Tomasz Wachowicz

APPLICATION OF MULTIPLE ATTRIBUTE STOCHASTIC DOMINANCE TO SELECTION OF NEGOTIATION STRATEGIES IN E-NEGOTIATIONS

INTRODUCTION

It can be derived from the empirical works [1; 2; 8] and some behavioural models [6; 7] that the negotiation strategy the parties use is one of the most important factors influencing the negotiation process and its outcome. Therefore the determination of the negotiation strategies that allow the negotiating subjects to best satisfy their goals is the major task for the mediator or the negotiation support system in the externally supported negotiations. We propose describing the negotiation situation as a two-person game, the strategies of which correspond to all the possible negotiation strategies that the parties can apply during the negotiation process. This way we find, by determining the solution of the game, the efficient mix of negotiation strategies which maximises the negotiation outcomes for both parties. To compare the payoffs given as the vectors of value distribution we apply the model of multi-attribute stochastic dominance proposed by Zaraś and Martel [11; 12] and to find the game solution we apply the procedure for determining the negotiation set of the game with the combination of the Zaraś and Martel model. The general procedure for determining the negotiation game solution and a numerical example of its application based on the Inspire empirical dataset are also presented.

1. INSPIRE E-NEGOTIATION SYSTEM

We consider bilateral business negotiations conducted via Web, as described in Inspire eNS[1] [5]. Inspire is a simple Internet tool, most frequently used for training and learning negotiations by means of which the hypothetical negotiations between buyer (bicycle manufacturer) and seller

[1] www.inerneg.org/inspire

(bicycle parts producer) can be conducted. It is assumed that the parties wish to sign a new contract and therefore they negotiate four different issues: price of the bicycle parts, time of delivery, time of payment and conditions of spoilage returns. All the issues have predefined values, the only ones that the negotiators can consider during the negotiation process. Inspire helps negotiators evaluate the offers by means of the utility functions that are individually determined in the pre-negotiation phase. In this phase the parties are also asked to fill the pre-negotiation questionnaires in which they describe their psychological profiles, the expectations towards the negotiation atmosphere, the expected behaviour of their opponents and the compromise they are going to achieve.

In the negotiation phase Inspire acts as a communication platform used by the parties to send the offers, arguments and comments. It also presents the history of the process in a graphical way, which helps negotiators analyse and evaluate the scale of concession.

In the post-negotiation phase Inspire analyses the compromise – if achieved – and searches for a better one, if the compromise is outside of the set of Pareto-optimal solutions. In this phase negotiators can also analyse the negotiation dance which is a graphical representation of the concessions made by both parties during the entire negotiation process. Finally, they fill the post-negotiation questionnaires in which they evaluate the negotiation process, their own and their opponents' attitude and behaviour, and the Inspire system itself. In the questionnaires they also describe the negotiation strategy which they applied during the bargaining process. To define the negotiation strategy Inspire users need to evaluate their behaviour on five different platforms: information, persuasion, honesty, exploitation, and co-operation. For each platform they assign a grade between 1 and 5. For example, assigning the grade 1 to the platform of information means that the user consider himself to be extremely informative, while assigning the grade 5 shows him or her to be extremely uninformative.

Gathering of all the detailed information about negotiation processes makes Inspire a powerful tool whose database can be used for many formal analyses. In Section 5 we will use the Inspire data to show an example of the application of the procedure for determining an efficient mix of negotiation strategies.

2. NEGOTIATION GAME

The recent behavioural works in the field of negotiation analysis point to a few factors that influence the negotiation process and its outcome. In summarising the results of these works we can consider the three major determinants of the negotiation outcome, namely: negotiation context, negotiators' psychological profiles and negotiation strategies used by the parties. The negotiation context describes the present and future relationships between the negotiating subjects and the level of conflict [8]. The negotiators' psychological profiles consist of their intrinsic, personal and demographical characteristics [1; 2; 3; 9] like sex, background, experience etc. Some characteristics cannot be changed (e.g. race and background); others can (e.g. emigration or education) but in the vast majority of situations they remain stable during the negotiation process. The negotiation strategies are defined as sets of rules guiding the negotiation process and determining the selection of tactics [6; 7]. Strategies can be perceived as the negotiators' particular ways of acting and behaving during the negotiation process and are purposely selected to fulfil their negotiation goals best.

Since the entire analysis to be conducted is based on the dataset obtained from negotiation experiments conducted in the past, we need to assume that the context of the supported negotiations is the same as the context of the negotiation experiments. Thus only the two remaining factors need to be considered. Therefore the problem under consideration is: how to support two negotiators, both having a particular psychological profile, in determining the efficient mixes of negotiation strategies. The analysis of such case needs to be divided into two separate steps. The psychological profiles of the negotiating subjects have to be identified first. Next, for the negotiators with the specified psychological profiles, the selection of negotiation strategies must be conducted.

