University of Economics in Katowice

Analyzing the concordance of principals' preference representation by agents with different decision-making profiles using generalized fuzzy approach

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Outline

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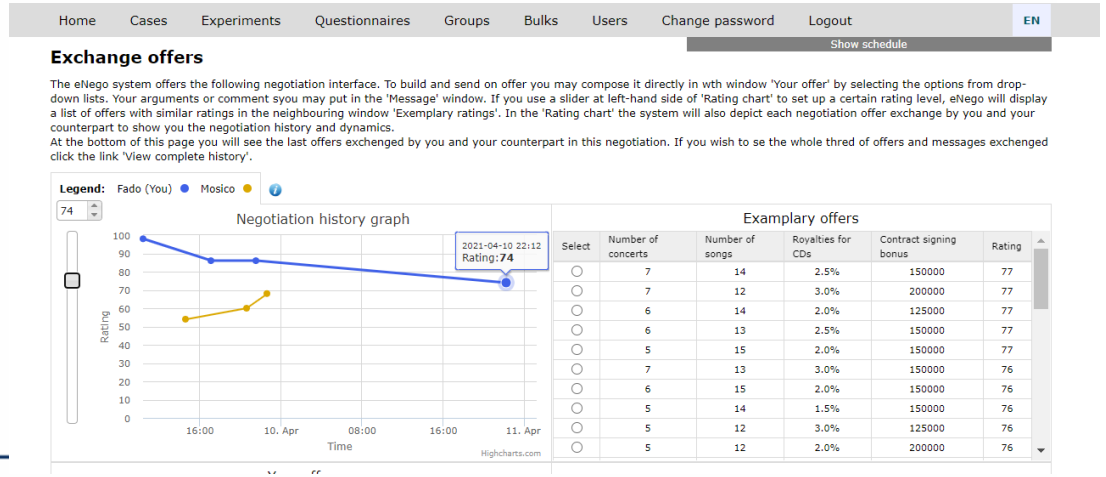
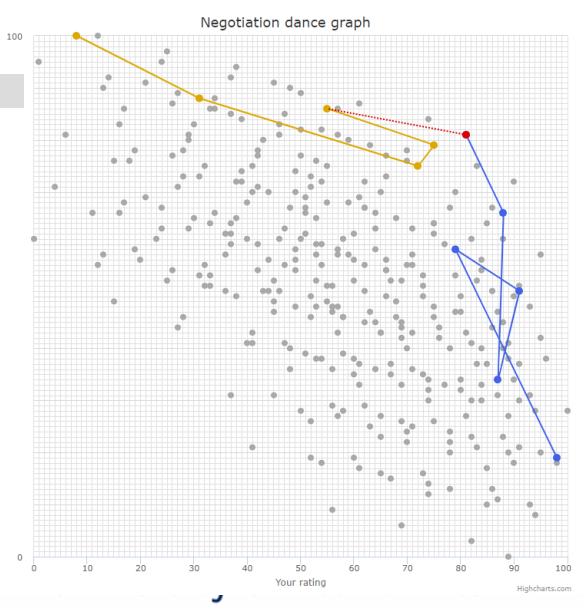
Motivation

- Negotiation theory recommends thorough **prenegotiation preparation** (Zartman 1989; Peterson and Lucas 2001), which amounts to determining the **negotiation template** and the negotiation offer **scoring system** (Raiffa et al. 2002).
- Scoring systems are used to offer negotiators **asymmetric and symmetric support** (Brahms 2001; Kersten, Lai 2021)





Motivation

- In **representative negotiations**, where the agents negotiate on behalf of their principals, determining **accurate scoring systems** seems particularly vital (Bottom et al. 2006).
- To be sure agents understand principals' preferences well, some **visualization** techniques are used (Miettinen 2014), e.g., **pie charts** (Wachowicz et al. 2019).
- Using circles is convenient and **cognitively easy for principals**; however:
  - it may raise **interpretational problems for agents** as the circles are two-dimensional.
  - it is **linked with uncertainty and imprecision** since pies if sketched out, are not based on the precise measurement of the preference.

Motivation

Research questions

- How can **agents interpret** the preference information visualized through pie charts and use it to determine the scoring systems for their principals?
- How such an interpretation:
  - is linked to **agents'** cognitive limitations resulting from their **information processing styles** (Stanovich 2011, Charter et al. 2018)?
  - affects the **concordance** (quality) or the negotiation offer scoring systems agents build for their principals?

