Group Decis Negot (2016) 25:1097–1136
DOI 10.1007/s10726-016-9475-9

The MARS Approach in the Verbal and Holistic Evaluation of the Negotiation Template

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Published online: 30 March 2016

Abstract The negotiation template, which defines a set of potential negotiation offers, is traditionally evaluated by means of the simple additive weighting method (SAW). However, some recent research reports on the potential problems and inconsistencies in using and interpreting SAW-based scores. Thus, in this paper we consider the issue of evaluating negotiation offers when the negotiator's preferences are expressed verbally. We present a new approach called Measuring Attractiveness near Reference Situations (MARS), which combines the algorithms of two multiple criteria decision making methods: ZAPROS and MACBETH. Applying the elements of ZAPROS allows identifying a small set of reference alternatives that consists of the best resolution levels for all the negotiation issues but one. In pair-wise comparisons of these alternatives negotiators need to evaluate trade-offs only, which means deciding which concessions are better to be made. Using the elements of MACBETH allows determining the strong interval scale based on verbal judgments defined by negotiators at the beginning of the preference elicitation process. We study in detail the legitimacy of hybridizing ZAPROS and MACBETH that differ in their philosophies of decision

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support as well as discuss the drawbacks of these two MCDM methods and propose some alternative solutions that make this approach applicable to supporting negotiators in the evaluation of negotiation offers. Finally, we present an example in which we indicate the differences in the negotiation offers' scoring process conducted by means of MARS and the traditional ZAPROS and MACBETH procedures.

Keywords Pre-negotiation preparation · Negotiation offer scoring system · Preference analysis · Verbal decision making · Holistic judgements · ZAPROS · MACBETH

1 Introduction

Negotiation is a decision making process, in which two or more parties talk with one another in effort to resolve their opposing interests (Thompson 2015). Its complexity results from a variety of elements that need to be taken into consideration simultaneously by the parties while solving their problems: behavioral ones—related to psychological issues such as subjective needs, desires and emotions of parties, demographical influences, trust and reputation or the future relationship; and formal ones—related to economic profitability of contracts, rational analysis of offers, measuring utility of compromises and their efficiency. To make the negotiation process easier the theory of negotiations recommend negotiators a thorough preparing and planning performed prior to the forthcoming talks, *i.e.*, during a pre-negotiation phase (Stein 1989; Zartman 1989). Various approaches, scenarios and techniques for negotiation preparation are proposed in the negotiation literature. One of the products of such a pre-negotiation preparation is a negotiation template, designed and evaluated by means of the negotiation offer scoring system (Raiffa et al. 2002). It describes the structure of the negotiation problem and is defined by a list of negotiation issues and feasible options of these issues. Being scored, it allows measuring the quality/profitability of the offers exchanged by parties and deciding on their acceptance and rejection using the economic basis. The scoring system may also be used at later stages of the negotiation process, for measuring the scale of concessions made by the parties; analyzing and visualizing the negotiation progress; searching for improvements in the contract negotiated by the parties (*e.g.*, by identifying the dominant solutions in a feasible negotiation space) or determining the arbitration (fair) solution of the negotiation problem (Raiffa 1982; Young 1991).

The problem of evaluating the negotiation template from an individual negotiator's viewpoint is similar to a decision making problem with multiple criteria involved. Therefore, a multiple criteria decision making (MCDM) approach (Figuera et al. 2005; Yoon and Hwang 1995) is recommended to determine such a negotiation offer scoring system. Mostly the scoring system is determined by means of the simple additive weighting (SAW) method (Keeney and Raiffa 1976), as in many popular negotiation support systems, such as, for instance, Inspire (Kersten and Noronha 1999), Negoist (Schoop et al. 2003) or SmartSettle (Thiessen and Soberg 2003). There are a few alternative techniques developed, such as the one based on AHP (Saaty 1980), which is applied in Web-HIPRE system (Mustajoki and Hamalainen 2000), where negotiators use a nine-point verbal scale and pair-wise comparisons of the elements of the negotiation template. Its application, however, is limited to support the discrete negotiation problems only. Recently, the TOPSIS method (Hwang and Yoon 1981) has also been proposed to evaluate the negotiation template (Roszkowska and Wachowicz 2015a; Wachowicz and Błaszczyk 2013). However, since TOPSIS applies the notion of distance measuring to evaluate the attractiveness of alternatives, the possibilities of defining individual preferences by negotiators are severely limited. Additionally, the recently published results of the experimental research in the field of the use and usefulness of the formal, usually SAW-based negotiation offer scoring systems (Roszkowska and Wachowicz 2014b, 2015b; Wachowicz and Wu 2010) reveal many problems negotiators or decision makers (DMs) face while using such a scoring system, which leads to misinterpretations of the results and negotiating worse contracts. Therefore, it seems vital to develop alternative methods for supporting negotiators in their tasks of designing and evaluating negotiation templates that would try to eliminate some drawbacks and limitations of the existing solutions.

