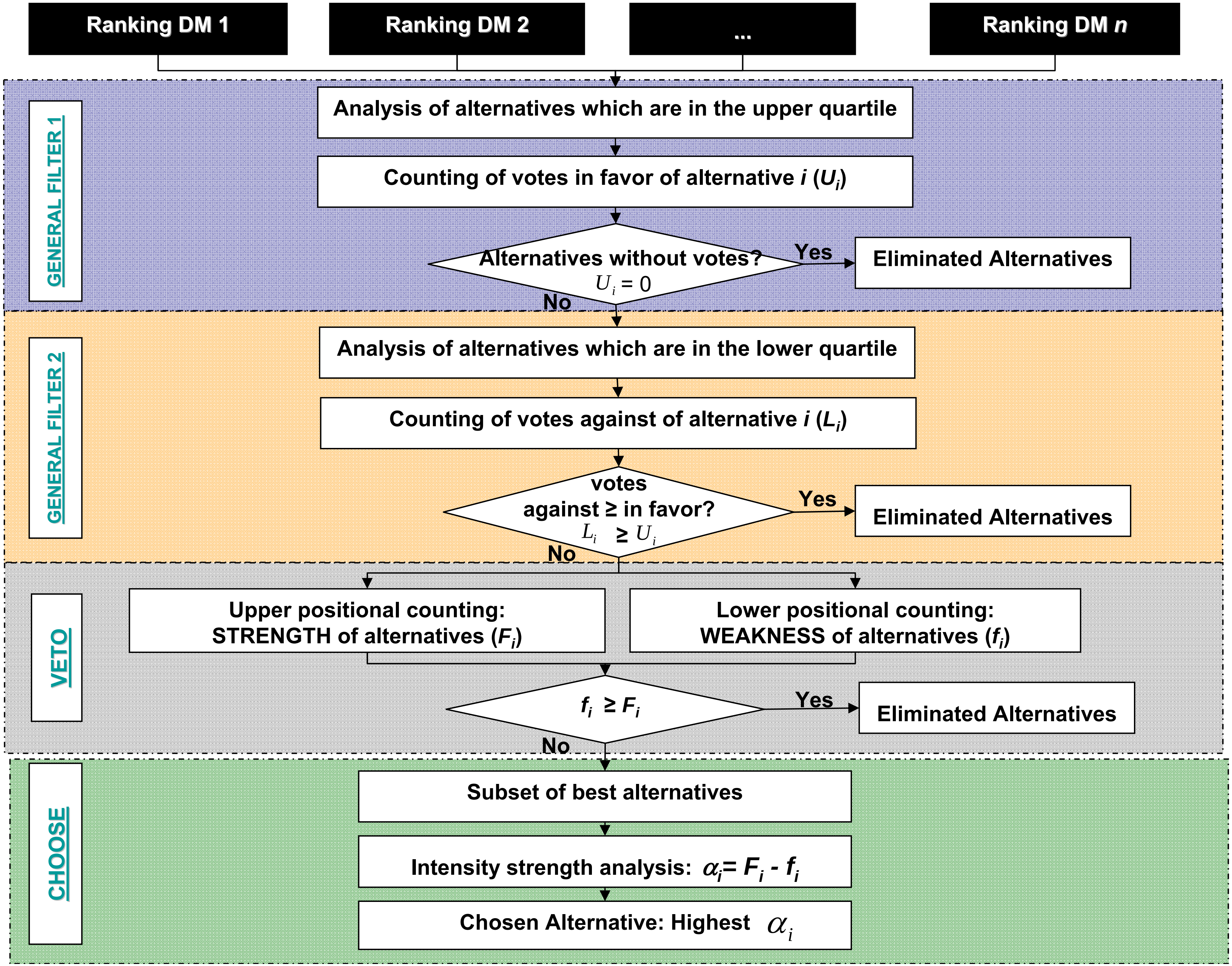
Weighted voting procedure based on quartiles classification

- Three regions
  - Upper Quartile
  - Median position
  - Lower Quartile

- Index of the strength of the alternative (Fi):
  - +1 point for the last position on the upper quartile
  - One point should be added for each position above

- Index of the weakness of the alternative (fi)
  - -1 point for the first position on the lower quartile
  - Diminish one point for each position below

(Morais, de Almeida, 2012).



Ranking DM 1
Ranking DM 2
...
Ranking DM n
GENERAL FILTER 1
Analysis of alternatives which are in the upper quartile
Counting of votes in favor of alternative i (Ui)
Alternatives without votes?
Ui = 0
Yes
Eliminated Alternatives
No
GENERAL FILTER 2
Analysis of alternatives which are in the lower quartile
Counting of votes against of alternative i (Li)
votes
against ≥ in favor?
Li ≥ Ui
Yes
Eliminated Alternatives
No
VETO
Upper positional counting:
STRENGTH of alternatives (Fi)
Lower positional counting:
WEAKNESS of alternatives (fi)
fi ≥ Fi
Yes
Eliminated Alternatives
No
CHOOSE
Subset of best alternatives
Intensity strength analysis: αi= Fi - fi
Chosen Alternative: Highest αi

Choice of a voting procedure

A framework for choice of a voting procedure

"A framework for aiding the choice of a voting procedure in a business decision context" (de Almeida and Hannu, 2015).

- The framework considers the following main issues:
  - the non-compensatory rationality for the DM;
  - the sequence of the decision process;
  - the kind of criteria to be considered.
- The set of relevant criteria and the evaluation matrix of properties by VPs is available in the literature
  - with several considerations to be included in the model

Choice of a voting procedure

- Context:
  - decision making in a business organization
- Decision process
  - Supported by an Analyst (or Facilitator)
- Who should choose the voting procedure (VP)?
  - The facilitator?
  - The DM’s?
    - supra-DM
- How DM evaluates the VP?
  - Within the decision context

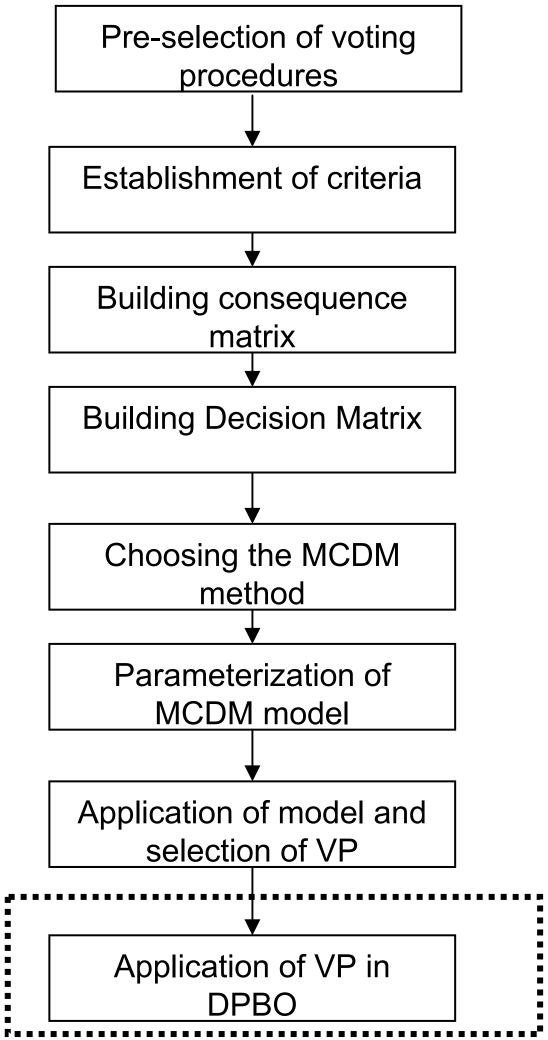
Choice of a voting procedure

- Laslier (2012)
  - "Experts have different opinions as to which is the best voting procedure"
  - "… different voting rules might be advisable under different circumstances…"
- With regard to voting procedure,
  - "Recommend and approve of are two different, albeit related – things, …", Nurmi (2012)

The Business Decision Process and the Modeling Process

- The whole decision process may be divided into two specific decision processes (de Almeida and Hannu, 2015):
- The decision process for choosing a voting procedure (DPVP),
  - aided by an MCDM model;
- The decision process for the business organization (DPBO),
  - analyzed by means of a VP, which is directed to a specific decision problem.

A Framework for Choosing a Voting Procedure – DPVP



(de Almeida and Hannu, 2015)

- It follows basic procedures for building multicriteria decision models
- The steps involves interaction between DM and analyst.
  - Structuring and modeling actions by the analyst and
  - Preference information by DM

Criteria Choice of a voting procedure

Two kinds of criteria may be considered for this problem of the DPVP (de Almeida and Hannu, 2015):

- The first is directly related to the DPBO,
  - in which the context of the business decision problem is considered.
  - For instance: Input to be given by DM
    - Nature and Amount of information
    - Time and effort to spend
- The second is related to the VPs themselves and their characteristics and how they affect the DPBO,
  - These are criteria associated with the properties of VPs,
  - such as paradoxes that may be relevant for consideration when analyzing a VP.

Voting rules and associated criteria (Nurmi, 1983; 1987; 2002).

- A: the Condorcet winner criterion: the procedure always chooses the Condorcet winner when one exists in the profile
- B: the Condorcet loser criterion: the procedure never chooses the Condorcet loser
- C: the strong Condorcet criterion: an alternative ranked first by more than half of the electorate will be chosen
- D: monotonicity: additional support for a winner – ceteris paribus – never makes it a non-winner
- E: Pareto: if all individuals strictly prefer X to Y, then Y is not chosen
- F: consistency: if an alternative is a winner in all subsets of a partition of the electorate, then it is also the winner in the superset
- G: Chernoff property: if X is the winner in set A of alternatives, it is also the winner in every subset of A that include**s** X
- H: independence of irrelevant alternatives: the collective preference between X and Y depends only on the individual preferences between X and Y
- I: invulnerability to the no-show paradox: the outcome that results from revealing one's preferences is never inferior to one resulting from one's abstaining

Framework for building decision models

Choosing a method

Choosing an aggregating method

Approaches
- Descriptive
- Normative
- Prescriptive
- Construtivism

Problematics
- Choice
- Sorting
- Ranking
- Description
- portfolio

Objectives
- Objective funcions
- Performance matrix

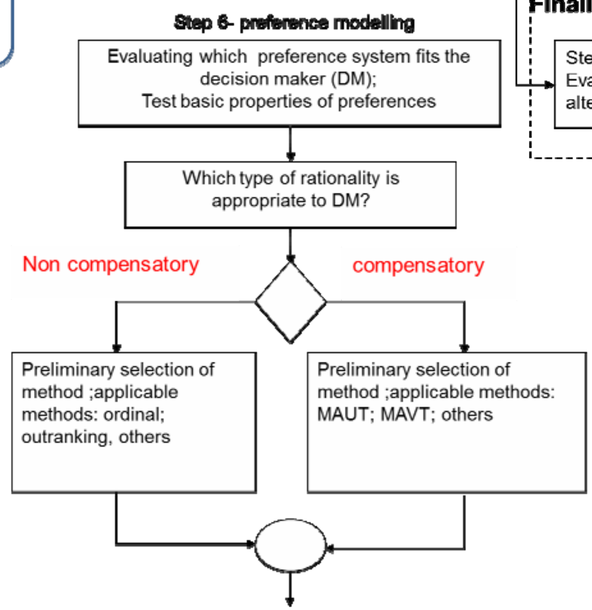
Alternatives and Consequences
- Discrete
- Continuous