Negotiation template and scoring system

Defining the problem and negotiation space

- The **negotiation template** is an ordered pair $\mathbb{T} = (F, X)$, where:
  - $F = (f_i)_{i=1}^{n}$ is a sequence of **negotiation issues** f_i,
  - $X = (X_i)_{i=1}^{n}$ is a sequence of **options lists** X_i related for issue f_i,
  - $X_i = \left(x_{i,j}\right)_{j=1}^{m_i}$ is a the **sequence of options** for issue f_i.

- The set $\mathbb{P}$ of **feasible negotiation offers** $\bar{P}_p$ (negotiation space) is defined as
  - $\mathbb{P} = X_1 \times X_2 \times \cdots \times X_n \ni \left(\bar{P}_p\right) = \left(x_{1(p)}, \ldots, x_{n(p)}\right)$
  - where $x_{i(p)} \in X_i$ denotes an option of issue i used to build the package p ($p = 1, \ldots, \text{card } \mathbb{P}$).

Negotiation template and scoring system

Scoring system for negotiation template

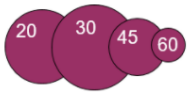
- Assuming the preferences are additive, the **scoring system** is an ordered pair $\mathbb{S} = (W, S)$ where:
  - $W = \left(v_{i,0}\right)_{i=1}^{n}$ is a sequence of **issues' importance** (weights) and
  - $S = (S_i)_{i=1}^{n}$ is a sequence of **lists of option scores** ($S_i = \left(v_{i,j}\right)_{j=1}^{m_i}$).

- The negotiation package from template $\mathbb{T}$ can be evaluated based on the scoring system S with the use **scoring function**
  - $F(\bar{P}_p) = \sum_{i=1}^{n} v_{i,0} v_{i(p)}$
  - where $v_{i(p)} \in S_i$ denotes the score of $x_{i(p)}$.

Representative negotiation

Principal's preference impartation

- In this paper, we will assume that the **principal uses circles $\mathcal{C}(R)$ of various radii R** to visualize their preferences over the template $\mathbb{T}$.
- The more important issue f_i is (or the better option $x_{i,j}$), the larger the size of the circle it represents:

Importance of the negotiation issues			
1.	**Price**	• Most preferred price is \$3.45. • The management preferences for other prices proportionally decrease as long as it is not higher than \$4.05, and are slightly worse from each other. • The price \$4.35 is much worse than \$4.05, and \$5.00 significantly worse than \$4.35. • Prices higher than \$5.00 are simply unacceptable.	
2.	**Delivery time**	According to the firm's purchasing policy, the orders should always be submitted no later than 30 days before the scheduled delivery date. Yet, due to limited storage capabilities too soon delivery may be troublesome. • Hence, the best option for delivery time is 30 days. • 20 days is somewhat worse than 30 but better than 45, • 45 days is worse than 20 and dangerous since in the periods of high production it may result in stock shortages and stop the production. • 60 is significantly worse than 45 and barely acceptable.	

- When building the scoring systems $\mathbb{S}$ an **agent assesses circle sizes** by value $V_{i,j} \in \mathbb{R}_0^+$ $(i = 1, \dots, n; j = 0, \dots, m_i)$.

Representative negotiations

Standardizing the preferences

- To determine the **value of negotiation offers** the issue importance is standardized:
  - $\forall_{i=1,2,\ldots,n}\ v_{i,0} = \frac{V_{i,0}}{\sum_{q=1}^{n} V_{q,0}}$.
- **Standardized preferences between options** can be determined using linear Max-Min (1) or linear Max (2) scaling:
  - $\forall_{i=1,2,\ldots,n}\ \forall_{j=1,2,\ldots,m_i} : (1)\ v_{i,j} = \frac{V_{i,j} - \min\{V_{i,q}: q=1,2,\ldots,n_i\}}{\max\{V_{i,q}: q=1,2,\ldots,n_i\} - \min\{V_{i,q}: q=1,2,\ldots,n_i\}}$; $(2)\ v_{i,j} = \frac{V_{i,j}}{\max\{V_{i,q}: q=1,2,\ldots,n_i\}}$
- The **absolute utilities** (standardized and weighted) $U(x_{i,j}) = u_{i,j}$ for any option $x_{i,j}$:
  - $\forall_{s=1,2}\forall_{i=1,2,\ldots,n}\forall_{j=1,2,\ldots,m_i}$: $u_{i,j} = v_{i,0} \cdot v_{i,j}$
  - where $v_{i,j}$ is normalized relative utility obtained by method (1) or (2).

