SAW-Based Rankings vs. Intrinsic Evaluations of the Negotiation Offers – An Experimental Study

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Abstract. In this paper we discuss the issue of evaluating the negotiation offers represented in a form of the complete packages and the negotiators' consistency in scoring such packages. We analyze the results of an experiment, in which the negotiators were asked to build the ranking of fourteen negotiation offers and then compare it with two predefined rankings obtained by means of SAW method. We verify how do the negotiators evaluate these SAW-based rankings and how they correspond to the negotiators' intrinsic ones. We discuss then both the negotiators' consistency in defining their preferences and the applicability of some formal methods in supporting them in such a definition.

Keywords: preference analysis, preference consistency, negotiation offer scoring system, unfolding analysis, SAW.

1 Introduction

Negotiation is a decision making process, in which at least two parties talk with one another in effort to resolve their opposing interests. Usually the negotiation involves a number of issues that needs to be discussed, so the decision problem that is faced by the negotiators is of multiple criteria. Therefore the negotiations are often supported by various multiple criteria decision making (MCDM) methods [2; 9; 11]. These methods are used to elicit the negotiator preferences and build the negotiation offer scoring system that helps negotiator to evaluate qualitatively the offers submitted during the negotiation process. The most popular MCDM technique widely used for eliciting the negotiators' preferences is the simple additive weighting (SAW), that stems from the fundamental notions of the multi-attribute value theory (MAVT) [5], and allows to build a value function over the negotiation issues and their options [7; 11]. However, one drawback of the SAW is, that while eliciting the preference it requires of the negotiator to assign the numerical scores directly to all the evaluated resolution levels within the negotiation template. Yet, the negotiators may not know how to interpret these scores and therefore misuse them while assigning them to the issues and options [4; 12]. Consequently, it may lead to the inconsistency between the

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evaluations generated by the scoring system obtained by means of SAW, and the subjective intrinsic preferences of the negotiators. There are some research studying the use and usefulness of SAW in negotiation support or the consistency of SAW rankings depending on various normalization procedures [3; 6], however, they do not focus on analyzing the if the SAW-based scoring systems are coherent and consistent with the negotiators intrinsic preferences.

This paper is a part of the bigger scientific project that focuses on building a new negotiation support system and identifying the formal tools for supporting the process of negotiation template design and evaluation in the ill-structured negotiation. In our earlier works we studied the usability of TOPSIS and fuzzy TOPSIS methods [8]. Here, we try to evaluate experimentally if the SAW algorithm can be effectively used as a supportive tool in describing precisely the negotiators' preferences. We use two SAW-based procedures, that differ in normalizing the issues' resolution levels. They are implemented to ease the process of analyzing the negotiators preferences by automatic generation of the options' ratings. The main goal of this paper is twofold: (1) we aim to analyze the usefulness of these two alternative SAW algorithms in generating the rankings of the negotiation offers, that we could use in developing the assessment capabilities of our NSS; and (2) we want to verify the consistency of the negotiators' evaluations of the SAW-based predefined rankings with their own rankings based on their intrinsic preferences and generated previously without any support mechanism.

The paper consists of three more sections. In section 2 we present these two alternative SAW algorithms we used for scoring the offers. In section 3 we describe the experiment we organized to verify the usefulness of SAW-based rankings and the consistency of the negotiators' preferences, while in section 4 we analyze the experimental results.

2 Two Alternative SAW Algorithms for Ranking the Offers

To release the negotiators from the tiresome process of evaluating the negotiation template we predefined two mechanisms for automatic scoring based on SAW. We used two scoring functions A and B that differ in the normalization procedures implemented to obtained the standardized values of issues' options, regarded as the options' ratings. The standard normalization formulas, different for benefit and cost issues, are used [10]. For scoring function A the normalization of the options of the benefit (cost) issue was conducted according to the following formula

$$z_{ij} = \frac{x_{ij}}{x_j^{asp}} \quad \left(z_{ij} = \frac{x_j^{res}}{x_{ij}} \right), \tag{1}$$

where: x_{ij} is the option of the *j*th issue in the *i*th offer that is to be normalized, x_j^{asp} (x_j^{res}) is the negotiator's aspiration (reservation) level for the *j*th issue.

In the scoring function B the formulas for benefit (cost) issues are

$$z_{ij} = \frac{x_{ij} - x_j^{res}}{x_j^{asp} - x_j^{res}} \quad \left(z_{ij} = 1 - \frac{x_{ij} - x_j^{res}}{x_j^{asp} - x_j^{res}} \right). \tag{2}$$

These two scoring functions are implemented in the SAW algorithm, in which the aggregation function S assigns to each negotiation package P_i a score, being the linear combination of the vector of issues' and the normalized option values:

$$S(P_i) = \sum_j w_j \cdot z_{ij}\,, \tag{3}$$

where w_j is the weight of *j*th issue.