Risk tolerance
- Risk prone
- Neutral
- Risk aversion

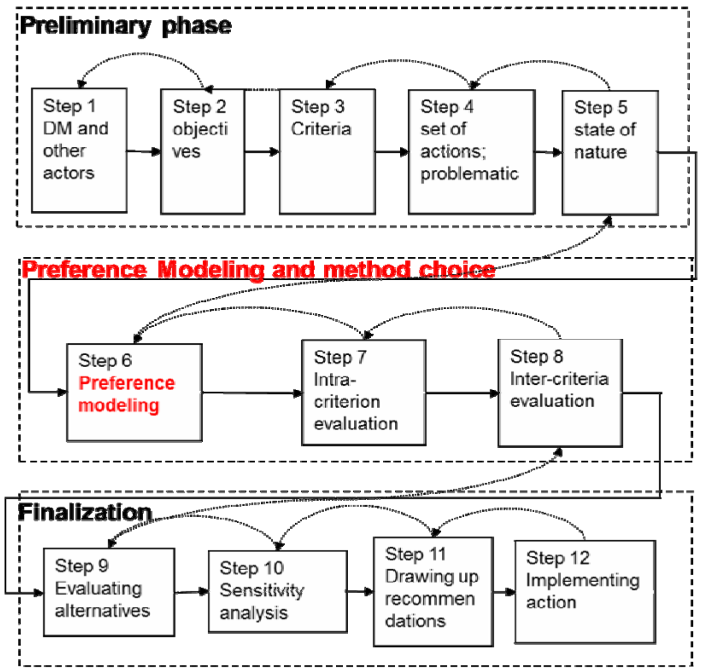
Uncertainty
- Probabilistic
- Deterministic

Other issues
- Ordinal aggregation
- Partial information
- Fuzzy logic

Pareto-front methods
Multi-objective Evolutionary Algorithms
NSGA-II, SPEA2 and others
Agregation Methods
Single-criterion synthesis
-MAUT, AHP, MACBETH, SMARTS, and TOPSIS
Outranking methods
-ELECTRE and PROMETHEE
Interactive methods
-MOLP and Goal Programming
Rationality
-Compensatory or non-compensatory

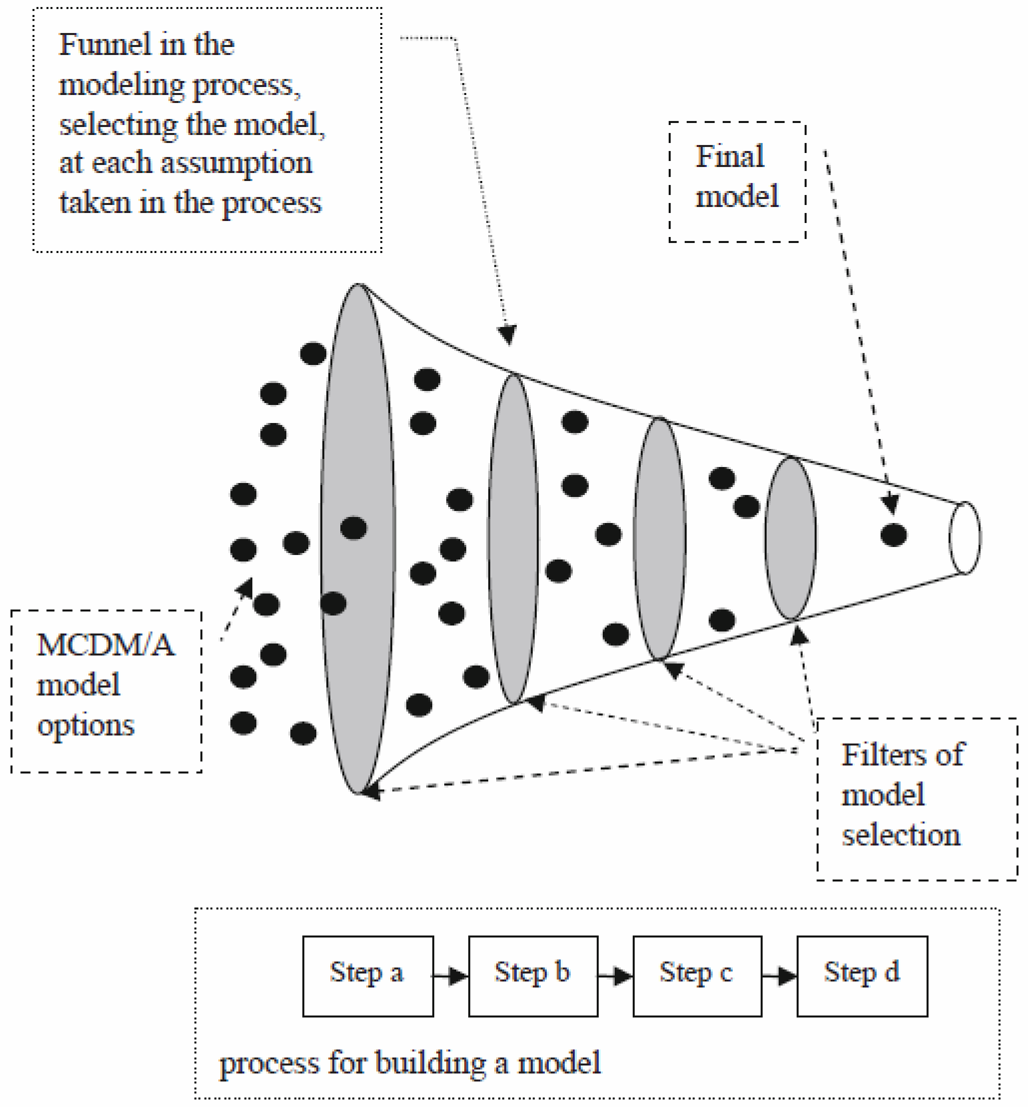


Framework for building decision models



More details in:
de Almeida et al (2015) Multicriteria and Multiobjective Models for Risk, Reliability and Maintenance Decision Analysis. International Series in Operations Research & Management Science. Vol 231. Springer.

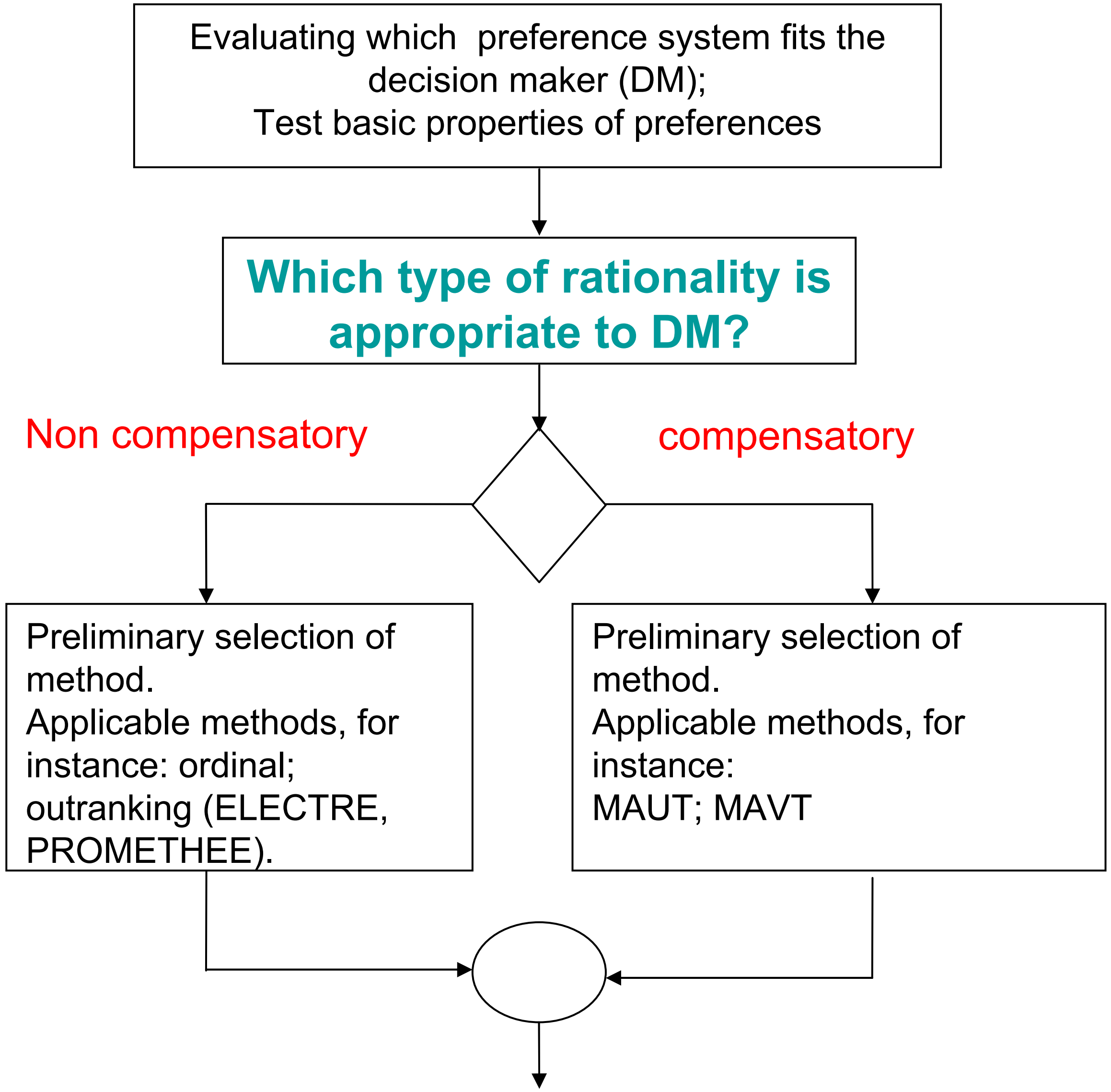
Building a multicriteria decision model



de Almeida et al (2015)

- Some model possibilities are eliminated with the filter,
  - In each decision made by the analyst.
- Decisions of the analyst:
  - Chosen approach,
  - Assumptions
- Through each filter
  - Smaller number of models, represented by the circles.
- Some models may not be perceived by the analyst.
  - These maybe eliminated
  - Based on the definitions and assumptions through the process

Step 6- preference modelling



Choosing a Multicriteria method

- Several ways of classification.
- Two kinds of rationality
- **Compensatory**, e.g.:
  - additive method
    - Weights or scales constant

$$v_k(x) = \sum_{i=1}^{n} k_{ki} v_{ki}(x_i)$$

- **Non-compensatory**, e.g.:
  - Lexicographical
  - outranking methods (ELECTRE, PROMETHEE, others).

Non-Compensatory Preferences

- A preference relation P is non-compensatory if the preference between two options x and y only depends on the subset of criteria in favor of x and y (Fishburn, 1976).

$$Let:$$

$$P(x,y) = \{j : x_j P_j y_j\} \quad \text{and}$$

$$I(x,y) = \{j : x_j I_j y_j\}$$

$$\left.\begin{matrix} P(x,y)=P(z,w) \\ P(y,x)=P(w,z) \end{matrix}\right\} \Rightarrow \{xPy \Leftrightarrow zPw\}$$

- In this case, it does not matter how much is the performance of x or y, in each criterion.

Two examples of non-compensatory rationality

Sports - Volleyball

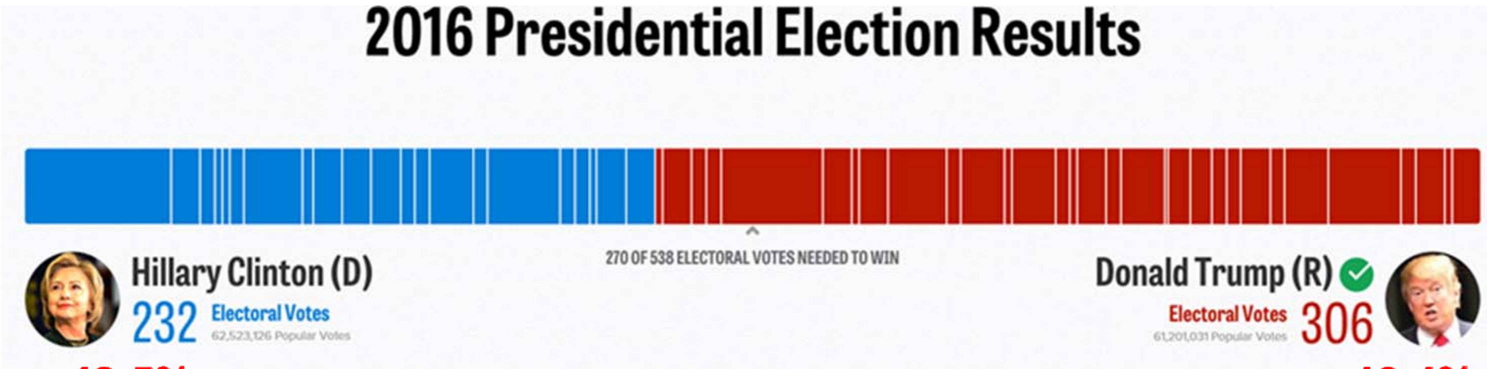
Team:	A	B
SET 1	25	23
SET 2	25	20
SET 3	11	25
SET 4	17	25
SET 5	15	11

Volleyball

Team:	A	B	SET winner
SET 1	25	23	A
SET 2	25	20	A
SET 3	11	25	B
SET 4	17	25	B
SET 5	15	11	A
Total points (additive model)	**A=93**	**B=104**	

Preference Modeling
non-compensatory rationality

- **How to asses it in DM's preference?**
- US presidential election
- Each state has a symbolic weight => proportional to the population of the state
- Then, the candidate running in the presidential election, who wins the majority of votes in a given state, keeps all the weight of that state.
- In the presidential election of the USA, the states are equivalent to criteria and the number of votes obtained in each state corresponds to the score for that criterion.
- The winner is the one who gets the best coalition of criteria (states), with the greatest summation of criteria weights.