Representation of preferences

Defining scoring systems of group of agents

- In our approach we examine the representation of preferences for **groups of agents with similar profiles of information processing styles**.
- Information processing style is identified using the **GDMS inventory** (Scott and Bruce, 1995):
  - Rational (R);
  - Intuitive (I);
  - Spontaneous (S);
  - Dependent (D);
  - Avoidant (A).
- We will build the **fuzzy scoring systems** $\langle \mathbb{P}, F \rangle$ representing a group of agents Q of particular profile for which the absolute utilities are represented by the sequence $\mathcal{U}_{i,j}^{(Q)} = (u_{i,j,k}^{(Q)})_{k=1}^{|Q|}$.

Representation of preferences

Generalized fuzzy scoring systems

- **Trapezoidal fuzzy numbers** $Tr(a,b,c,d)$ depending on the sequence $\mathcal{U}_{i,j}^{(Q)}$ will constitute the generalized fuzzy scoring system for a group Q.
- For group Q we can determine **absolute utilities** as function $U^{(Q)}\colon \bigcup_{i=1}^{n} X_i \longrightarrow \mathbb{F}_{Tr}$ given by the identity

$$U^{(Q)}(x_{i,j}) = Tr\left(\breve{u}_{i,j}^{(Q)}, \bar{u}_{i,j}^{(Q)}, \bar{\bar{u}}_{i,j}^{(Q)}, \hat{u}_{i,j}^{(Q)}\right) \qquad (*)$$

where: $\breve{u}_{i,j}^{(Q)} = \min\left\{y\colon y \in \mathcal{U}_{i,j}^{(Q)}\right\}$, $\quad \bar{u}_{i,j}^{(Q)} = \min\left\{y\colon \frac{\operatorname{card}\left\{z\colon z\leq y, z\in \mathcal{U}_{i,j}^{(Q)}\right\}}{\operatorname{card} Q} \geq \frac{1}{3}, y \in \mathcal{U}_{i,j}^{(Q)}\right\}$,

$\bar{\bar{u}}_{i,j}^{(Q)} = \max\left\{y\colon \frac{\operatorname{card}\left\{z\colon z\geq y, z\in \mathcal{U}_{i,j}^{(Q)}\right\}}{\operatorname{card} Q} \geq \frac{1}{3}, y \in \mathcal{U}_{i,j}^{(Q)}\right\}$, $\quad \hat{u}_{i,j}^{(Q)} = \max\left\{y\colon y \in \mathcal{U}_{i,j}^{(Q)}\right\}$.

Representation of preferences

Fuzzy global scores of negotiation offers

- In generalized fuzzy scoring system, the score of negotiation package $\overline{P_p} \in \mathbb{P}$ is represented in the following way:

$$F^{(Q)}\left(\bar{P}_p\right) = \oplus_{i=1}^{n} Tr\left(\breve{u}_{i,j(p)}^{(Q)}, \bar{u}_{i,j(p)}^{(Q)}, \bar{\bar{u}}_{i,j(p)}^{(Q)}, \hat{u}_{i,j(p)}^{(Q)}\right) =$$

$$= Tr\left(\sum_{i=1}^{n} \breve{u}_{i,j(p)}^{(Q)}, \sum_{i=1}^{n} \bar{u}_{i,j(p)}^{(Q)}, \sum_{i=1}^{n} \bar{\bar{u}}_{i,j(p)}^{(Q)}, \sum_{i=1}^{n} \hat{u}_{i,j(p)}^{(Q)}\right).$$

Experiment

Setup

- We organized a **prenegotiation experiment** to analyze the differences in the representation of the scoring systems by agents of various profiles.
- A **negotiation case from Inspire©** negotiation system was used, in which agents of a musician (Fado) and a broadcasting company (Mosico) discuss the terms of a potential contract.
- The negotiation template consisted of **four issues** and lists of predefined options that allow building **240 various packages**:

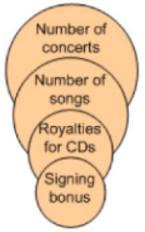
Negotiations issues	Lists of feasible options
Number of promotional concerts (per year)	5; 6; 7 or 8 concerts
Number of new songs introduced and performed each year	11; 12; 13; 14 or 15 songs
Royalties for CDs (in percent)	1.5; 2; 2.5 or 3 %
Contract signing bonus (in dollars)	$125 000; $150 000 or $200 000

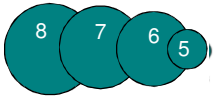
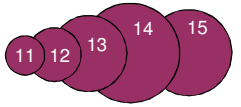
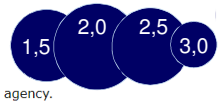
Experiment