It should be noted, that in the scoring function B the global score of any package P_i that is comprised of the options worse than aspiration and better then reservation levels is in the range $\langle 0;1 \rangle$, while for scoring function A the range of the scores is not unitarized but depends on the aspiration and reservation packages defined in the negotiation template.

3 Experimental Setup

In our experiment, organized as an in-class assignment, eighty undergraduate students of international business and computer science took part. They fit the profile of the future users of our NSS, which is being designed to support the business negotiation/e-negotiation (e.g. in procurement). However, since no research has already been conducted to identify the characteristics of the true NSS users, we cannot conclude on the representativeness of the group of our responders.

The participants were asked to play the role of the negotiators and to conduct a prenegotiation analysis in the multiple issue business negotiation problem. They were presented the negotiation template, in which fourteen feasible negotiation packages were identified, each described by means of three negotiation issues, i.e. price, time of delivery and time of payment (Table 1).

Table 1. The negotiation template and the general preference information

Issue	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}
1. Price (USD)	20	20	20	20	20	20	22	22	22	25	25	25	25	25
2. Time of delivery (days)	2	2	7	7	14	14	2	7	14	2	7	7	14	14
3. Time of payment (days)	3	20	3	20	3	20	7	20	7	7	3	7	3	20

For each issue the reservation and aspiration level was predefined: $x^{res} = (18, 2, 21)$ and $x^{asp} = (30, 20, 1)$, as well as the issues' importance was fixed (vector of weights $w = (0.8, 0.1, 0.1)$).

Each participant was asked then to build a strict ranking of the packages, taking into account the general preference information (assigning the rank of 1 to the most preferred package, and the rank of 14 to the least preferred one). Next the participants were proposed two alternative SAW-based rankings, obtained by means of the scoring functions A and B (see formulas 1-3). These two rankings, together with the accompanying ratings are shown in Table 2.

Table 2. The rankings and ratings of the packages for the SAW-based scoring system

Package	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}	P_{11}	P_{12}	P_{13}	P_{14}
Scoring function A														
Rank	12	14	11	13	7	10	9	8	6	5	3	4	1	2
Rating	0.577	0.548	0.602	0.573	0.637	0.608	0.611	0.627	0.671	0.691	0.735	0.716	0.770	0.742
Scoring function B														
Rank	11	14	10	13	9	12	7	8	6	5	2	3	1	4
Rating	0.223	0.138	0.251	0.166	0.290	0.205	0.337	0.299	0.403	0.537	0.584	0.564	0.623	0.538

Having analyzed the above rankings the participants had to evaluate each of them by assigning the score reflecting the ranking usefulness in ordering of the package according to their individual preferences. For the evaluation an ordinal 5-point scale was used (1 – very good, 2 – good, 3 – average, 4 – poor, 5 – very poor).

4 Results

4.1 Participants' Individual Rankings

There are 14! different rankings that may be identified for fourteen packages, however, in our experiment the negotiators built 60 of them: 47 orderings were unique (declared by one negotiator only), while 13 were repeated in declarations of at least two negotiators. The most frequently used (7 instances) was the ranking of the same order to the one obtained by means of scoring function B. These numbers may suggest that the respondents differ a lot in setting the ranks. To verify, if the dispersion of the individual evaluations over the ranks of each package is big, we conduct the unfolding analysis [1].

Analyzing the unfolding graph (Fig. 1) we see, that the numbers representing our respondents are clustered around the (0,0) point (an "ideal point"), which means that their rankings (vector of ranks) are quite a similar (the distances between them are short). To verify the high degree of agreement among the negotiators we determined the Kendall's W coefficient of concordance, obtaining $W = 0.8046$. The significance of the concordance measured by W was tested using the value of chi-square statistic

$$\chi_r^2 = m(n-1)W = 836.78, \tag{4}$$

where m is a number of respondents, and n – the number of packages.

For $\alpha = 0.0001$ and $m-1 = 79$ df we obtain $\chi_\alpha^2 = 134.49$, thus $\chi_r^2 > \chi_\alpha^2$. Hence, we may reject the hypothesis on the independence of the respondents' individual rankings, i.e. they rankings seem to be similar and quite homogenous.