48,5%
Voters

46,4%
Volters

How to evaluate Non-Compensatory Preferences

- How to evaluate in DM's preference?
  - Not much work on this
- Olympic games
  - **How to consider different medals**?
    - Gold
    - Silver
    - Bronze
- The **lexicographical** procedure
  - Non-compensatory rationality
- The additive aggregation:
  - **How many silver = 1 gold**?
  - Compensatory rationality
- This depends on **cultural issues?**
  - Examples in USA and Brazil
- Maybe not
  - Football World Cup in Brazil

Additive Model
for aggregating DMs' preference

May be applied for both
Procedure #1 - Aggregation of DMs' Initial Preferences
OR
Procedure #2 - Aggregation of DMs' Individual Choices

Additive aggregation of DMs

- The most applied compensatory model is the additive one
  - Which can be presented in various formats,
  - including the possibility of partial information, with several existing proposals.
- Many procedures consider the use of precise weights (w_k), even if equal weights
  - Additive model for aggregation of DMs (assuming t DMs):

$$v(x) = \sum_{k=1}^{t} w_k v_k(x)$$

  - From each DM *k*, the $V_k(x)$ is obtained, aggregating the *n* criteria:

$$v_k(x) = \sum_{i=1}^{n} k_{ki} v_{ki}(x_i)$$

Additive Model for Aggregation of DMs' individual choices

- Axiomatic presentation of the additive model for group decision aggregation (Keeney and Kirkwood, 1975; Keeney, 1976; Keeney, 2009; Dias & Sarabando, 2012)
  - considering aspects of the formulation provided by Arrow (1950).
- A difference of additive model to Arrow formulation (1950) is
  - the use of cardinal value functions, instead of using only ordinal information (Keeney, 2009)
  - Adaptation of some of the conditions (Keeney, 2009) given by Arrow (1950).
- Critical issue for using additive methods or outranking methods:
  - **Defining DMs' weights**
- **DMs' weights means degree of importance?**
  - **DMs are compensated within the additive model?**

Weights in the Additive Model

- In a compensatory aggregation model one must be careful to combine the different assessments of the consequences.
- In the case of additive model the group value function is given by the equation

$$v(v_1, v_2, ..., v_t) = \sum_{k=1}^{t} w_k v_k$$

Additive Model with Veto

balancing the compensation

Additive Model with Veto

- *Individual Value Function:*

$$U_i\,(c1,c2,\ldots,cn)=K_{1i}\,U_i(c1)+K_{2i}\,U_i(c2)+\ldots+K_{ni}\,U_i(cn)$$

- *Global Value Function:*

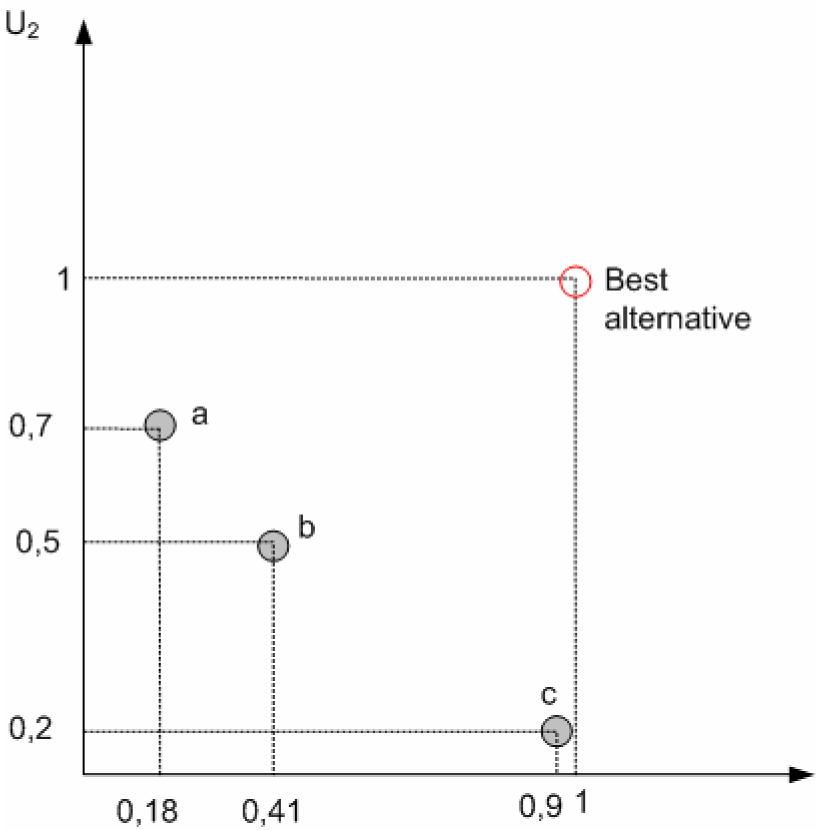
$$U_{Global} = \Sigma\, W_i * U_i\,(c1,c2,\ldots,cn)$$

Additive Model with Veto

- The global value function does not assure that the final solution represents the preferences of DMs, due to the compensatory effect of the additive model (Daher & de Almeida, 2011).
  - The final aggregation may select alternatives with lower value to DMs than others available.
  - Problems of compensatory models
    - An alternative could be the worst to one of the DMs and be compensated by another DM.
    - The solution may not be balanced

Additive Model with Veto

- Consider two DMs:



$U(c) = 0,55$

$U(b) = 0,45$

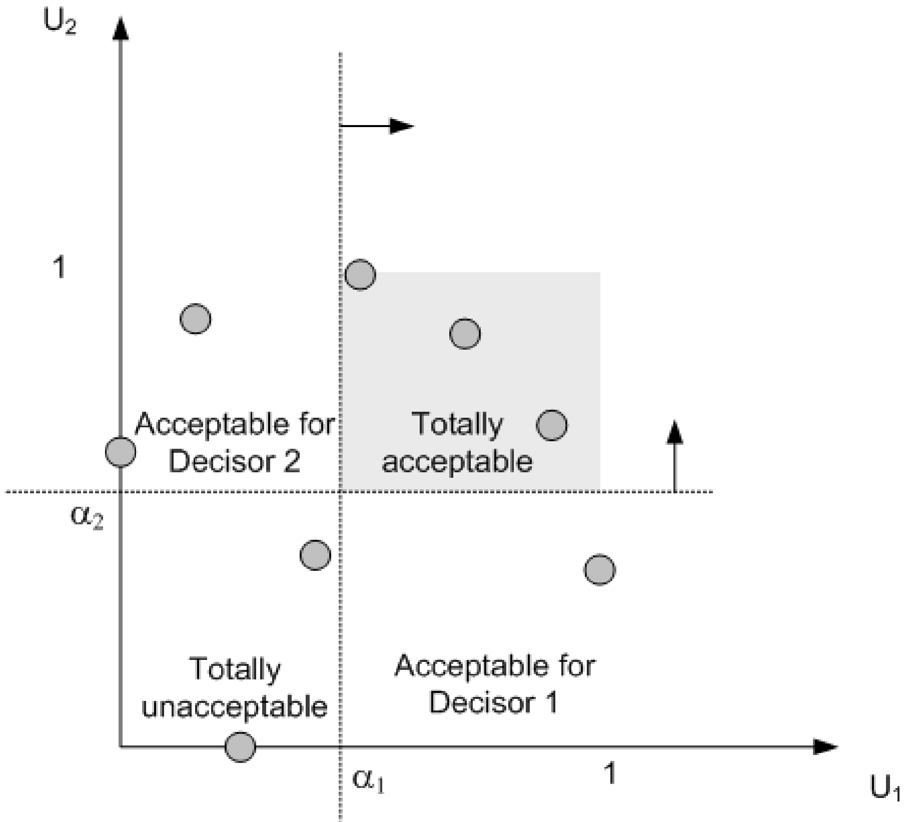
$U(a) = 0,44$

$U(c) > U(b) > U(a)$

- Alternatives A and C: Conflict !
- Alternative B: can represent consensus!

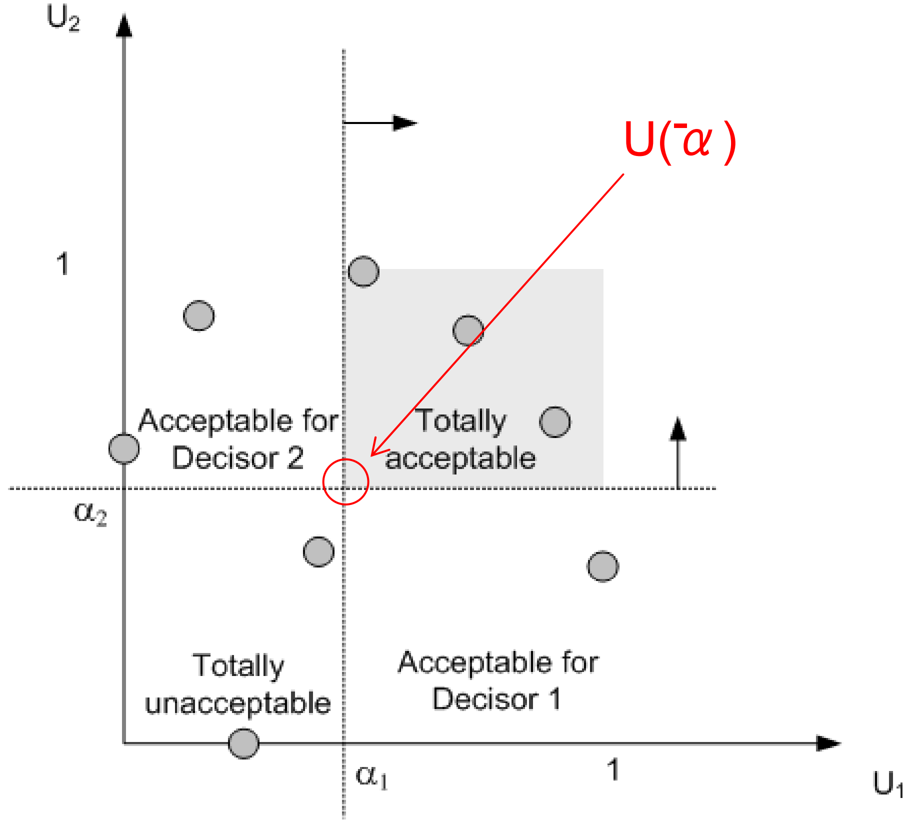
Additive Model with Veto

- Looking again for our two decision makers...



Additive Model with Veto

- Let include a reduction factor (RF) in the model
- $U = RF^* \Sigma\, W_i\, U_i\, (OC, WL)$
- If an alternative is located in the favorable agreement zone the *RF* is equal to 1, otherwise *RF < 1*.