The identification of negotiators' psychological profiles comprises a separate analytical problem that can be solved by applying some clustering methods and was previously discussed by Wachowicz [10]. In this paper we assume that we have already identified the psychological profiles of both negotiators and will focus only on the procedure for determining the efficient mix of negotiation strategies.

Since we introduce a mediator (or a software agent) into a negotiation process it is justified to propose a symmetric-prescriptive approach to solve the problem of determining the efficient negotiation strategies. We will construct a two-person negotiation game whose strategies correspond to negotiation strategies which the parties (of specified psychological profiles) can use during the negotiations. If the number of all possible negotiation strategies is too big to consider[2], they can be clustered into a few similarity classes [10]. Each mix of game strategies can be perceived as a separate alternative leading to the outcome described by the payoff value in this matrix cell. The payoffs

---

[2] With regard to the calculations required.

of such game can be considered as single variables or vectors of variables; they reflect the criteria used by negotiators to evaluate the negotiation outcome. The matrix of payoffs is constructed on the basis of the subset of data applied by the mediator in the analysis[3]. Since the subset of data is relatively large it usually consists of more than one record describing the payoff for each matrix cell. Therefore the payoffs have to be considered not as vectors of deterministic values, but as vectors of value distributions. Solving such game will allow us to find the efficient negotiation strategies for both negotiators.

The general scheme of constructing the negotiation game to support the Inspire users in selection of their negotiation strategies is shown in Figure 1.

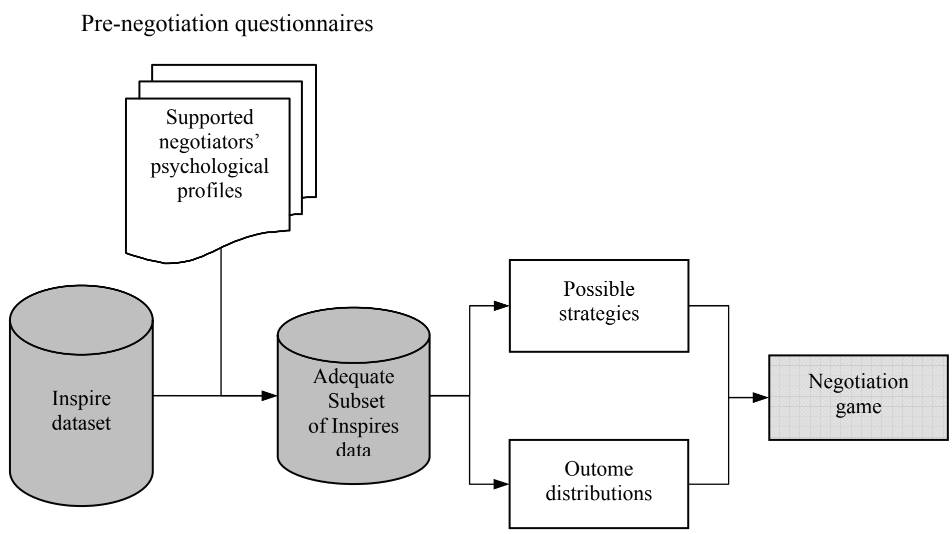

Fig. 1. Construction of the negotiation game for Inspire users

To solve the negotiation game we propose an algorithm of determining the negotiation set of the game developed originally by von Neumann and Morgenstern for the bimatrix game with the utility payoffs [4]. It allows for elimination of the outcomes dominated by individual min-max options of both players from the set of all possible outcomes comprising the game. The elimination prevents from suggesting a mutual agreement which payoffs are worse for one or both the parties that they could assure playing the game non-cooperatively.

[3] The subset of the original dataset consisting of data describing the experiments conducted by negotiators of the same psychological profiles as those of the supported ones.

To compare the alternatives presented as vectors of value distribution we will use stochastic dominance. We propose to apply the Zaraś and Martel model for constructing the global relation of preference [11; 12] which operates with multiple-attribute stochastic dominance. Furthermore, it operates with different types of stochastic dominance which allows finding relation of preference for decision makers with different risk attitudes[4].

We will combine these two procedures to solve the negotiation game, which allows to determine the mix of efficient negotiation strategies. Having identified the efficient mix (or mixes) of strategies the mediator knows the most appropriate way for both negotiators which should suggest to the parties to apply during the negotiation process in order to assure its efficient outcomes.