Setup

- The participants represented Mosico party, for which preference information of principals was provided in a form of a short **verbal description** and **circle-based visualization**:

- It is clear that the most important issue is the **number of promotional concerts**. This is because successful concerts are critical to the artists' popularity and approval ratings. Without the concerts the agency cannot establish the artist in a particular market.
- Almost as important an issue is the **number of new songs**. Obviously the artist has to produce new songs to be recognized and accepted.
- **Royalties for CDs** are less important than the number of songs. The management considers the royalties to be a motivating factor for the artist to produce good CDs.
- The **contract signing bonus** is the least important issue. It is less important than the royalties for CDs. This is because the agency views a contract as an investment opportunity that can bring in many of millions of dollars. The bonus size is seen as a token of appreciation, but obviously within limits.
- The illustration of the issue importance is given in the figure.



Importance of the negotiation issues		
1.	**Number of promotional concerts (per year)**	This is the most important issue for the management. The more concerts the better for WorldMusic. From your discussion with the management, it follows that: • The most preferred option is 8 concerts. • The difference between 7 and 8 concerts is almost the same as between 6 and 7 concerts. • 5 concerts is significantly worse than 6. • Less than 5 concerts cannot be accepted because it makes little sense in the entertainment business. 
2.	**Number of new songs**	It is a long established practice that too few songs are disastrous but too many are also not profitable. The best number of songs is 14; 14 songs make two full CDs. • 15 songs are worse than 14 because it is considered somewhat too many. • 13 songs are almost as good as 15. • 12 songs are worse than 13 because 13 songs allow the discarding of the worst song if necessary. • Having 11 new songs is the worst option because only one CD can be produced. 
3.	**Royalties for the CDs**	Royalties strongly depend on the artist's present standing. Typically, WorldMusic pays between 2.0% and 2.5% royalties. If the artist is very well known during contract signing, the royalties can go up to 3%. Based on the research done regarding Ms. Sonata's standing, the management considers: • 2.0 % the best option; • 2.5% is considered somewhat too high. • The management prefers 2.0% much more than 1.5% because of the artist's standing. • And it makes little sense to try and save a little now and loose the artist's interest in cooperating with the agency. • The research done convinced the management that 3.0% is too much. 
4.	**Contract signing bonus**	This issue is considered the least important, although the agency does not want to be seen as throwing money away. The management's preference is to pay less rather than more. 

Experiment

Setup

- Based on this information, the participants, were asked to:
  - provide the quantitative representation of the priorities, i.e., the circle sizes $V_{i,j}$, to construct the scoring system.
  - fill the General Decision-Making Style Inventory.
- The experiment was conducted in the form of an **in-class survey**.
- The participants were the bachelor and master students of four Polish universities.
- We received 141 completed questionnaires; 83 were filled by males (~59%), while 41% by females.