Weights in the Additive Model for Group Decision

Weights in the Additive Model for Group Decision

- Each DM explicits the value function v_i
  - An important issue is how to obtain the scale constant w_i
- This may not be related to determine the degree of importance of the DM_i.
  - This is not the relevant point, although many misunderstand this situation and adopt a wrong procedure.
  - The question is to determine how the value function v_i (of DM_i) contributes to the global value function of the group.
- This should be done considering the value of consequences obtained by as the value function v_i, and
  - How it contributes to the global value function of the group

Weights in the Additive Model

- Since the scale of each function v_i can be established arbitrarily, it is considered from 0 to 1 (Keeney and Kirkwood, 1975; Keeney, 1976).
- i.e. , $v_i(w) = 0$ e $v_i(b) = 1$, where:
  - $v_i(w)$ = value that the DM_i assign to the consequence w (worst)
  - $v_i(b)$ = value that the DM_i assign to the consequence b (best).
- Then, $v(w) = v(0, 0, ..., 0) = 0$.
  - i.e., v(w) represents the global value
  - when all DMs are evaluating their worst consequences by the value function v_i.
  - Note that the worst consequence for one DM can be different for the others.
- Then, $v(b) = v(1, 1, ..., 1) = 1$.
  - i.e., v(m) represents the overall evaluation
  - when all DMs are evaluating the best consequences by the value function v_i.

Weights in the Additive Model

- When assigning the values of the scale constants, the supra-DM should consider the consequences evaluated by DMs, rather than the DMs themselves (Keeney and Kirkwood, 1975; Keeney, 1976).
- In this case, the supra-DM should consider issues such as:
  - What is the preferable consequence?
    - (b_1, w_2, w_3, ..., w_t) or
    - (w_1, b_2, w_3, ..., w_t)
- It can be observed that
  - $v(b_1, w_2, w_3, ..., w_t) = w_1$ and
  - $v(w_1, b_2, w_3, ..., w_t) = w_2$.
    - Since :
    - $(b_1, w_2, w_3, ..., w_t) = (1, 0, ..., 0)$; and
    - $(w_1, b_2, w_3, ..., w_t) = (0, 1, ..., 0)$
- If the first consequence is preferable, then $w_1 > w_2$.
- The value v_k, related to the DM k, is associated to the value of the consequence in the additive model.

$$v(v_1, v_2, ..., v_t) = \sum_{k=1}^{t} w_k v_k$$

Weights in the Additive Model

- Analogously to the elicitation procedures of the scale constants for the criteria for multicriteria problems,
  - It is possible to develop an adaptation
  - To obtain a compatible procedure
  - To obtain the scale constants related to the value functions of the different DMs.
- This is not always trivial.
- On the other hand, what it is not adequate is simply assigning to the scale constant w_k
  - Values of degrees of importance for DMs
  - This seems simple, but it may not make much sense.
  - **This will depend on the organizational context.**
- At the end, what is desired is to assign a global value (of the group of DMs) to consequences of the evaluated alternatives.

“Importance of the Decision Makers” in Additive Model

- The weights can be considered a combination of two aspects (Keeney and Nau, 2011):
  - The consequence evaluated by each DM k, and
  - The relative importance (power) of each DM in the group.
- Technically (Keeney and Nau, 2011),
  - It is easier to specify the relative importance of DMs than make comparisons among values of consequences of the DMs
- Nevertheless, behavioral and political aspects may arise
  - When trying to assign the relative importance of DMs

Additive aggregation of DMs

- Many procedures consider the use of precise weights (w_k), even if equal weights
  - Additive model for aggregation of DMs

$$v(x) = \sum_{k=1}^{t} w_k v_k(x)$$

  - From each DM k, the $V_k(x)$ is obtained, aggregating the n criteria:

$$v_k(x) = \sum_{i=1}^{n} k_{ki} v_{ki}(x_i)$$

Additive aggregation of DMs
imprecise weights

- Some studies consider imprecise weights for aggregation of DMs in the additive model, for instance:
  - Kim and Ahn (1999) use two additive models
    - for aggregation of both: criteria and DMs.
  - A LLP formulation considers constraints on weights for importance of DMs.
    - For instance, $w_1 > 2w_2$.

Preference elicitation and **partial information**

- Partial information
  - Incomplete information
  - Imprecise information
- Some justifications
  - elicitation of weighs can be time consuming and controversial (Kirkwood and Sarin, 1985; Kirkwood and Corner, 1993)
  - the DM may not be able to respond specifically tradeoff questions (Kirkwood and Sarin, 1985)
  - DMs are often more comfortable in making natural language statements during the elicitation process that can be interpreted as linear inequalities (White III & Holloway, 2008)
  - Simulation analysis - for identify situations in which detailed elicitation is not needed (Kirkwood and Corner, 1993)

Partial information – some methods

Some work consider **MAUT**, with probabilities and use of lotteries for preference statements - Fishburn (1965), Hazen (1986), Jiménez et al (2003), Danielson et al (2007).

Additive value functions in the **MAVT** context

- PAIRS (Salo and Hämäläinen, 1992)
- VIP Analysis (Dias and Climaco, 2000)
- Mármol et al (2002) consider the interactive process
  - the DM offers the information in a sequential way
- PRIME (Salo; Hämäläinen, 2001) - swing method.
- RICH (Salo and Punkka, 2005).
  - After examining results, the DM may either
    - choose to accept one of the alternatives in the kernel, or
    - continue with the specification of further preference information.
- Mustajoki & Hamalainen (2005) integrate preference elicitation in the partial information framework, for the SMART/SWING method.
- White III & Holloway (2008) also consider an interactive process to collect information
  - they use Markov process and dynamic programming analysis in order to reduce the number of questions.
- A few procedures use surrogate weights, with the ordered weights space (Stillwell et al 1981; Edwards and Barron, 1994; Barron and Barrett, 1996b)

Framework for classifying partial information decision process

Preference statements:

- Structured elicitation or no structured elicitation;
- All at once or interactively;
- Flexible or fixed process

→

Forms of partial information:

- Rankings,
- Bounds,
- Holistic judgments,
- Arbitrarily linear inequalities

→

Synthesis step:

- Surrogate weights
- Decision rules
- LPP models for identifying potential optimal alternatives
- Simulation and sensitivity analysis

de Almeida et al, 2016

Multicriteria Additive Models without assign weights for DMs

- Weber (1987) pointed out group decision making as an important area of possible applications for the concept of incomplete information.
- Anandaligam (1989) showed that even without specifying exact preference weights, dominance relationships can be established between alternatives, in order to obtain a compromise solution
- Salo (1995) uses an interactive additive model with incomplete information for individual preferences of DMs, in order to provide information to them, so they can seek for consensus.
- Hämäläinen and Pöyhönen (1996) used preference programming as decision support technique, in which individual preferences can be combined into an interval model and the negotiation process seeks on decreasing the width of the intervals.
- Hämäläinen et al (2000) uses a decision conference for integrate the group of DM in a multicriteria risk analysis, using smart approach.
- Baucells and Sarin (2003) obtain agreement for weights and apply in the multicriteria additive model, instead of aggregate global values of DM.
- Dias and Climaco (2005) outlines a distributed GDSS, based on the VIP Analysis.
  - These ideas have been extended in Climaco and Dias (2006).
- FITradeoff Group Decision (de Almeida, 2014) uses partial information with tradeoff procedure, with flexible and interactive approach.

Decision process
Aggregation of DMs Preference

- Concerning the decision process two possibilities (Hämäläinen and Pöyhönen, 1996):
  - Begin by eliciting the individual DMs for seeking a common interval thereafter.
  - Start directly with the group's joint interval model.
- They suggest that the latter is more appropriate in "soft" negotiation (integrative negotiation) and
  - the former for distributive negotiation.
- They are concerned with anchoring effect,
  - when DMs specify their own individual preferences,
  - they may be more reluctant to change preferences
  - than those DMs who start working for a group interval model.

Decision process

Aggregation of DMs Preference

- Keeney (2009) supports the former approach (begins by eliciting the individual DMs),
  - considering that when different evaluations are made explicit it may provide some very useful insights.
- For this former approach, it has been shown that group results can be obtained and a facilitator can bring this information for further discussion on specific issues that may deserve additional attention. (Adla, Zarate and Soubie, 2011):
  - Group results include group averages and standard deviations
  - A large standard deviation may indicate a lack of consensus on an issue.
  - Large standard deviations may be shown to DMs for further discussion.
- A warning (de Almeida, 2014)
  - In group interval model, the DM may not think clearly about their own preferences.

Preference elicitation

Preference elicitation

- Using the Additive model for aggregating criteria
- With so **many concerns** in the elicitation process,
  - **many methods** have been proposed
  - in order to improve
  - the **consistency of models**
    - with **real problem**,
    - Using information that can actually translate DM's preferences.

Basic Procedures for Scale Constants Elicitation

- Scale Constants **Elicitation Procedures** for Additive Model aggregation
  - –Tradeoff
  - –Swing
  - –Ratio

Inconsistencies in the elicitation procedure

- **Other procedures** for precise elicitation of weights appear to be **better** than the **tradeoff**.
- Inconsistencies reported in behavioral studies (Borcherding et al, 1991):
  - **30%** of the time using the **ratio procedure**
  - **50%** of the time using the **swing procedure**
  - **67%** of the time using the **tradeoff procedure**

MCDM/A Methods for Additive model in MAVT context

- Several Methods using the **additive model** for aggregation
- For instance
  - SMARTS; SMARTER
  - AHP
  - MACBETH
  - TOPSIS
  - FITradeoff
  - Several others
  - UTA (holist evaluation)

Preference elicitation

- Behavioral studies
- Many behavioral experiments with subjects
  - In many cases these experiments are not based on a real decision problem
  - Instead of that, some standard instance is applied,
- However, in preference elicitation,
  - Motivation for the decision problem is an important issue.
  - Motivation for thinking hard and answering the preference questions

Preference elicitation

- Many issues still to be considered in practical applications
  - Particularly with preference elicitation
- The elicitation process may be associated to
  - The intellectual and cultural background of the DM (Bouyssou et al, 2006)
- An elicitation procedure considers that the DM is rational
- What if they are ‘intuitive’ on answering preference elicitation questions?

Two cognitive systems for choices

- Psychologists consider the mind uses two separate cognitive systems (Kahneman, 2011):
  - System 1 – quick;
  - System 2 – slower – for more reasoned choices.
- Experiment on trolley problem reveals possibility of
  - intuitive judgment in decision making
  - rather than reasoned choices

Language effect

- Earlier work found that people tend to perform better on tests of pure logic in a foreign language
- Trolley dilemma
  - The **language** in which the **dilemma is posed**,
    - **can alter how people answer**?
- Experiment in four different countries (Costa et al; 2014),
  - when asked in **their native language**,
    - **less subjects** said they would **push the man**,
  - **than** when **asked in the foreign language**;
- In the foreign language, the proportion jumped to higher levels.
- The **merely competent** speakers must **spend more brainpower**, and **reason much more carefully**, when operating in their less-familiar tongue.
  - that kind of thinking helps to provide **psychological and emotional distance.**
  - The **effect** of speaking the foreign language **became smaller** as the **speaker's familiarity** increases.