3. PROCEDURE FOR DETERMINING AN EFFICIENT MIX OF NEGOTIATION STRATEGIES

Let us denote:

A, B – the negotiating parties (negotiator A and negotiator B),

s_A – the negotiation strategy applied by the negotiator A, where $s_A \in S_A$ and S_A is a set of the feasible strategies of the negotiator A ($s_B \in S_B$ is defined similarly for the negotiator B),

$o_A(s_A, s_B)$ – the vector of outcomes obtained by the negotiator A using strategy s_A while the negotiator B is using the strategy s_B, where $o_A(s_A, s_B) \in O_{s_A}$ and O_{s_A} is a set of feasible outcomes for the negotiator A while using the negotiation strategy s_A ($O_{s_A} \in O_A$), ($o_B(s_A, s_B)$ is defined similarly for the negotiator B).

The procedure for solving a two-person negotiation game to find the efficient mix of negotiation strategies for both negotiators can be represented as follows:

1. Determine the worst outcomes $\breve{o}_A(s_A)$ for each game strategy s_A of the negotiator A:

$$\breve{o}_A(s_A) = \Big\{ \breve{o}_A(s_A, s_B) \in O_{s_A} : \underset{s_B \in S_B}{\forall} \; \underset{o_A(s_A, s_B) \in O_{s_A}}{\neg\exists} \; \breve{o}_A(s_A, s_B) \, \mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(A)}} \, o_A(s_A, s_B) \wedge \wedge \underset{o_A(s_A, s_B) \in O_{s_A}}{\exists} \; o_A(s_A, s_B) \, \mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(A)}} \, \breve{o}_A(s_A, s_B) \Big\} \quad (1)$$

[4] Risk attitude of Inspire users can be inferred from the pre-negotiation questionnaires.

where:

O_{s_A} – set of feasible outcomes for the negotiator A when he or she uses the strategy s_A, (O_{s_B} is defined analogously for the negotiator B),

$\mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(A)}}$ – is a relation of preference in the sense of Zaraś and Martel, determined by means of multi-attribute stochastic dominance with weights of the attributes and the concordance threshold assumed by the negotiator A ($\mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(B)}}$ is defined analogously for the negotiator B).

The outcomes $\breve{o}_A(s_A)$ for all strategies of the negotiator A constitute the set $\breve{O}_A$ of the worst outcomes for this negotiator.

2. Determine the worst outcomes $\breve{o}_B(s_B)$ for each game strategy s_B of the negotiator B:

$$\breve{o}_B(s_B) = \left\{ \breve{o}_B(s_A, s_B) \in O_{s_B} : \underset{s_A \in S_A}{\forall} \ \underset{o_B(s_A, s_B) \in O_{s_B}}{\neg\exists} \ \breve{o}_B(s_A, s_B)\, \mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(B)}}\, o_B(s_A, s_B) \wedge \right. \\ \left. \wedge \underset{o_B(s_A, s_B) \in O_{s_B}}{\exists} \ o_B(s_A, s_B)\, \mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(B)}}\, \breve{o}_B(s_A, s_B) \right\} \tag{2}$$

The outcomes $\breve{o}_B(s_B)$ for all strategies of the negotiator B constitute the set $\breve{O}_B$ of the worst outcomes for this negotiator.

3. Identify the best outcomes out of the worst ones from the sets $\breve{O}_A$ i $\breve{O}_B$ of both negotiators such that:

$$\tilde{o}_A = \left\{ \breve{o}_A^*(s_A) \in \breve{O}_A : \underset{\breve{o}_A(s_A) \in \breve{O}_A}{\neg\exists} \ \breve{o}_A(s_A)\, \mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(A)}}\, \breve{o}_A^*(s_A) \right\} \tag{3}$$

$$\tilde{o}_B = \left\{ \breve{o}_B^*(s_B) \in \breve{O}_B : \underset{\breve{o}_B(s_B) \in \breve{O}_B}{\neg\exists} \ \breve{o}_B(s_B)\, \mathrm{SD}_{\mathrm{ZM}}^{\mathrm{p(B)}}\, \breve{o}_B^*(s_B) \right\} \tag{4}$$

where $\tilde{o}_A$ and $\tilde{o}_B$ are the equivalents of min-max solutions defined by von Neumann and Morgenstern.