In general, such a negotiation offer scoring system can be constructed using direct or indirect preference information provided by the negotiator (Figueira et al. 2009). The direct preference elicitation requires from the negotiator a clear and precise definition of all the parameters of the preference model (*e.g.*, issue weights, option rates, aspiration and reservation values, etc.), whereas the indirect preference information requires predefining selected examples of negotiation offers which are used to infer all of the parameters of the preference model and, consequently, determine the ratings of all remaining packages considered within the decision making problem. The direct preference information is used in the traditional aggregation paradigm, according to which the aggregation model is first constructed and then applied to rank the alternatives, as in, for instance, SAW, AHP or TOPSIS algorithms. Indirect preference information is used in the disaggregation (or regression) paradigm, according to which the holistic preferences on a subset of alternatives are known first, and then a consistent aggregation model is inferred from this information to be applied on the set of other alternatives, as in UTA or GRIP (Figueira et al. 2009; Siskos et al. 2005).

The goal of this paper is to develop a new approach in evaluating the negotiation template and to build a negotiation offer scoring system that meets some postulates formulated on the basis of the results of experimental works on using the SAW-based scoring systems (Roszkowska and Wachowicz 2014b, 2015b), namely: (1) avoiding the direct assignment of numerical scores to the elements of the negotiation template; (2) using verbal scales in defining the preferences by negotiators; and (3) applying the holistic definition of preferences by means of the examples of full packages instead of considering the atomic elements of the template, abstract and out of the context if not considered as the constituents of the whole contract. Therefore, the approach we propose is based on the following two MCDM methods: ZAPROS (Larichev and Moshkovich 1994) and MACBETH (Bana e Costa et al. 2005). The new approach called Measuring Attractiveness near Reference Solutions (MARS) allows eliciting the attractiveness of offers by means of a procedure that transforms verbal preferential information defined for a reference set for cardinal information spanned on the whole negotiation template. Such an approach is useful especially when the negotiation problem is poorly defined by means of qualitative issues, as well as when negotiators provide imprecise information about preferences. The MARS is based on the holistic indirect evaluation, which means that negotiators define preferences for examples of offers (full packages) and those are next decomposed to obtain a scoring system for all elements of the template. The algorithm requires negotiators to compare reference alternatives that differ from the ideal one (or the anti-ideal one) in the resolution level of one issue only. This is a typical situation that negotiators face during the negotiation process, when they need to compare and evaluate the subsequent offers describing the terms of two alternative contracts and consider, which of them is better, and if they exceed their BATNAs and meet their aspirations both defined by means of some reference alternatives. It is also worth noting that MARS approach eliminates the necessity of defining explicitly the issue weights. Thus, the authors' contribution to the negotiation analysis presented within this paper can be defined as building a new algorithm for individual decision support in negotiations, which combines some selected ideas of ZAPROS and MACBETH and allows parties to build their individual negotiation offers scoring systems using holistic and linguistic definition of preferences. It is worth noting that such a support tool is of particular interest in bilateral negotiations, where the issue of fairness and the contract balance are of special importance, and the accurate scoring systems of both parties are the prerequisite to conduct further symmetric analysis of the final compromise. However, it can also be applied to support the negotiators or decision-makers in group decision problems, but an additional procedure for aggregating the individual preferences of the parties should be applied in such a case, which is beyond the scope of this paper.