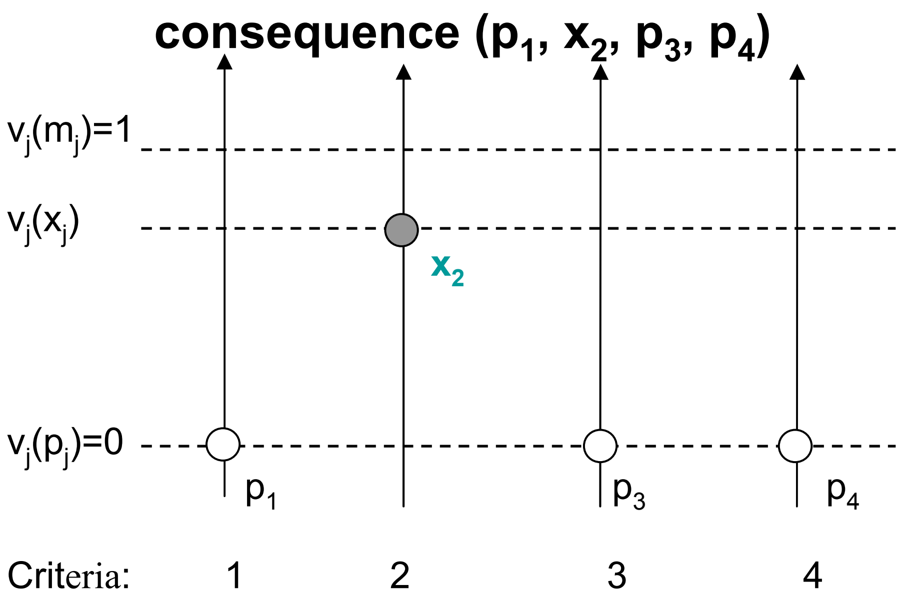
Preference elicitation Multicriteria Additive Model MAVT scope

FITradeoff
Flexible and Interactive tradeoff Elicitation

FITradeoff-GD – Group Decision

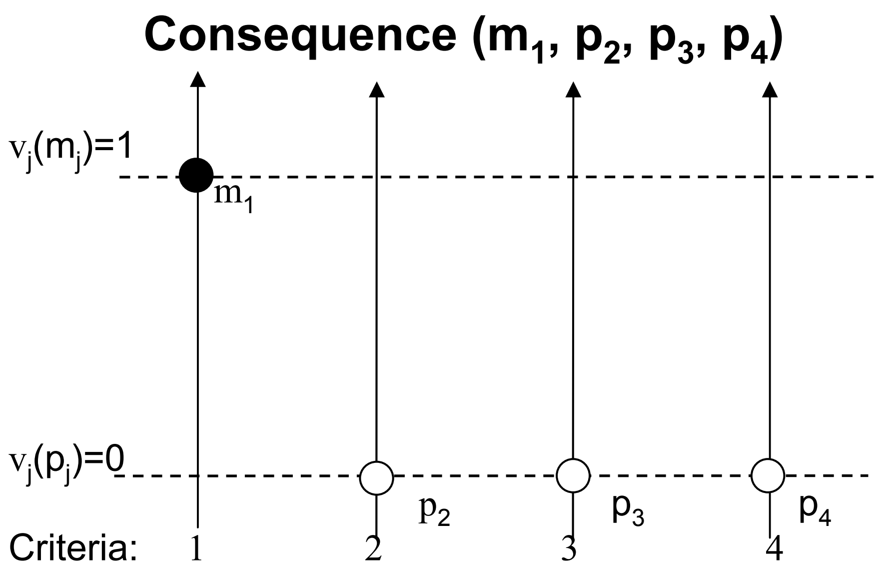
- The traditional tradeoff procedure has a **strong axiomatic foundation** (Weber & Borcherding, 1993)
- However, inconsistencies have been reported in behavioral studies:
  - 67% of the time using the tradeoff method (Borcherding et al, 1991)
- Reducing DM's cognitive effort is **a way to minimize such inconsistencies**
- **FITradeoff** **improves the decision process** by reducing inconsistencies
- **FITradeoff** uses partial information in the tradeoff procedure

Recall Tradeoff elicitation procedure



Ask DM:

'for which outcome x_2 there is indifference between the two consequences?'



If there is indifference between the two consequences, then
A equation is obtained

$v(p_1, x_2, p_3, p_4) = v(m_1, p_2, p_3, p_4)$.

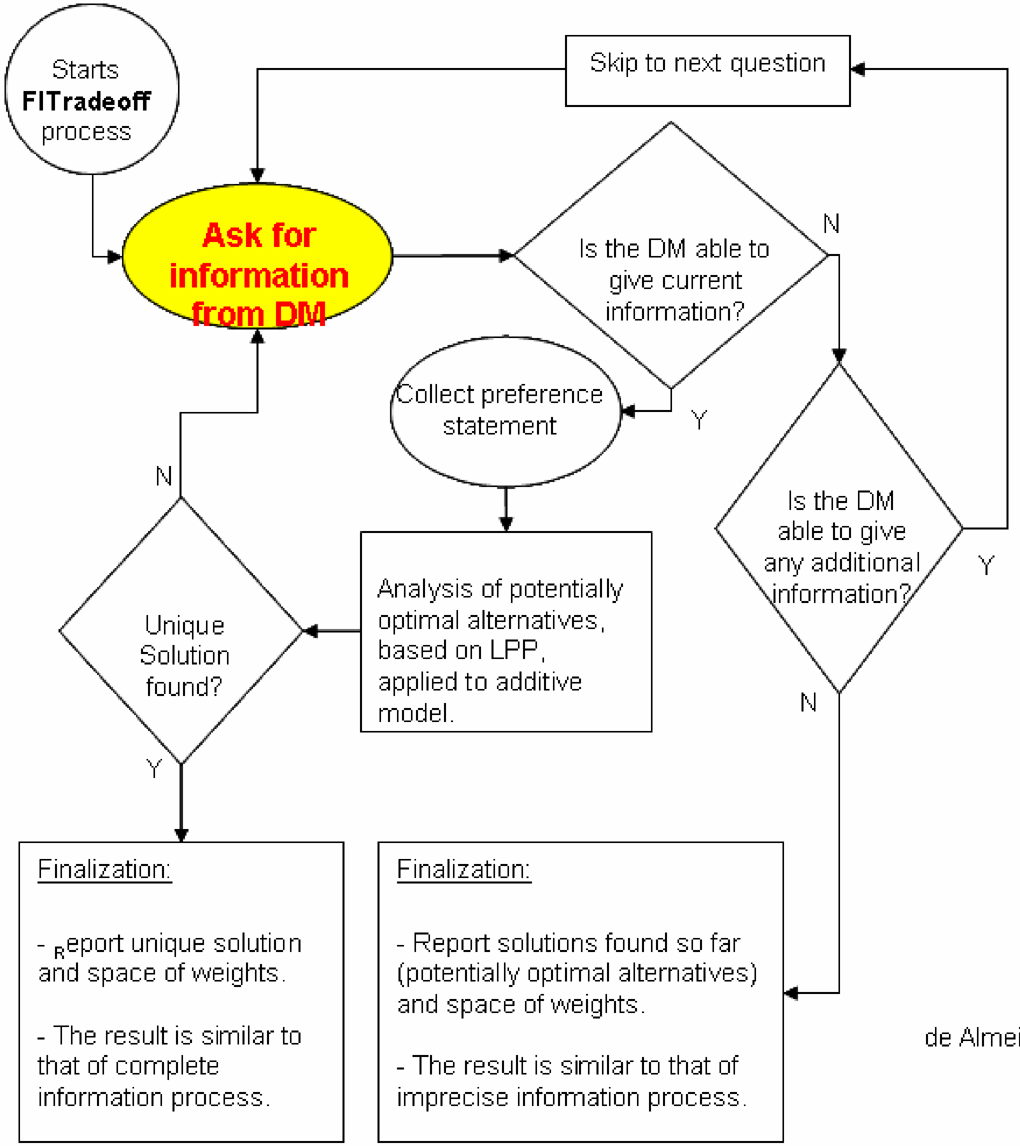
=> $k_2 v_2(x_2) = k_1$.

FITradeoff

Flexible and Interactive Tradeoff

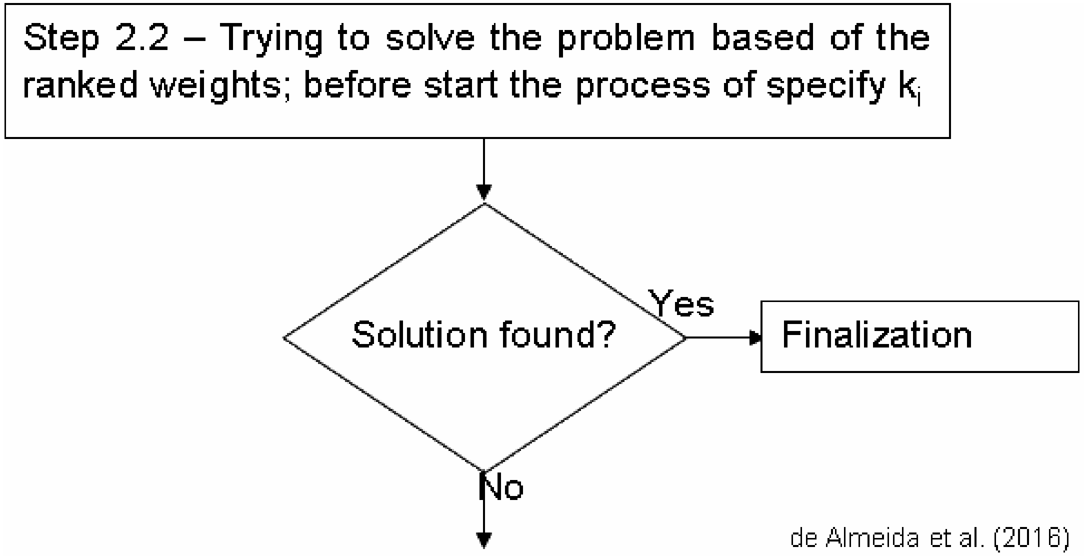
- Uses partial information in the tradeoff procedure
  - The indirect process is kept, using strict preferences instead of indifferences between consequences
- For instance, at the beginning the weights are ordered and this partial information can be applied

$$\varphi_n = \left\{ \left(w_1, w_2, w_3, \ldots, w_n \right) \mid w_1 > w_2 > w_3 > \ldots > w_n ; \sum_{j=1}^{n} w_j = 1) \right\}$$



de Almeida et al. (2016)

FITradeoff procedure

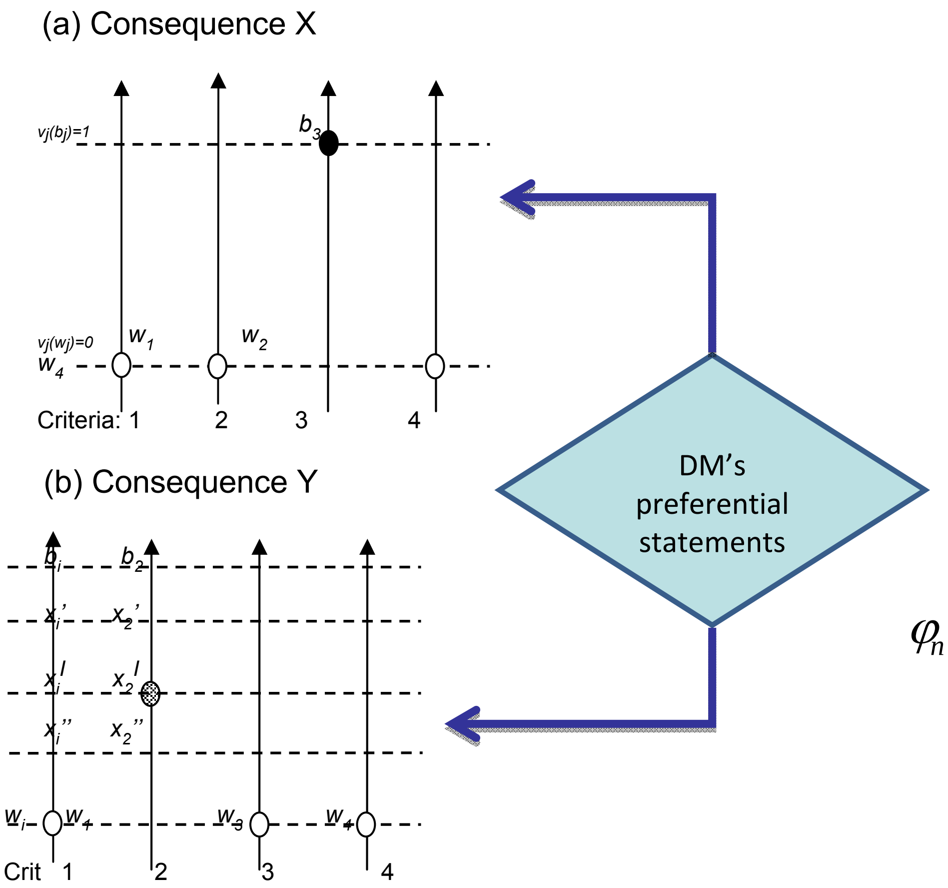


- available space of weights:

$$\varphi_n = \left\{ (k_1, k_2, k_3, \ldots, k_n) \mid k_1 > k_2 > k_3 > \ldots > k_n ; \sum_{i=1}^{n} k_i \ = 1) \right\}$$

- Simulations studies have shown that for some patterns of distribution of weights and alternatives performance
  - Many decision problems may be solved at this step
  - with the information of ranked weights, only.