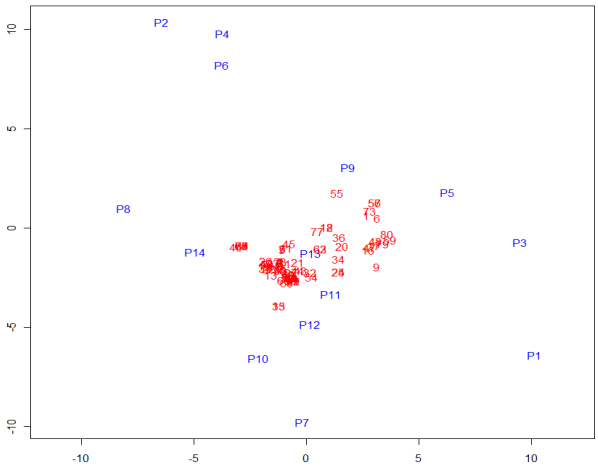

Fig. 1. The results of the unfolding analysis for negotiators (numbers) and packages (P_i)

This result indicates an important issue that should be taken into consideration while designing the assessment capabilities of NSS. Namely, the individual preferences of negotiators may be sometimes approximated by means of a group profile reflecting the ranking that describes a representative evaluation of packages within a particular group of negotiators. Such a group profile may be constructed on the basis of the unfolding graph too. As it is depicted in Fig. 1 the closest to the ideal point is the package P_{13}, the second closest is P_{11}, then P_{12}, P_{14}, $P_{9,}$ …. The graph indicates however, that the individual rankings differ, and, for instance, the negotiator number 55 considered the package P_9 to be the best (the distance between the point represented the negotiator 55 and P_9 is shorter than to any other P_i), while for the negotiator 35 the best is P_{12} and then P_{11}. Naturally, a group profile may be determined by using other notions too, e.g. the average or dominant ranks. What is interesting here, the dominant-based ranking is the same to the one obtained by means of scoring function B.

4.2 SAW-Based Rankings and Their Evaluation

We compared then the respondents' individual rankings with the ones obtained by means of scoring functions A and B and analyzed, how had the respondents evaluated the usefulness of these two functions. Scoring function A was evaluated positively (as being very useful or useful) by 40 participants (50%), while scoring function B – by 44 of them (55%). There was also very low percentage of the respondents that negatively evaluated each of these functions. The details of the scoring functions evaluations are presented in Table 3. Despite the high percentage of positive evaluations we decided to analyze how the rankings evaluations (o_A and o_B for ranking A and B respectively) correspond with the ones individually built by respondents at the beginning of the experiment. We used the Spearman's rank correlation coefficient (r_s) to measure the consistency of the respondents preference definitions with the predefined ranking A (r_{SA}), and the ranking B (r_{SB}).

Table 3. Distribution of the scoring function evaluations

Evaluation (o)	*Scoring function A*				*Scoring function B*			
	No. of respondents	Min $r_{SA}(k)$	Max $r_{SA}(k)$	Avg. $r_{SA}(k)$	No. of respondents	Min $r_{SB}(k)$	Max $r_{SB}(k)$	Avg. $r_{SB}(k)$
1 – very good	17	0.530	1.000	0.864	20	0.490	1.000	0.918
2 – good	23	0.591	0.982	0.881	24	0.466	1.000	0.868
3 – average	32	0.486	0.969	0.863	25	0.578	1.000	0.866
4 – poor	3	0.763	0.965	0.903	10	0.525	0.987	0.882
5 – very poor	5	0.648	1.000	0.909	1	0.618	0.618	0.618

As shown in Table 3, there are examples of evaluations that cannot be considered as reliable, e.g. there are respondent(s) that evaluated ranking A as very poor, however it is highly coherent with their own ranking they prepared on the basis of their preferences (maximum r_{SA} in this group is 1.0, while an average $r_{SA} = 0.909$). Therefore we defined 5 different types of inconsistency that may appear in our research for each of participants. We will consider the preferences of kth respondent to be inconsistent according to:

- Type I if: ($o_A(k) \in \{1,2\}$ and $r_{SA}(k) \in \langle 0.4;0.7 \rangle$) or ($o_B(k) \in \{1,2\}$ and $r_{SB}(k) \in \langle 0.4;0.7 \rangle$);
- Type II if: ($o_A(k) \in \{4,5\}$ and $r_{SA}(k) \in \langle 0.9;1.0 \rangle$) or ($o_B(k) \in \{4,5\}$ and $r_{SB}(k) \in \langle 0.9;1.0 \rangle$);
- Type III if: $o_A(k) = o_B(k)$ and $r_{SA}(k) \neq r_{SB}(k)$;
- Type IV if: $o_A(k) \neq o_B(k)$ and $r_{SA}(k) = r_{SB}(k)$;
- Type V if: ($o_A(k) < o_B(k)$ and $r_{SA}(k) < r_{SB}(k)$) or ($o_B(k) < o_A(k)$ and $r_{SB}(k) < r_{SA}(k)$).