The paper is organized as follows. In Sect. 2 we discuss the issue of pre-negotiation preparation and building the negotiation template. We define the template formally and present then classic tools used for supporting negotiators in its evaluation, *i.e.*, building a negotiation offer scoring system. Next, the potential consequences of operating with such a system for further negotiation process are briefly discussed based on the example of the Inspire negotiation system (Kersten and Noronha 1999). Finally, the problems resulting from using SAW-based scoring systems indicated by experimental researches are discussed, that were the triggers to develop our own alternative approach. In Sect. 3 the fundamentals of the ZAPROS and MACBETH algorithms are presented as a reminder of the general philosophy and the approach specific to both these methods, that are late combined while designing MARS procedure. The examples of using the classic algorithm of these two methods to scoring the negotiation template are also provided. In Sect. 4 the MARS algorithm is described as well as an example of building a negotiation offers scoring system by means of MARS is provided. We conclude by summarizing the key concepts of our approach, analyzing the differences and similarities between MARS and original algorithms of ZAPROS and MACBETH procedures, considering the advantages and disadvantages of the approach we proposed and discussing the future work.

2 Pre-negotiation Preparation and Support

2.1 Negotiation Template Design and Evaluation

The pre-negotiation phase takes place prior to the actual conduct of negotiation talks. Among many functions of pre-negotiation (Zartman 1989) at least three refer to some economic aspects of the negotiation process and emphasize the pre-negotiation significance in: (1) analyzing the costs of the negotiation process in comparison to potential gains (profit); (2) elaborating the alternatives that may be used during the negotiation process as the compromise proposals; and (3) lowering the risk associated with cooperation. Some other functions refer, on the other hand, to behavioral aspects of forthcoming negotiations, such as (1) understanding the needs of all participants; (2) building the bridges from conflict to conciliation or (3) understanding the necessity of the requirement or a belief of reciprocity. One may expect then that within the pre-negotiation phase some strategic and analytical preparation work needs to be performed that will allow to build a detailed vision of the negotiation problem, the parties involved and the context and, after analyzing them, define a negotiation strategy that would allow the party to obtain the goals. Indeed, the pre-negotiation literature provides various recommendations regarding the required tasks and assignments that should be performed to result in a comprehensive and effective negotiation preparation and provide the negotiator with sufficient and adequate information to conduct the negotiation consciously in a way that enables him to achieve a satisfying agreement (Fisher et al. 2011; Peterson and Lucas 2001; Wheeler 2003; Zwier and Guernsey 2005). These various recommendations are summarized in a synthetic pre-negotiation checklist proposed by Simons and Tripp (2003). Its general scheme is presented in Fig. 1 below.

Within the checklist both behavioral elements (blocks C and D) as well as the formal ones (blocks A and B) are analyzed. The questions specified within block A aim at precise structuring and definition of the negotiation problem and eliciting negotiators' preferences, and, consequently, building a negotiation offer scoring system. Within the theory of negotiation analysis such a process is referred to as a negotiation template design and evaluation (Raiffa et al. 2002). It is worth noting that first four questions in block A describe a list of tasks typical of any multiple criteria in a decision making problem, and are similar to some parts of general algorithms for structuring individual MCDM problems, such as, for instance, PrOACT (Hammond et al. 1998) or SMART (Edwards and Barron 1994). Since in this paper we focus on decision support in negotiation, we will discuss only the first two blocks of negotiation preparation.

By defining the goal in A.1 the negotiator answers the question concerning their basic needs that the agreement is going to address. Consequently, they will identify the problem that they want to solve as well as its elements that required clarifying and taking common decisions with the counterpart(s). In this way they will specify all of the points that should be discussed and agreed—the negotiation issues. Formally, a set of issues may be denoted by $F = \{f_1, f_2, \ldots, f_n\}$, where n is a number of all issues to be discussed. The more issues the negotiator identifies, the more possibilities in making concessions, trade-offs and compensations they have during the actual conduct of negotiations. Next, the negotiator needs to think of possible settlements (options) for each issue. The set of options should consists not only of those that are most expected