Partial information in FITradeoff



$$k_i v_i(x_i') > k_{i+1}$$
$$k_i v_i(x_i'') < k_{i+1}$$

inequalities between scale constants

$$\varphi_n = \left\{ \begin{array}{l} (k_1, k_2, k_3, \ldots k_n) \mid \sum_{i=1}^{n} k_i = 1; k_i \geq 0 \\ k_1 v_1(x''_1) < k_2 < k_1 v_1(x'_1); \ldots; k_i v_1(x''_i) < k_{i+1} < k_i v_1(x'_i); \ldots; \\ k_{n-1} v_1(x''_{n-1}) < k_n < k_{n-1} v_1(x'_{n-1}) \end{array} \right\}$$

space of weights

LPPs uses Partial information in FITradeoff

Using LPPs, alternatives are classified into those that are:

– Potentially optimal

– Dominated

– Optimal

$$\underset{k_1,k_2,\ldots,k_n}{Max} \sum_{i=1}^{n} k_i v_i\left(x_{ij}\right),\ j = 1,2,\ldots,m$$

s.t.

$$k_{i+1} \le k_i v_i(x_i') - \varepsilon \qquad \text{for } i = 1 \text{ to } n-1$$

$$k_{i+1} \ge k_i v_i(x_i'') + \varepsilon \qquad \text{for } i = 1 \text{ to } n-1$$

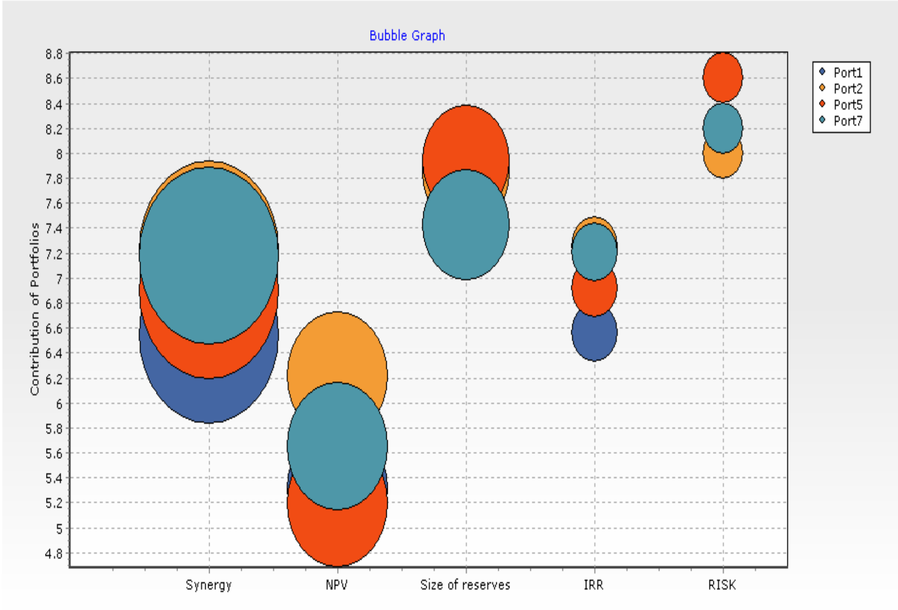
$$\sum_{i=1}^{n} k_i = 1$$

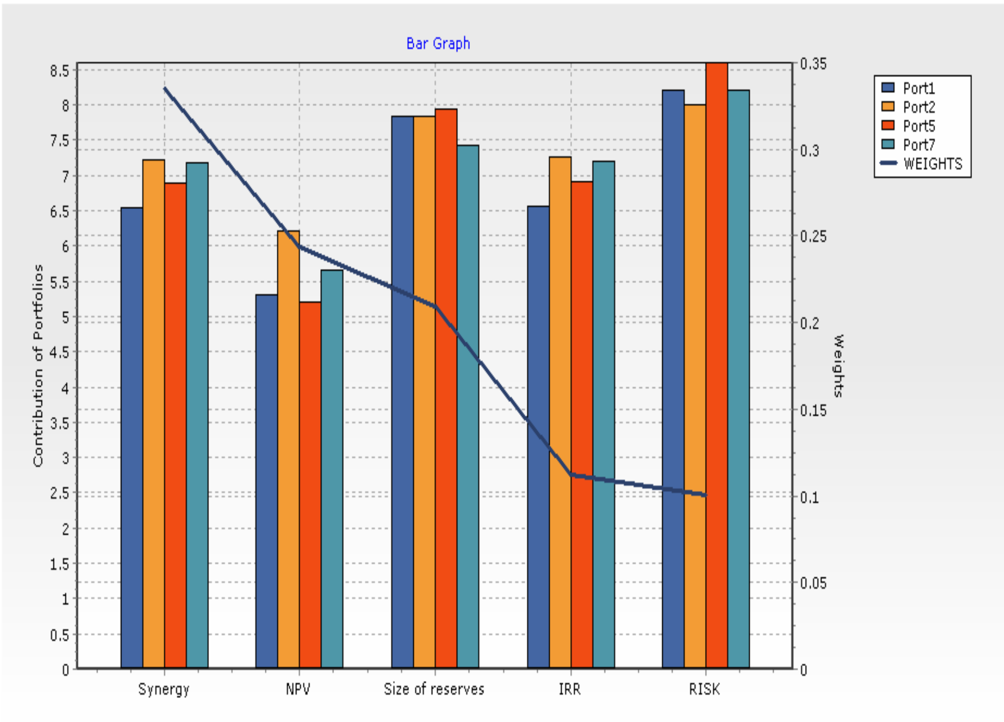
$$k_i \ge 0, i = 1,2,\ldots,n$$

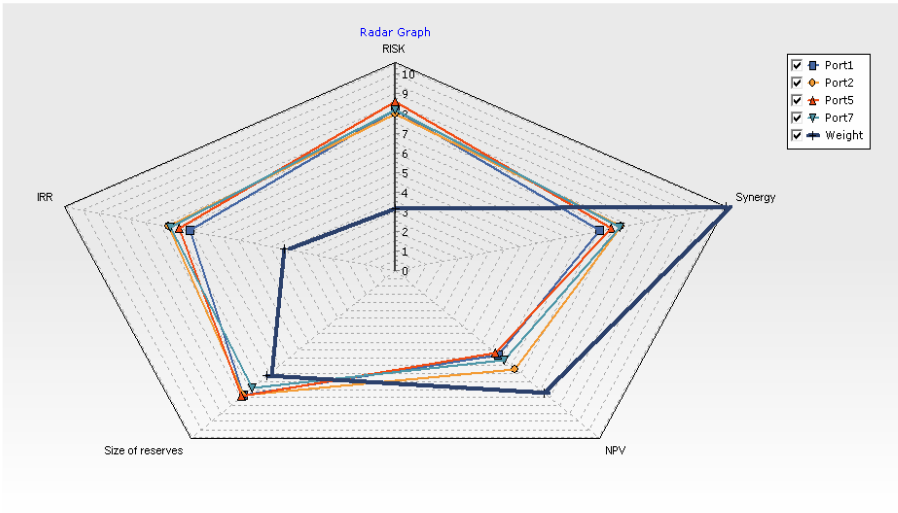
FITradeoff

Graphical information shows the performance of the Potentially Optimal Alternatives (POA)

- Different formats







Graphical visualization: flexibility analyzing the partial result

- DM has the **flexibility** of interrupting the elicitation process in the tradeoff pattern
  - for **analyzing the partial result** by other means,
  - such as **graphical visualization** of POA.
  - This flexibility is available in the whole process.
- Evaluating the **visualization confidence** for decision support in FITradeoff method is crucial.
- Furthermore, information for designing of this visualization is relevant.
- These issues are being approached based on
  - **Behavioral neuroscience expriments**,
  - with particular focus given on EEG and eye tracking resources.

Cognitive neuroscience experiments for graphical visualization

Experiment results may be applied

- For **designing changes in** the DSS **visualization** and
- For **instruction to the analysts** regarding the use of visualization analysis in FITradeoff.
- **Hit rate** information is obtained
  - can show how the **confidence of graphical analysis**
  - changes with the **number of items**, for instance.

- (de Almeida & Roselli, 2017; Roselli & de Almeida, 2017)

Group decision with FITradeoff

Two processes can be conducted, with the system:

- Jointly elicitation
  - The elicitation of DMs' is conducted jointly
  - The DMs' have to make their agenda so that their availability can be made simultaneously
- Separately elicitation
  - The elicitation of each DM is conducted separately, according to their own availability, within a deadline
  - A final joint meeting may be necessary, in order to make a final group decision
    - If there is no common solution in the final subset of alternatives of all DMs.
  - A final joint meeting may be not necessary, if the analyst manage to obtain an agreement for compromising with the DM (or DMs) with more discordance within the group.

Group decision with FITradeoff

The group decision process, with flexible preference elicitation can be supported with information and indexes, at each step in the process:

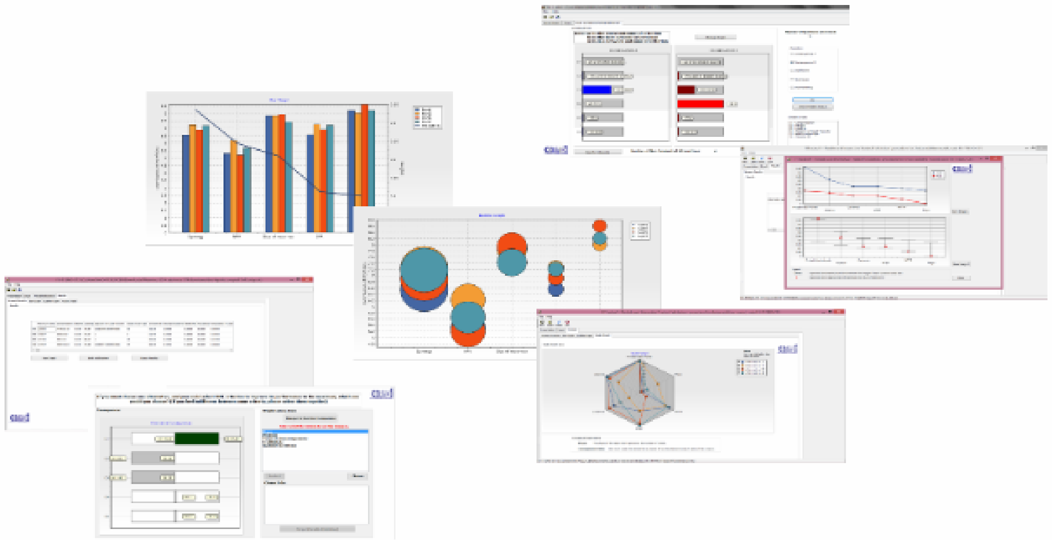
- The current subset of potential optimal alternatives;
  - Also, a partial order of group of subset of alternatives
- Ranking of alternatives
- With Decision Rules (Salo and Hämäläinen, 2001; Dias and Climaco, 2005)
  - the system can give information on performance of remained alternatives and comparison amongst them.
  - For instance: Maximax; maximin; minimax regret ; central values (Dias and Climaco, 2000; Salo and Punkka, 2005; Sarabando and Dias, 2009)
- Indices for comparisons of alternatives
- Voting procedure
  - For instance, approval voting procedure

Software available at:

www.fitradeoff.org

FITradeoff

FITradeoff is a Flexible and Interactive Tradeoff elicitation procedure for multicriteria additive models in MAVT scope



The Flexible and Interactive Tradeoff (FITradeoff) method, is a new method proposed for eliciting scaling constants or weights of criteria. The FITradeoff uses partial information about decision maker (DM) preferences to determine the most preferred in a specified set of alternatives, according to an additive model in MAVT (Multi-Attribute Value Theory) scope. This method uses the concept of flexible elicitation for improving the applicability of the traditional tradeoff elicitation procedure. FITradeoff offers two main benefits: the information required from the DM is reduced and the DM does not have to make adjustments for the indifference between two consequences (trade-off), which is a critical issue on the traditional tradeoff procedure. It is easier for the DM to make comparisons of consequences (or outcomes) based on strict preference rather than on indifference.