4. Eliminate all the outcomes from the set of feasible outcomes that are worse than min-max solutions for each negotiator separately. Thus the sets of acceptable outcomes $\tilde{O}_A$ and $\tilde{O}_B$ for both negotiators are created:

$$\widetilde{O}_A = \{o_A(s_A, s_B) : \widetilde{o}_A \neg\mathrm{SD}^{\mathrm{p(A)}}_{\mathrm{ZM}}\ o_A(s_A, s_B)\} \tag{5}$$

$$\widetilde{O}_B = \{o_B(s_A, s_B) : \widetilde{o}_B \neg\mathrm{SD}^{\mathrm{p(B)}}_{\mathrm{ZM}}\ o_B(s_A, s_B)\} \tag{6}$$

5. Determine the set of acceptable outcomes consisting of outcomes accepted by both negotiators simultaneously:

$$\widetilde{O} = \left\{\left(o_A(s_A, s_B), o_B(s_A, s_B)\right) : o_A(s_A, s_B) \in \widetilde{O}_A \wedge o_B(s_A, s_B) \in \widetilde{O}_B\right\} \tag{7}$$

6. Find the non-dominated outcomes in the set $\widetilde{O}$ with respect to the attributes of both negotiators simultaneously:

$$\begin{aligned}\left(o_A^*, o_B^*\right) = \Big\{\left(o_A^*(s_A, s_B), o_B^*(s_A, s_B)\right) \in \widetilde{O} :\\ : \underset{\left(o_A(s_A,s_B), o_B(s_A,s_B)\right) \in \widetilde{O}}{\neg\exists} \left(o_A(s_A, s_B), o_B(s_A, s_B)\right) \mathrm{SD}^{\mathrm{p(A,B)}}_{\mathrm{ZM}} \left(o_A^*(s_A, s_B), o_B^*(s_A, s_B)\right)\Big\}\end{aligned} \tag{8}$$

where:

$\mathrm{SD}^{\mathrm{p(A,B)}}_{\mathrm{ZM}}$ – is a relation of preference in the sense of Zaraś and Martel, with weights of the attributes and the concordance threshold recalculated with respect to the ones assumed by negotiators *A* and *B*.

The non-dominated outcomes, considered as the solutions of the game, are related to the specific alternatives representing the mixes of game strategies. These mixes correspond to the efficient mixes of negotiation strategies which can be suggested to the supported negotiators.

4. EXAMPLE

We now apply the procedure proposed in Section 3 to the process of determining an efficient mix of negotiation strategies for Inspire users. We assume that the mediator has already identified the psychological profiles of the parties and selected the subset of data to be used in construction of the matrix of payoffs for the negotiation game. We assume further that she or he agreed with the parties on the criteria they will use to evaluate the negotiation outcomes, which are perceived by both parties multi-attributively. These criteria are:

– utility of the agreement (o^1), of importance (weight) equal to 0.5,
– control held over the negotiation process (o^2), weight: 0.3,
– satisfaction from their own performance (o^3), weight: 0.2.

For simplification, the mediator will consider only four different feasible negotiation strategies defined as the four different ways the negotiators can choose on the honesty platform (see Inspire's negotiation strategy definition – section 1)[5]. We number the strategies; thus "1" means strategy of being extremely honest, "2" – honest, "3" – indifferent (neither honest nor dishonest) and "4" – dishonest. The number of records in Inspire's dataset that we will use to describe the distributions of payoffs for different mixes of strategies is given in Table 1.

Table 1

Number of records for the mixes of strategies

		Buyer			
		1	2	3	4
Seller	1	25	29	20	4
	2	25	70	42	21
	3	13	48	39	17
	4	5	11	20	12

Since the matrix of payoffs consists of vectors of value distributions it can not be presented in the traditional game-theoretic way. We will describe it symbolically as the set of alternatives representing the outcomes for each mix of strategies (Table 2).

Table 2

Symbolic representation of the matrix of payoffs

		Buyer			
		1	2	3	4
Seller	1	alternative 1	alternative 2	alternative 3	alternative 4
	2	alternative 5	alternative 6	alternative 7	alternative 8
	3	alternative 9	alternative 10	alternative 11	alternative 12
	4	alternative 13	alternative 14	alternative 15	alternative 16

[5] Originally there were five different possible ways to choose by Inspire users on this platform, but the dataset we use in the analysis consisted of too few observations to construct a matrix of dimensions 5 x 5. Therefore we decided to merge strategies number 4 and 5 into a single strategy.

To find the efficient negotiation strategies for both negotiators the mediator starts the procedure (see Section 3):

1. Determine the worst outcomes $\breve{o}_A(s_A)$ for each game strategy s_A of the negotiator A (seller):

The mediator has to analyse all the alternatives for each feasible strategy of the negotiator A and find the worst ones (giving the worst payoffs for criteria defined by the negotiator A) for each of them. First he analyses the strategy number 1. According to the procedures within the Zaraś and Martel model, he needs to identify the global relation of preferences by determining the stochastic dominances between the alternatives 1, 2, 3 and 4 for every single criterion separately. The results of this procedure are shown in Table 3.