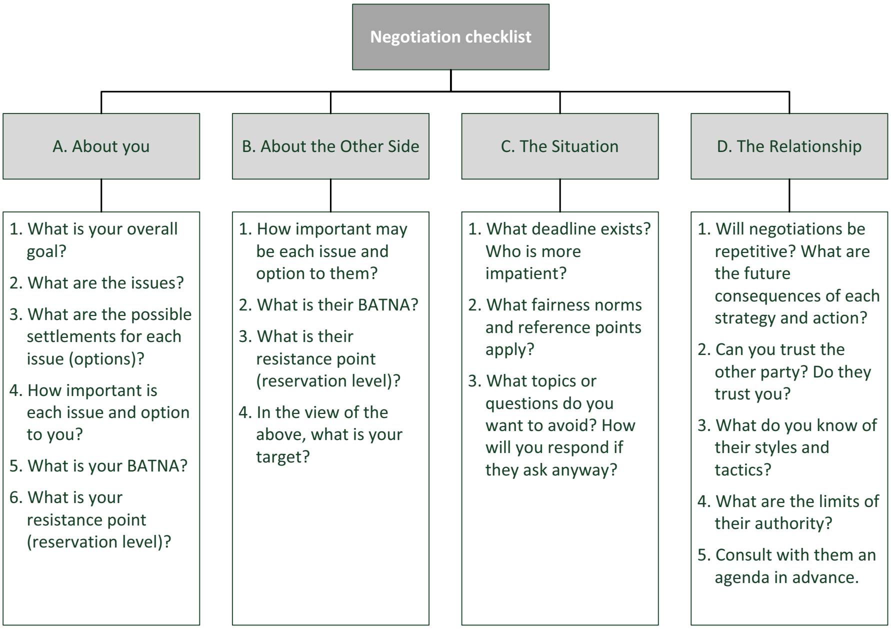


Fig. 1 The pre-negotiation preparation checklist (based on Simons and Tripp 2003)

and most valuable for the negotiator, but also of such options that may be offered by the counterpart, *i.e.*, that are usually less profitable. In other words, sets of all feasible options should be identified and that can be denoted by $X_k = \{x_k^1, x_k^2, \ldots, x_k^{m_k}\}$, where m_k denotes the number of options defined for kth issue, for $k = 1, \ldots, n$. The negotiation template, which is a detailed specification of the structure of the negotiation problem (Hammond et al. 2002), may be then represented formally by the following n+1-tuple

$$T = \{F, X_1, \ldots, X_n\}. \tag{1}$$

It should be noted that for some issues, especially those quantitative ones, it would be more convenient to define the feasible options in a form or ranges. However, to make the process of analyzing and evaluating the template easier, it is recommend to use the finite and countable sets of options (discrete template definition), and hence, the ranges should be replaced with sets of salient options (Kersten and Noronha 1999) that represent the most important values within the whole range.

Based on the template (1), it is possible to identify all feasible negotiation offers by determining the combinations (Cartesian product) of various options for each issue. Formally, the set of feasible alternatives is defined as

$$X = \prod_{k=1}^{n} X_k. \tag{2}$$

Knowing how the feasible negotiation space looks like, negotiators may now analyze the profitability of various contracts. According to question 4 in block A, they should conduct a thorough evaluation of the importance of issues and options defined within a template. This evaluation should take into account the negotiator's preferences of various settlement levels that reflect the goals defined before while answering question A.1. There is a huge variety of methods that may be used to support negotiators in defining their preferences and build the negotiation offer scoring system, however, there are the SAW-based techniques (Churchman and Ackoff 1954; Keeney and Raiffa 1976) that are commonly recommended in the literature and applied in many software negotiation support tools (Jarke et al. 1987; Kersten and Noronha 1999; Raiffa 1982; Schoop et al. 2003). Within this method it is assumed that negotiators' preferences are additive and the negotiation issues and are preferentially independent. Defining preferences within the SAW-based approach requires a direct assignment of rating points (scores, utilities or desirability values) to the elements of the negotiation template T. The whole procedure that allows building SAW-based scoring systems consists of the following three steps:

Step 1 The negotiator evaluates the relative importance of all negotiation issues by assigning the score (weight) to each of the issues such as:

$$\sum_{k=1}^{n} w_k = P, \tag{3}$$

where P is a pool of scoring points used for building the scoring system (usually $P = 100$ or $P = 1$).

Step 2 The negotiator evaluates each option $x_k^r \in X_k$ within each negotiation issue i by assigning a score $u(x_k^r)$ such as:

$$u\left(x_k^r\right) \in [0, w_k], r = 1, \ldots, |X_k|, k = 1, \ldots, n. \tag{4}$$

The most preferred (best) option receives the maximum score resulting from the issue weight w_k, while the worst—the rating equal to 0.

Step 3 The global scores of offers from X are determined as an additive aggregate of ratings of options that comprise this offer. For any offer $a_j \in X$ the score is determined by the following formula:

$$S(a_j) = \sum_{k=1}^{n} \sum_{r=1}^{|X_k|} z_k^r(a_j) \cdot u\left(x_k^r\right), \tag{5}$$

where $z_k^r(a_j)$ is a binary multiplier indicating if the rth option of the kth issue was used to build the jth offer (1) or not (0).