FITradeoff software is available for download on request.

A new method for elicitation of criteria weights in additive models: Flexible and interactive tradeoff

De Almeida A , De Almeida J , Costa A , De Almeida-Filho A

European Journal of Operational Research, vol. 250, issue 1 (2016)

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FITradeoff

FITradeoff is a Flexible and Interactive Tradeoff elicitation procedure for multicriteria additive models in MAVT scope

Cases

Supplier selection in a food industry

Abstract: In this supplier selection problem, the aim is to select a vendor to supply packaging material for a food industry in Brazil. The alternatives of the problem are five potential suppliers pre approved by the company. These alternatives are evaluated with respect to seven criteria: price of the material, reliability of the freight, accuracy of the deliveries, quality of the material, promptness of the deliveries, flexibility of the vendor and lead time.

Frej, E.A., Roselli, L.R.P., de Almeida, J.A., de Almeida, A.T.: A Multicriteria Decision Model for Supplier Selection in a Food Industry Based on FITradeoff Method. Mathematical Problems in Engineering. 2017, 1-9 (2017). doi: 10.1155/2017/4541914

Healthcare facility location – La Citta Della Salute

Abstract: La Citta Della Salute is a project in the city of Milan, Italy, that aims at relocating two existing hospitals in a unique pole focused and specialized on research, teaching, science and training, and also able to meet new health demands of the population. Six potential areas in the city of Milan were proposed for siting the new hospital. These areas were evaluated with respect to sixteen criteria, divided into four key dimensions: functional, location, environmental and economic.

Dell'Ovo, M., Frej, E. A., Oppio, A., Capolongo, S., Morais, D. C., & de Almeida, A. T. Multicriteria Decision Making for Healthcare Facilities Location with Visualization Based on FITradeoff Method. In: Linden, I., Liu, C., Colot, C. Decision Support Systems VII. Data, Information and Knowledge Visualization in Decision Support Systems. LNBIP 282, pp. 32-44. Springer, Cham. (2017) doi: 10.1007/978-3-319-57487-5_3

CDSID UFPE
CENTRO DE DESENVOLVIMENTO EM SISTEMAS DE INFORMAÇÃO E DECISÃO

Application from 2016 MCDM SS

Multicriteria decision making for healthcare facilities location with visualization based on FITradeoff method

(Dell'Ovo et al, 2017; Dell'Ovo et al, 2018)

- **Winner of the** EWG-DSS 2017 Young Researcher of the Year **Award.**

- Dell'Ovo, M., Frej, E. A., Oppio, A., Capolongo, S., Morais, D.C., de Almeida, A.T.: Multicriteria Decision Making for Healthcare Facilities Location with Visualization Based on FITradeoff Method. In: Linden, I., Liu, C., Colot, C. Decision Support Systems VII. Data, Information and Knowledge Visualization in Decision Support Systems. LNBIP 282, pp pp. 32–44, (2017)
- Dell'Ovo M., Frej E.A., Oppio A., Capolongo S., Morais D.C., de Almeida A.T. (2018) FITradeoff Method for the Location of Healthcare Facilities Based on Multiple Stakeholders' Preferences. In: Chen Y., Kersten G., Vetschera R., Xu H. (eds) Group Decision and Negotiation in an Uncertain World. GDN 2018. Lecture Notes in Business Information Processing, vol 315. Springer, Cham. DOI 10.1007/978-3-319-92874-6_8.

Applying FITradeoff to the

School Case Study

Urban Sustainability Assessment

Urban Sustainability Assessment

Selecting the best alternative

- **12 alternatives:**
  - Beijing, Berlin, Copenhagen, Hong Kong, London, New York, Paris, Prague, Seoul, Shanghai, Stockholm, Tokyo
- **Number of criteria: 23**

Three decision makers

- Criteria weights for each DM
  - with very conflictive order
  - Just for illustrating
- DM1
  - Criteria with different weights;
  - criteria with first ranked weights:
    - Employment; Doctors per capita; Mid-school students; Pension security coverage
- DM2
  - Criteria with different weights
  - criteria with first ranked weights:
    - Government investment R&D; Energy consumption unit GDP; Residential power consumption; Total water consumption
  - Ranking of criteria weights different of DM1
- DM3
  - Criteria with same weights

Some results for each DM

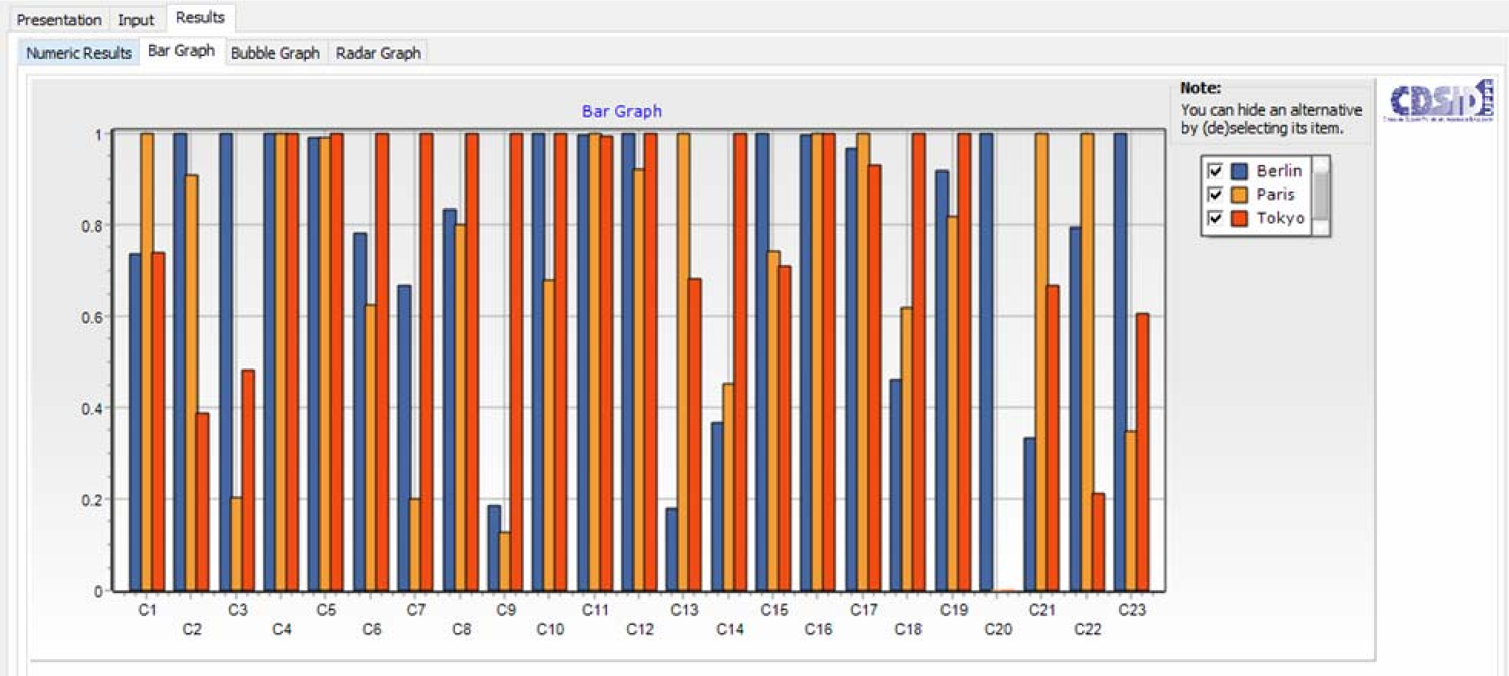
- **Number of POA,** after ranking criteria weights
  - DM_1: 5
  - DM_2: 9
  - DM_3: 1 (solved)
- **Number of POA,** after **first** elicitation question in FITradeoff
  - DM_1: 4
  - DM_2: 9
- **Number of POA,** after **10th** elicitation question in FITradeoff:
  - DM_1, **3 POA**
  - DM_2, **7 POA**

Some results for each DM

- Final solution:
  - DM_1: Berlin, Paris (equivalence threshold)
  - DM_2: Copenhagen, Seoul (equivalence threshold)
  - DM_3: Tokyo
- **Number of FITradeoff questions for final solution:**
  - DM_1: 27
  - DM_2: 40
  - DM_3: 0
- **Number of questions** with the traditional **tradeoff procedure**
  - Only indifference questions: **(n-1) = 22**
  - Indifference questions plus two general questions: **3(n-1) = 66**