Table 3

Single-attribute stochastic dominances for alternatives constituting the seller's strategy number 1

Attribute 1 – utility				
	alternative 1	alternative 2	alternative 3	alternative 4
alternative 1		TISD2	SSD	SISD
alternative 2	SSD		SSD	SISD
alternative 3				
alternative 4			SSD	
Attribute 2 – control				
	alternative 1	alternative 2	alternative 3	alternative 4
alternative 1		SISD	FSD	SISD
alternative 2	TSD		FSD	SSD
alternative 3				
alternative 4			TSD	
Attribute 3 – satisfaction				
	alternative 1	alternative 2	alternative 3	alternative 4
alternative 1		SISD	SISD	SISD
alternative 2	TSD		FSD	FSD
alternative 3				FSD
alternative 4				

Next, he needs to calculate the explicable (CE) and non-explicable (CN) concordance rates assuming that the seller is risk-averse (see Table 4).

Table 4

Explicable (CE) and non-explicable (CN) concordance rates

Alternatives	1	2	3	4
1 CE 1 CN		0 1	0.8 0.2	0 1
2 CE 2 CN	1 0		1 0	0.5 0.5
3 CE 3 CN	0 0	0 0		0.2 0
4 CE 4 CN	0 0	0 0	0.8 0	

The mediator wants to find an alternative represented by the worst outcome for the highest possible concordance threshold *p*. Thus he first determines the global relation of preferences for $p = 1$, taking into account the first order, the second order and the third order stochastic dominance only. The relation of preferences is given graphically on Figure 2.

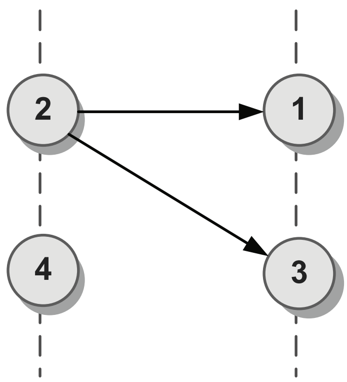

Fig. 2. Relation of preferences for $p = 1$

There are two worst alternatives for the strategy number 1 of negotiator *A*. Since the sum of the explicable and non-explicable concordance rates calculated for the alternative 1 over the alternative 3 is equal to 1, the mediator can explain the relation between these alternatives directly with the negotiator *A*. If the negotiator considers the alternative 1 better than 3, the latter would be chosen as the worst one. The mediator can also lower the concordance threshold *p*, if he wants to distinguish a single alternative as the worst one. For the level $p = 0.8$ the alternative 1 dominates the alternative 3 (see Table 4), thus the latter can be considered the worst of all for the strategy number 1. We assume that the mediator considers both alternatives 1 and 3 as equally bad, thus: $\breve{o}_A(1) = \{o_A(1,1), o_A(1,3)\}$. A similar analysis must be provided for all the remaining strategies of the negotiator *A*. We obtain then:

- for strategy number 2: alternative 7 $\left(\breve{o}_A(2) = o_A(2,3)\right)$,
- for strategy number 3: alternatives 11 and 12 $\left(\breve{o}_A(3) = \{o_A(3,3), o_A(3,4)\}\right)$,
- for strategy number 4: alternative 15 $\left(\breve{o}_A(4) = o_A(4,3)\right)$.

2. Determine the worst outcomes $\breve{o}_B(s_B)$ for each game strategy s_B of the negotiator *B* (buyer):

The mediator finds the alternatives that give the worst outcomes (evaluated by criteria defined by the negotiator *B*) for every feasible strategy of the negotiator *B*. He conducts the same procedure as in step 1 and obtains:

- for strategy number 1: alternatives 9 and 13 $\left(\breve{o}_B(1) = \{o_B(3,1), {}_B(4,1)\}\right)$,
- for strategy number 2: alternative 10 $\left(\breve{o}_B(2) = o_B(3,2)\right)$.
- for strategy number 3: alternative 11 $\left(\breve{o}_B(3) = o_B(3,3)\right)$,
- for strategy number 4: alternative 16 $\left(\breve{o}_B(4) = o_B(4,4)\right)$.