Experiment

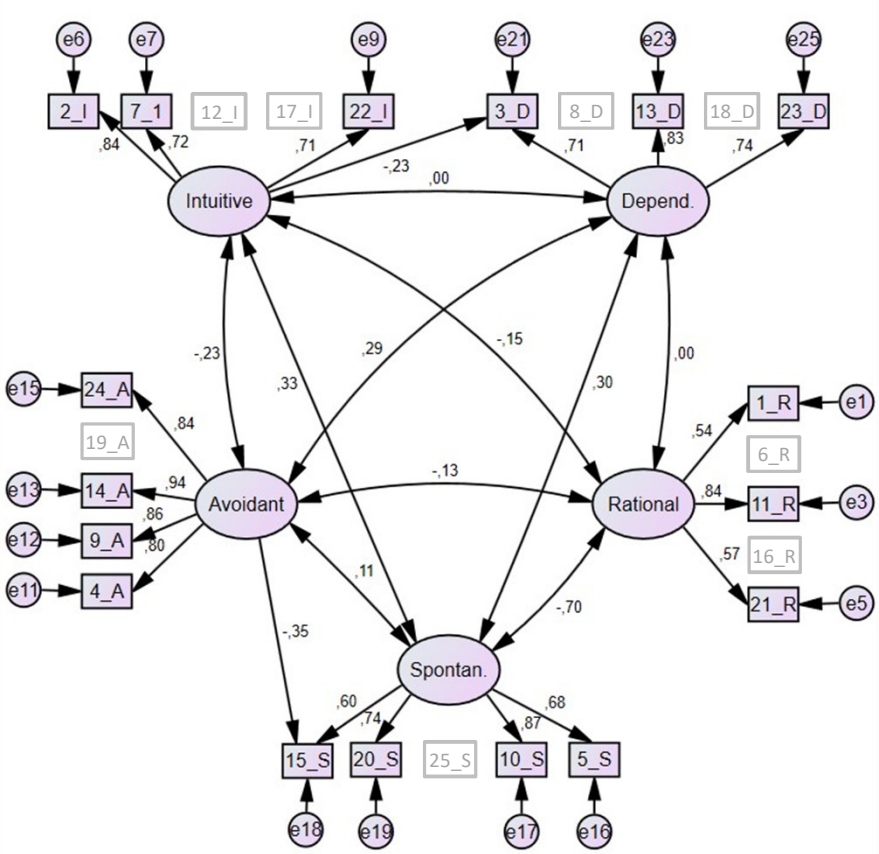
Analytical approach

- Our analytics consisted of the **five following steps**:
  - Step 1. Determining the participants' decision-making profiles using GDMS and E/CFA.
  - Step 2. Verifying scores $V_{i,j}$ declared by the agents and differences in their normalization.
  - Step 3. Building the clusters of GDMS-homogenous agents.
  - Step 4. Determining the fuzzy scoring systems for clusters.
  - Step 5. Comparing rankings of packages from each cluster with the principal's ranking.

Results

Step 1. Agents' profiles

- The combined exploratory and confirmatory factor analysis was used (E/CFA) to determine the participants' styles.
- The reduced 17-item model with five factors revealed a satisfactory fit with:
  - $\chi^2_M/df_M = 1.33$
  - $RMSEA = 0.048,$
  - $CFI = 0.966,$
  - the Bollen-Stine bootstrap with $p = 0.197.$



Results

Step 2. Verifying standardization modes used

- Surprisingly, 28% of agents had assigned the least preferred option with a score of 0, implicitly using the max-min standardization procedure.

> They used their knowledge on MCDA techniques (future aggregations), as they could not have interpreted the smallest circle as having zeroth radiuses!

- When the perception of circles is to be determined according to eq. (*) these zeroes cannot be compared to non-zero circles drawn by the principals to avoid false-negative conclusions.
- Thus, the results will be analysed **separately for two groups of agents**:
  - Q1 (38 agents) - for which the max-min standardizing formula will be used, and
  - Q2 (103 agents) - where max formula will be applied.

Results

Step 3. GDMS-based clusters of agents

- Clusters of agents with homogenous GDMS styles built using k-means clustering separately for subgroups Q1 and Q2 were **too small** to provide any reliable statistical comparison.
- It occurred that **both groups Q1 and Q2 differ significantly** in terms of the decision-making style characteristics.
- Average values of factors representing each decision-making style for each group of agents are the following:

Group	Decision-making style				
	D	S	A	I	R
Q1	3.299	**1.188**	2.340	**3.013**	*1.871*
Q2	3.191	**1.428**	2.287	**3.419**	*1.745*
p*	0.287	0.015	0.838	0.003	0.077

Results

Step 4 & 5

- In step 4 the fuzzy scoring systems were determined for both groups of agents: Q1 and Q2.
- In step 5, the ranking of all 240 packages were compared:
  - Ranking for principal was determined using precisely measured radiuses
  - Rankings for Q1 and Q2 agents - using the generalized fuzzy scoring systems from step 4.
- The Tau Kendall coefficients **between principal's and agents' rankings** are the following:

Group	Tau Kendal			
	Chen	Hsieh &Chen	Wei&Chen	Ponnialagan et al.
Q1	0.906	0.908	0.844	0.904
Q2	0.832	0.837	0.790	0.848

- All results show a **high and statistically significant ($p<0.01$) correlation** between agents' and principals' ranking, **higher for group Q1.**

Conclusions

- Agents with **higher rational modes and lower intuitive and spontaneous** ones behave differently while representing the preferences of their principals:
  - They **process the preference information in a different way** (Q1) than the highly spontaneous and intuitive agents (Q2),
  - Are aware of its further use in the scoring system (a need for standardization and use of standardized scores in the classic additive scoring formula).
  - Are able to **produce the scoring systems that result in more similar representation** of principal's preferences.
- Using a fuzzy generalized approach allows **resigning from the classic aggregation** of differences of preference representation within clusters (as averaging) and **convey a whole spectrum of representation** typical for this group of agents.

Conclusions

- Our results confirm that agents vary in the representation of principals' preferences.
- There is a **need for developing the decision support tools tailored to the agents' cognitive capabilities** to improve the adequacy of their decision analysis and preference elicitation to assure good representation of their preferences in negotiation.

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