Thus, from the formal viewpoint, the negotiation offer scoring system is a compound of the following elements:

$$SS = \{w, U, \Omega, S\}, \tag{6}$$

where w is a vector of issue weights, $U = \{u(x_k^r)\}_{\forall k=1,\ldots,n;\forall r=1,\ldots|X_k|}$ is a set of scores of options defined in template T, Ω describes a preference aggregation mechanism, and $S = \{S(a_j)\}_{\forall j=1,\ldots,|X|}$ is a set of offers evaluation determined by means of mechanism Ω. Within SAW-based scoring systems Ω is represented by an additive function defined by formula (5). However, if other preference aggregation philosophies are used, *e.g.*, the ones deriving from the notions of outranking (Roy 1991), the aggregation mechanism may be represented by a far more complicated algorithm or procedure.

The last pre-negotiation tasks specified within block A require identifying the negotiator's BATNA, *i.e.*, Best Alternative to a Negotiated Agreement (Fisher et al. 2011), that defines their bargaining strength and may be used as a reference point in defining the aspiration and reservation levels. Those levels may be set on the option values directly, but having their scoring systems the negotiator may define them in terms of global scores. This makes the negotiator more flexible in considering the offers, since he is not required to reject the offers because of their poor performance on single issue only. The offer's global score is determined and compared with reservation score, which allows to analyze whether some poor performances are compensated by some other good settlements in other issues.

From the viewpoint of individual decision support in negotiation the tasks specified in block A are of great importance. However, by answering the questions from block B the negotiator determines, even if only vaguely, the scoring system of their counterpart, which makes the symmetric analysis of the offers and the compromise possible and allows conducting the negotiation in a more conscious, cooperative and collaborative way, paying attention to the needs of both parties and looking for a mutually satisfying and fair solution.

2.2 Using Negotiation Offer Scoring Systems in Actual Negotiation

Having completed the pre-negotiation preparation, the negotiator knows the template T and the accompanying scoring system SS. Now, during the actual conduct of negotiations, they may be used to analyze the incoming offers as well as to determine the negotiator's best responses to such offers that require the minimum possible concessions. The situation of using SS in such analyses is presented in Fig. 2, where the user interface of Inspire system (Kersten and Noronha 1999) is displayed. Here bilateral contract negotiations between an entertaining company and a musician are considered, in which the template consists of four issues and a predefined list of options amounting to 240 feasible offers. The template used in Inspire negotiation is contained in Table 1.

The situation presented in Fig. 2 illustrates an initial stage of the actual negotiation process, in which two offers were submitted at the negotiation table, one by each of the parties. They are listed in a table in the top-left part of the interface, in the section entitled "Recent history". The first offer (at the bottom of the table) was sent by the negotiator himself, called Mosico, and specifies the following contract proposal: 8 concerts, 14 songs, 2 % of royalties and \$ 125,000 as bonus. It was rated 100, which means—according to the SAW-based scoring system rules presented in Sect. 2.1—that it is the best possible solution to Mosico. Fado's counter offer (5 concerts, 14 songs,