3. Identify the best outcomes out of the worst in sets $\breve{O}_A$ i $\breve{O}_B$ of both negotiators:

The mediator needs to find the best alternative (giving the best outcomes) out of the six alternatives $\breve{o}_A(s_A)$, defined in step 1 as the worst for each strategy of the negotiator *A*, that constitute the set $\breve{O}_A$. He determines the global relation of preferences for different concordance thresholds *p*, looking for the most satisfying order[6]. The mediator obtains the results shown in Table 5.

---

[6] As the most satisfying order we will consider the one with the highest possible value of concordance threshold *p* that allows to find a single alternative at the first level of hierarchy or giving the fewest alternatives at the first level of hierarchy.

Table 5

Relations of preferences for different concordance thresholds (negotiator *A*)

Concordance threshold	Order of alternatives – levels of preferences				
	1	2	3	4	5
1	1, 3, 11, 12	7, 15			
1 + CN	1	7	3, 11	12	15

For $p = 1 + \text{CN}$ the mediator obtains $\tilde{o}_A = \breve{o}_A(1) = o_A(1,1)$. Thus the alternative 1 is the best out of the worst ones for the negotiator *A* (the equivalent of min-max option). The $\tilde{o}_B$, corresponding to the best alternative out of the worst ones of the negotiator *B* is determined in a similar way. The global relation of preferences for the alternatives from the set $\breve{O}_B$ is shown in Table 6.

Table 6

Relations of preferences for different concordance thresholds (negotiator *B*)

Concordance threshold	Order of alternatives – levels of preferences		
	1	2	3
1	9, 10, 11	13,16	
1 + CN	10	9, 11	13, 16

For $p = 1 + \text{CN}$ the mediator obtains $\tilde{o}_B = \breve{o}_B(2) = o_B(3,2)$. Thus the alternative 10 is the best out of the worst ones for the negotiator *B*.

4. Eliminate all the outcomes from the set of feasible outcomes that are worse than min-max solutions of each negotiator separately.

The mediator needs to order all the alternatives constituting the game to find the worse ones than min-max options $\tilde{o}_A$ and $\tilde{o}_B$ of both negotiators. First he analyzes the outcomes of the negotiator *A*. For the concordance threshold $p = 0.8 + \text{CN}$[7] he finds ten different alternatives dominated by $\tilde{o}_A$, shown in Table 7 (shaded).

[7] In determining the global relation of preferences we consider the concordance threshold to be acceptable as long as it is greater than 0.5, which means that more than 50% of all criteria were taken into consideration in determining the relations of preferences.

Table 7

Alternatives dominated by $\widetilde{o}_A$

		Buyer			
		1	2	3	4
Seller	1	alternative 1	alternative 2	alternative 3	alternative 4
	2	alternative 5	alternative 6	alternative 7	alternative 8
	3	alternative 9	alternative 10	alternative 11	alternative 12
	4	alternative 13	alternative 14	alternative 15	alternative 16

The sets of acceptable outcomes:

$$\widetilde{O}_A = \{o_A(1,1); o_A(1,2); o_A(1,4); o_A(2,1); o_A(3,1); o_A(4,2)\}.$$

Next, the mediator analyses the outcomes for the negotiator *B*. For the concordance threshold $p = 0.8 + \text{CN}$ he finds seven different alternatives dominated by $\widetilde{o}_B$, shown in Table 8 (shaded).

Table 8

Alternatives dominated by $\widetilde{o}_B$

		Buyer			
		1	2	3	4
Seller	1	alternative 1	alternative 2	alternative 3	alternative 4
	2	alternative 5	alternative 6	alternative 7	alternative 8
	3	alternative 9	alternative 10	alternative 11	alternative 12
	4	alternative 13	alternative 14	alternative 15	alternative 16

The sets of acceptable outcomes:

$$\widetilde{O}_B = \{o_B(1,1); o_B(1,2); o_B(1,4); o_B(2,1); o_B(2,2); o_B(2,3);$$
$$o_B(2,4); o_B(3,2); o_B(4,2)\}.$$

5. Determine the set of acceptable outcomes consisting of outcomes accepted by both negotiators simultaneously.

The set $\widetilde{O}$ of outcomes accepted by both negotiators simultaneously can be derived from the alternatives which are accepted by the parties individually. If the outcomes of one particular alternative are accepted by the negotiator *A* (that is, they belong to the set $\widetilde{O}_A$) and by the negotiator *B* (that is, they belong to the set $\widetilde{O}_B$), they comprise the outcome accepted simultaneously that comprise the set $\widetilde{O}$. The alternatives whose outcomes belong to the set $\widetilde{O}$ are shown in Table 9 (shaded).