Having analyzed the dataset we found the inconsistencies of at least one type for 42 respondents (52%), for 15 of them two types of inconsistency were identified at a time. The histogram in Figure 2 shows the numbers of the inconsistencies within each type defined above. The highest number of inconsistencies was observed for the Type V (32 respondents). It was exactly half of them (16 respondents) who considered ranking A to be better than B, however B was more similar to their own subjective ranking; while the remaining 16 respondents reckoned quite the opposite – that B is better than A despite $r_{SB}(k) < r_{SA}(k)$. There were 12 participants whose evaluation was classified as the inconsistency of Type II: six of them considered ranking A as poor or very poor, while the Spearman coefficient for their own evaluation compared to ranking A was extremely high ($r_{SA}(k) \in \langle 0.9;1.0 \rangle$), the remaining six of them revealed similar inconsistency in evaluation of ranking B. Another 8 participants revealed the inconsistent evaluations of Type I: five of them regarded ranking A to be very good or good, while the Spearman coefficient proved very weak correlation of this ranking and the their own one ($r_{SA}(k) \in \langle 0.4;0.7 \rangle$); the remaining three evaluated ranking B positively, while it does not fit their own one too much.

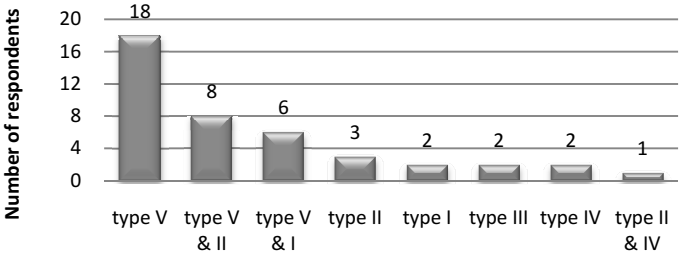

Fig. 2. Number of inconsistent respondents within each type of inconsistency

5 Conclusions

In this paper we analyzed the usefulness of SAW in defining the rankings of the negotiation offers and their consistency with the negotiators' preferences. The experiment we conducted was to prove the applicability of the SAW algorithm in the precise elicitation of the negotiator's preferences that could be used in the NSS we aim to design and implement. We found that:

- The SAW-based scoring systems, despite their disadvantages raised by some researchers [4; 12], are acceptable by the majority (from 50% to 55%) of the potential negotiators, who evaluate them positively as being good and useful tools (which confirms some earlier research [6]).
- More than half of the negotiators (52%) are inconsistent in evaluating and choosing the SAW-based rankings that fit their preferences. Most frequently the negotiators evaluated as a more useful (better) a particular predefined ranking that was more different from his own subjectively defined one (32 respondents). It questions SAW based scoring systems as being the tools that precisely describe the intrinsic preferences of the negotiators.
- The SAW-based rankings may be useful, however, if the group profile of the preferences should be determined to represent the negotiator's individual preferences. The ranking obtained by means of the scoring function B is the same to the one obtained by means of dominant rank in our group of the respondents, and is also very similar to the one determined by means of average ranks in the group.
- The unfolding analysis may be an effective tool that would allow to identify the groups of negotiators of the similar preferences and define their group profile ratings. Such an analysis may be applied for facilitating the process of preference elicitation in negotiation support systems operating on the electronic markets. Instead of following the tiresome and complicated algorithm of building an individual scoring system the negotiator's bargaining profile may be determined (e.g. using his business, psychological and demographical characteristics) and then the scoring system may be automatically suggested to the negotiator using the average or dominant ratings defined by other negotiators of similar profile in previous negotiations.

Our experiment proves that the problem of defining preferences, even for such a simple negotiation problem that consist of fourteen packages only, requires a special consideration and some support techniques that will explore the preferences in detail and result in scoring systems consistent with the negotiators intrinsic preferences. The classic SAW does not seem to be an effective tool here. It may be, however, that some modifications will improve the SAW-based approach in building the reliable and sound negotiation offers scoring systems. In our future work we will focus on testing the use and usefulness of the fuzzy SAW and developing its extensions, which would allow for determining the scoring system most coherent with the negotiators subjective and intrinsic preferences.

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