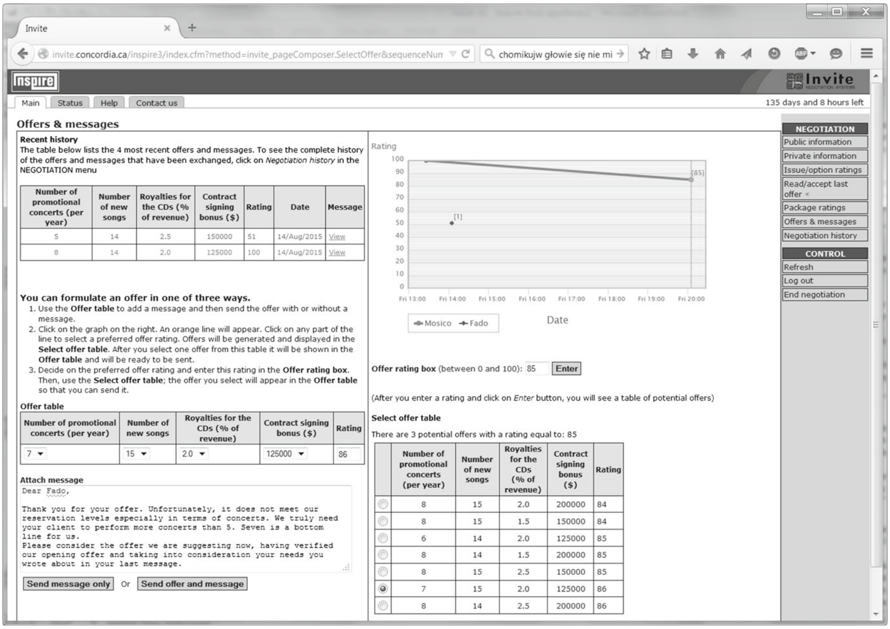


Fig. 2 An offer received and scored by means of the negotiator's individual *SS* in Inspire

Table 1 The negotiation template for bilateral negotiations in the Inspire system

Issues to negotiate	Issue options
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; $200,000
Number of promotional concerts (per year)	5; 6; 7 or 8 concerts

2.5 % of royalties and $ 150,000 USD as bonus), scored according to Mosico's *SS*, is worth 51 rating points only. The scoring system allows now to measure the gap between the opening offers of both parties (and for both parties, since Fado operates with an analogous scoring system determined based on Fado's subjective preferences). Seeing such a discrepancy between his needs and those of Fado, Mosico may now think of concessions he wants to make and evaluate them in terms of ratings (the measure used is cardinal). While building a new offer ('Offer table' section presented in Fig. 2) Mosico knows that conceding 1 concert and requiring 1 song more will 'cost' him 14 rating points. He may analogously measure the costs of other concessions made in the case of other issues and try to identify additional requirements that may compensate concessions to be made by him. For instance, Mosico knows that a similar scale of concessions (worth 15 rating points) will be attainable by keeping the options for the last three issues unchanged and conceding 2 concerts to the other party (see the third offer in the table of alternative offers in the bottom-right part of Fig. 2). Similar

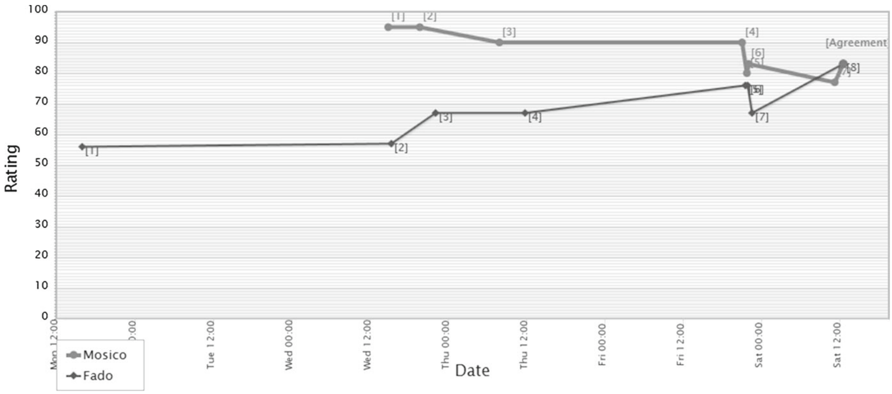


Fig. 3 Negotiation history graph in the Inspire system

analysis may be performed by the negotiators also at the later stages of the negotiation process.

It should also be noted that a scoring system may be used by negotiation software tools for some additional individual support provided to the parties. Based on the history of offers exchange during the negotiation process, it is possible to draw a negotiation history graph (see the top-right chart in Fig. 2) that shows two curves reflecting the scale and pace of concessions made by the parties over time. At each negotiation stage it shows the negotiator the scale of differences that need to be eliminated to achieve a compromise between the parties and what their endeavors in achieving the current negotiation status. It also allows identifying the moments of reverse concessions and, by analyzing the structure of the offer sent, focusing on the most competing issues. An example of full negotiation history depicted by the Inspire system for the Mosico party in a form of the negotiation history graph is presented in Fig. 3.

Analyzing the negotiation history graph the party may easily track their own (the upper broken line) as well as the counterpart's concessions (the lower broken line). For instance, Mosico sees that the offer number seven sent by his counterpart was quite a big reverse concession (of approximately 10 rating points), if compared to Fado's offers number five and six. The Fado's concession curve slumps in this negotiation round. However, he should be aware that it was probably Fado's reaction to Mosico's own reverse concession made a round earlier, where Mosico's concession curve goes up between the offers numbered five and six (Mosico offers something better for himself than he agreed to have a round before). A detailed study on the effects of using the negotiation history graph in software supported negotiation can be found in (Weber et al. 2006).