Table 9

Alternatives outside the set $\widetilde{O}$

		Buyer			
		1	2	3	4
Seller	1	alternative 1	alternative 2	alternative 3	alternative 4
	2	alternative 5	alternative 6	alternative 7	alternative 8
	3	alternative 9	alternative 10	alternative 11	alternative 12
	4	alternative 13	alternative 14	alternative 15	alternative 16

6. Find the non-dominated outcomes in the set $\widetilde{O}$ with respect to the attributes of both negotiators simultaneously:

The mediator must now find the global relation of preferences for the five alternatives comprising the set $\widetilde{O}$. He analyses the outcomes of both negotiators simultaneously, thus he needs to change weights of all the attributes whose sum must be equal to 1. We assume that the mediator wants to act fairly, thus he decides to divide the initial weights specified by both negotiators by 2. Due to that the criteria of each negotiator will have an equal share in the sum of 1 (both of 0.5).

According to Zaraś and Martel model the mediator needs now to determine the stochastic dominance between the alternatives for every single criterion separately. The results are given in Table 10.

Table 10

Single-attribute stochastic dominances for alternatives from the set $\widetilde{O}$

Attribute 1 – utility of negotiator *A*						Attribute 2 – control of negotiator *A*					
alternative	1	2	4	5	14	alternative	1	2	4	5	14
1		TISD2	SISD		TISD2	1		SISD	SISD		
2	SSD		SISD	TSD	TSD	2	TSD		SSD		
4						4					
5	SSD	SISD	SISD		SISD	5	FSD	FSD	FSD		FSD
14	SSD	SISD	SISD			14	SSD	FSD	SSD		

Attribute 3 – satisfaction of negotiator *A*						Attribute 4 – utility of negotiator *B*					
alternative	1	2	4	5	14	alternative	1	2	4	5	14
1		SISD	SISD			1				SSD	SISD
2	TSD		FSD			2	TISD2			SSD	SISD
4						4	SSD	SSD		SSD	SISD
5	FSD	SISD	FSD		SISD	5	TISD2				SISD
14	SSD	SISD	FSD			14				TSD	
Attribute 5 – control of negotiator *B*						Attribute 6 – satisfaction of negotiator *B*					
alternative	1	2	4	5	14	alternative	1	2	4	5	14
1		FSD	FSD	SSD	FSD	1				SISD	FSD
2				SSD	FSD	2	TISD1			SISD	FSD
4		TSD		SSD	FSD	4	FSD	SSD		FSD	FSD
5		TISD2			SISD	5					SSD
14						14					

Having analysed the single-attribute dominances, the mediator, using the weights of the attributes, calculates the explicable (CE) and non-explicable (CN) concordance rates (Table 11).

Table 11

Explicable (CE) and non-explicable (CN) concordance rates

Alternative	1	2	4	5	14
1 CE		0.15	0.15	0.4	0.25
1 CN		0.5	0.5	0.1	0.25
2 CE	0.5		0.25	0.65	0.5
2 CN	0.35		0.25	0.2	0.35
4 CE	0.35	0.5		0.5	0.25
4 CN	0.5	0.25		0.25	0.5
5 CE	0.5	0.15	0.25		0.25
5 CN	0.1	0.2	0.25		0.5
14 CE	0.5	0.15	0.25	0.25	
14 CN	0.25	0.35	0.5	0.5	

Based on these concordance rates the mediator affirms that all the alternatives from the set $\widetilde{O}$ are equally good for the parties for the threshold $p = 1$ (there is no alternative that dominates another one). But the mediator can determine the most satisfying global relation of preferences by lowering the concordance threshold to the value of 0.75 and analysing the non-explicable concordance rates. In that case she or he obtains the relation of preferences as shown in Figure 3.

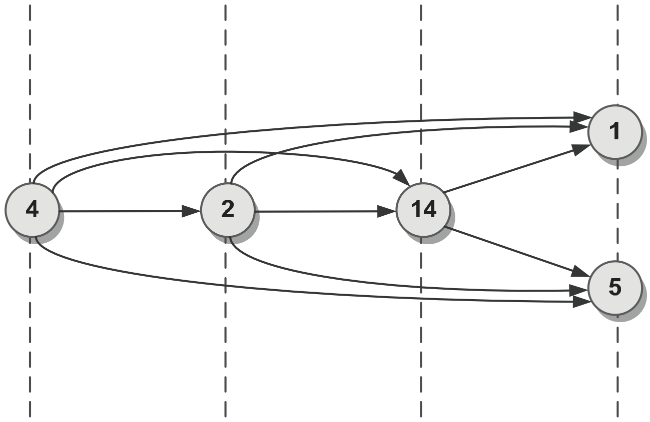

Fig. 3. Global relation of preferences for alternatives from the set $\widetilde{O}$ (p = 0.75 + CN)