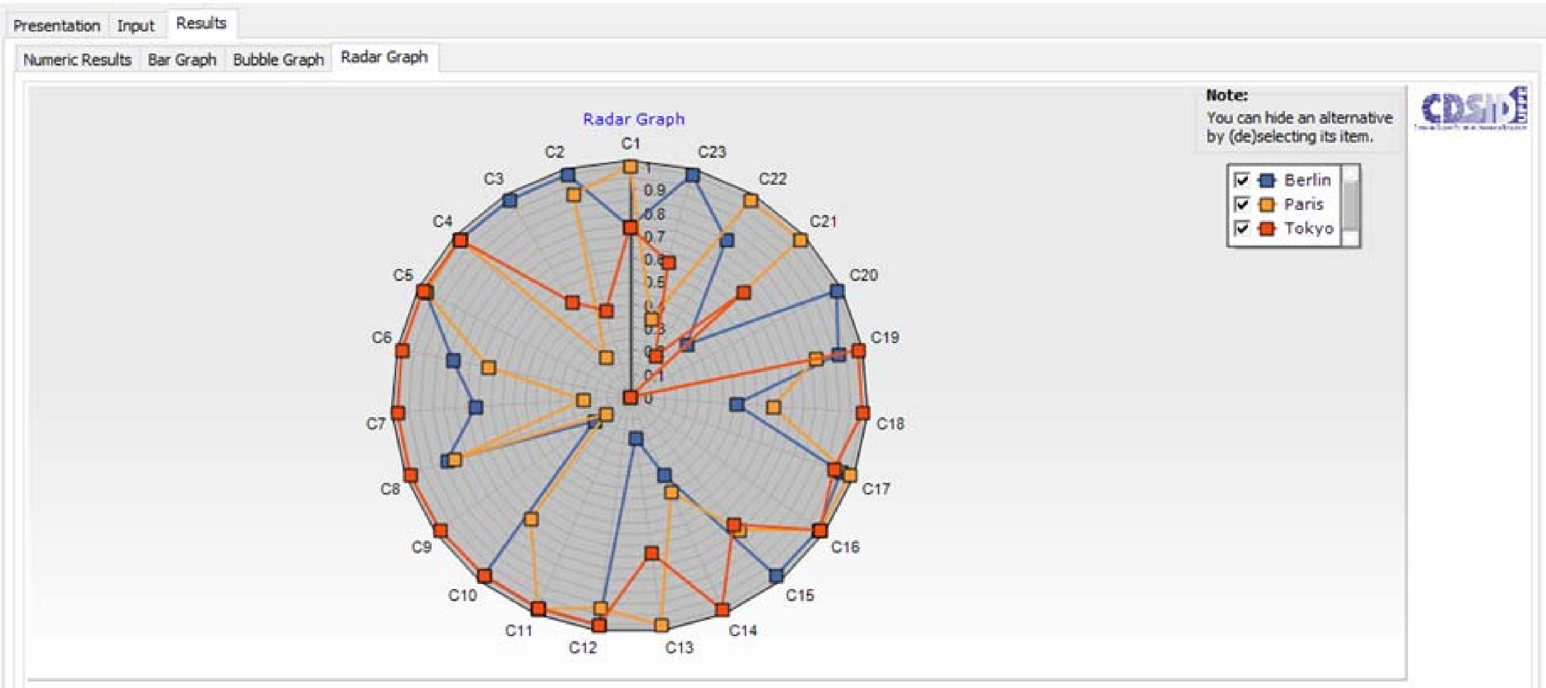
POA with graphical visualization

- DM_1: 3 alternatives



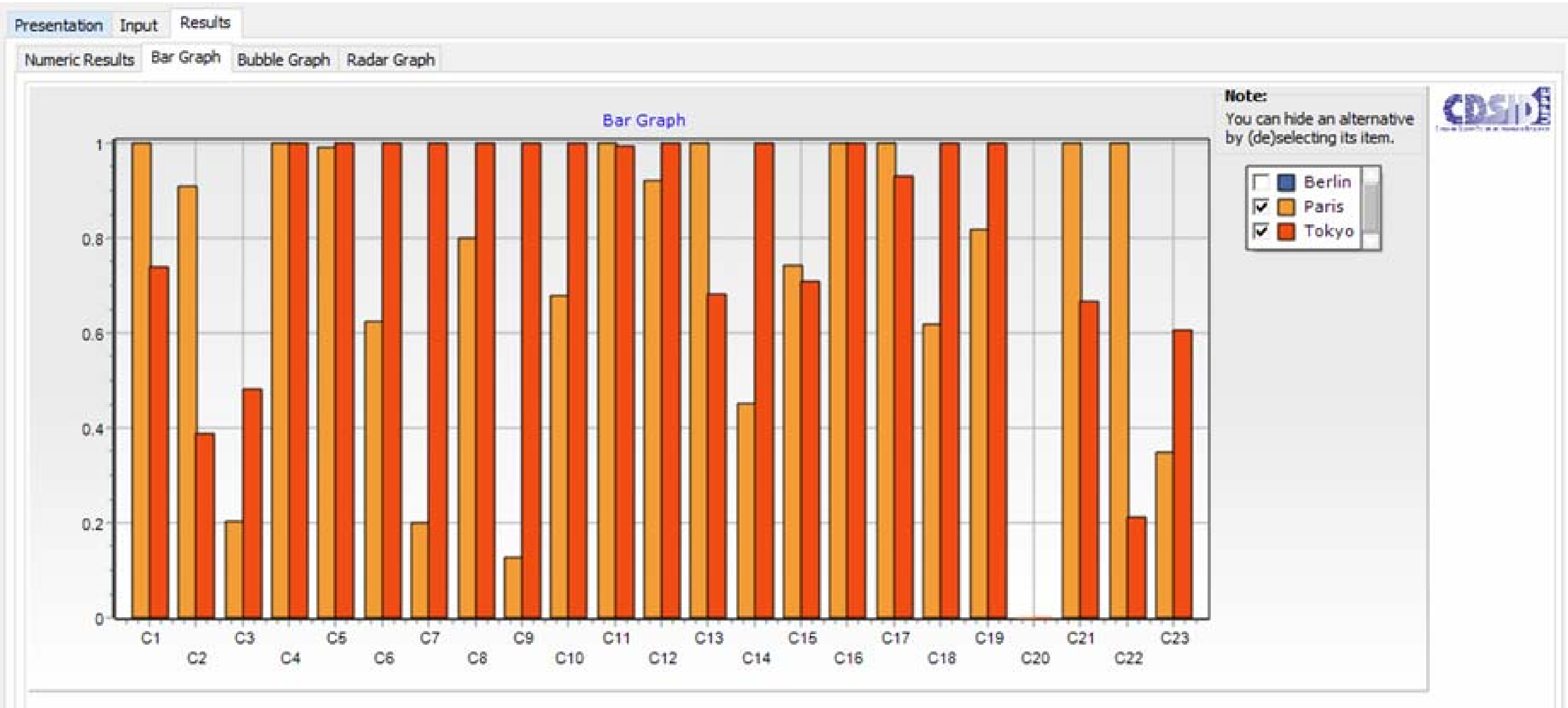
POA with graphical visualization

- DM_1: 3 alternatives



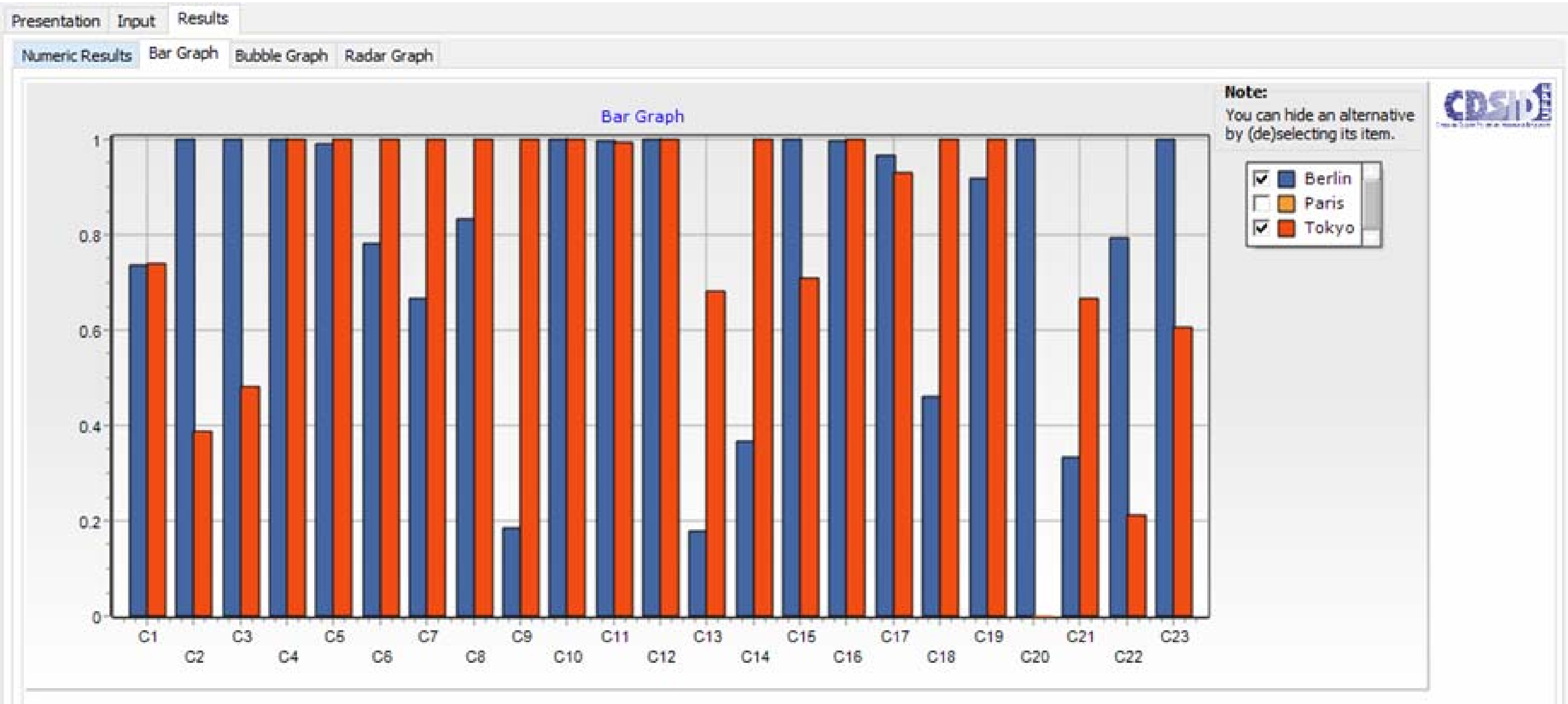
POA with graphical visualization

- DM_1:
  - Choosing **visualization of two alternatives** of POA



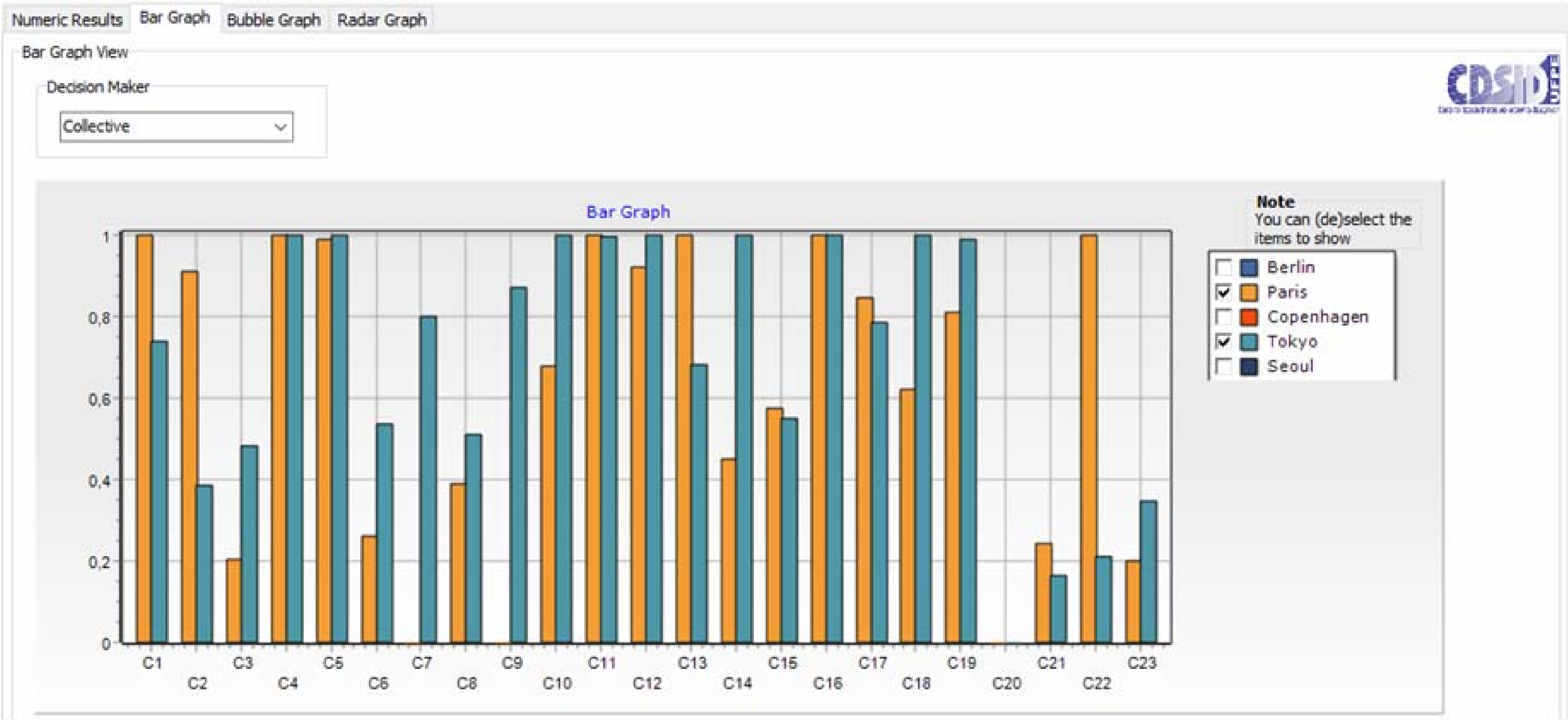
POA with graphical visualization

- DM_1:
  - Choosing **visualization of two alternatives** of POA



POA with graphical visualization

- Comparing DM_1 and DM_3 solutions



Remarks on FITradeoff

- Use of the concept of flexible elicitation of **FITradeoff** for
  - implementing a group decision process on a multicriteria additive model.
    - More reliable elicitation procedure,
    - **less effort** is required from the DM
    - reducing of elicitation errors.
- Simulation analysis have shown that in some situations of distribution of weights, a solution is likely to be found at the beginning of the process.
- Several applications conducted with list of publications at www.fitradeoff.org

More on GDN

GDN Section of INFORMS

- http://connect.informs.org/group-decision-and-negotiation/home

Conferences

- http://gdnconference.org/

GDN Journal

- https://www.springer.com/business+&+management/operations+research/journal/10726

Thanks!

Questions?

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