Since we have determined the alternative 4 to be the most preferable (the best), we obtain $\left(o_A^*, o_B^*\right) = \left(o_A^*(s_A, s_B), o_B^*(s_A, s_B)\right) = \left(o_A^*(1,4), o_B^*(1,4)\right)$. Hence an efficient mix of negotiation strategies for both parties is $(s_A, s_B) = (1, 4)$. It is the strategy number 1 for the seller (negotiator *A*), which recommends acting in a very honest way, and the strategy number 4 for the buyer (negotiator *B*) – acting in a dishonest way.

Knowing the efficient strategies for the negotiating parties, the mediator has to convince them, using some method of persuasion, to apply such strategies, since they assure the most satisfying and efficient outcomes for both parties.

CONCLUSIONS

From the recent behavioral research and studies we concluded that the strategies applied by the negotiators during the negotiation process are the key factors (along with the negotiation context and negotiators' psychological profiles) determining the outcomes achieved by the parties. Therefore in the paper we proposed the concept of supporting mediator helping with the selection of the negotiation strategies for parties negotiating by means of an e-negotiation system. We suggested a symmetric-prescriptive approach for solving such decision problem. The two-person negotiation game, whose strategies correspond to the feasible negotiation strategies, was constructed. To solve the game we applied the Von Neumann and Morgenstern procedure for determining the negotiation set of the game. It allows for reducing the number of feasible solutions to the individually non-dominated ones. Although the game theory requires the decision problem to be simplified, such a structured problem can be easily implemented as a software module in a negotiation support system.

Since the game payoffs are defined as vectors of value distributions, to compare all feasible alternatives we apply the Zaraś and Martel model for determining the global relation of preferences based on multi-attribute stochastic dominance. It allows for construction of the relation of preferences for decision makers (negotiators) with different risk attitude. By combining these two procedures we obtain the game solution which is a mix of efficient negotiation strategies. The mediator knows then how the parties should act to achieve the efficient outcomes for both and a mutually most satisfying agreement.

REFERENCES

1. Adair W.L., Brett J.M.: Culture and Negotiation Processes. In: Negotiation and Culture: Integrative Approaches to Theory and Research. Eds. M.J. Gelfand & J.M. Brett. Stanford University Press, Stanford, CA 2002. DRRC Working Paper No 256.
2. Cai A.D, Wilson S.R., Drake L.E.: Culture in the Context of Intercultural Negotiation. Individualism-Collectivism and Paths to Integrative Agreements. "Human Communcation Research" 2000, Vol. 26, No 4, pp. 591-617.
3. Kersten G.E., Köszegi S., Vetschera R.: The Effects of Culture in Anonymous Negotiations: Experiment in Four Countries. INR01/02.
4. Luce R.D., Raiffa H.: Games and Decisions. Introduction and Critical Survey. John Wiley & Sons, New York 1958.
5. Madanmohan T.R., Kersten G.E., Noronha S.J., Kersten M.J., Cray D.: Learning Negotiations with Web-Based Systems. INR 06/99.
6. Mastenbroek W.: Negotiate. Basil Blackwell, Oxford 1989.
7. Pruitt D., Rubin J.Z.: Strategic Choice. In: Negotiation. Eds. R.J. Lewicki, D.M. Saunders, J.W. Minton. Irwin/McGraw-Hill, Boston 1999.
8. Savage G.T., Blair J.D., Sorenson R.L.: Consider Both Relationship and Substance When Negotiating Strategically. In: Negotiation. Eds. R.J. Lewicki, D.M. Saunders, J.W. Minton. Irwin/McGraw-Hill, Boston 1999.

9. Thatcher S., Karen A., Chadwick C.: What Makes A Difference? The Impact of Individual Demographic Differences, Group Diversity, and Conflict on Individual Performance. Presented at the Academy of Management annual meetings, San Diego, CA, August 1998.
10. Wachowicz T.: Model wspomagania mediatora w negocjacjach dwustronnych – część I. „Badania Operacyjne i Decyzje" 2004, 3/4 (extended English abstract).
11. Zaraś K., Martel J.M.: Multiattribute Analysis Based on Stochastic Dominance. In: Models and Experiments In Risk and Rationality. Kluwer Academic Publishers, 1994, pp. 225-248.
12. Zaraś K.: Dominances stochastiques pour deux classes de functions d'utilité: concaves et convexes. RAIRO: Recherche Operationnelle 1989, 23, pp. 57-65.