Apart from the passive support described above, the scoring system may be also used in more proactive facilitation of the negotiation process. If scoring systems of both parties are known to any third party such as a mediator or an arbitrator or to a negotiation support system, they can be applied in analyzing the efficiency of the negotiation compromise and measuring its fairness by means of selected notion of arbitration solution (see Kalai and Smorodinsky 1975; Nash 1950; Raiffa 1953). The latter is of great importance for the collaborative aspects of the negotiation process, since it provides a clear evidence that the needs, aspiration and reservation levels of both parties were taken into account mutually and processed adequately to find the satisfying and balanced solution. Naturally, the key factor in reliable and fair symmetric support of both the parties is their truthfulness in revealing their preferences and providing the third party with an authentic scoring system. It is, however, the issue of ethics and reputation related to the behavioral aspects of negotiations and goes beyond the scope of this paper.

2.3 Problems with Using Classic SAW-Based Scoring Systems in Negotiation

Despite the fact that SAW seems to be technically simple, some experimental research on electronic negotiations and multiple criteria decision making reveals various problems with correct and adequate usage of the SAW-based negotiation support tools. One of such problems is an interpretation of the cardinal utility scores obtained by means of the SAW-based scoring procedure. In one of the experiments conducted by means of the Inspire system, the participants were asked about the meaning of the scores they assign to the issues and options and interpreting the score differences between various offers (Wachowicz and Kersten 2009; Wachowicz and Wu 2010). Surprisingly only 4 % of the participants were aware of cardinal interpretation of scores and when asked to compare the differences between four exemplary offers exchanged in two negotiation rounds by both parties, they tended to use rather a linguistic evaluation (*e.g.*, 'the difference is not significant', 'this concession is rather big', etc.) and did not refer to the interval scale interpretation that could be used to measure the scale of concessions precisely. Such a vague, qualitative and imprecise evaluation of offer values was confirmed in another in-class decision making experiment, in which the decision makers were selecting a flat to rent and to be shared with a flat mate (Roszkowska and Wachowicz 2014a). The decision makers were asked to evaluate four predefined rental offers obtained from the market in a synthetic way that presents their preferences of the offers best. They had a free choice of the way in which their preferences were expressed, no examples of such a preference definition were provided. It turned out that 57 % of the participants described their preferences in a non-numeric way, using a verbal description (full sentences) or chosen linguistic scales. Another 21 % of respondents used the ordinal scale (*i.e.*, defined a complete order of alternatives by means of numbers) and only 16 % of them operated with a stronger interval scale describing their preferences mostly by means of a 0–100 rating scale. The participants were asked later to define the reference points for all of the attributes (the evaluation criteria) of that case and which could be used as boundaries of the feasible decision space and the formulation of the extreme, *i.e.*, ideal and anti-ideal packages were used mostly with vague and imprecise definitions (*e.g.*, 'the worst price is the one at the unacceptable level, around 2,000 PLN', 'the best option for number of rooms is the one in which all flat mates feel comfortable'), and avoided declaring clearly a specific resolution level for each issue. Thus we see that the imprecise and linguistic definition of preferences is common and considered by the majority of the DMs as a natural and intuitive way of the evaluation of both decomposed elements of a negotiation/decision making problem and the full packages/alternatives.

Another problem with using SAW-based scores was observed by Wachowicz et al. (2015). Within a series of experiments the authors attempted to find out whether negotiators were able to map the preferential information described in the negotiation case verbally and visualized graphically, into a coherent system of scores required by the SAW mechanism. It appeared that negotiators find it difficult to assign scores to the elements of the negotiation template accurately according to the preferential information. Their individual SAW-based scoring systems were on average very distant (a special distance measure was introduced to measure the scale of their inaccuracy) from the reference one that might have been determined by accurate mapping of the graphical preference information into the numerical equivalents. The accuracy varied depending on the preference visualization technique used, however, the differences were not significant. It is worth noting that the most evident mistakes in assigning scores were made at the first stage of the negotiation offers scoring system preparation, *i.e.*, during the issue rating phase. This resulted in bigger mistakes in the next step of SAW-based template evaluation, *i.e.*, during the option rating, and, consequently, in more inaccurate scoring systems in general. The further investigation of the impact of inaccurate scoring systems on the negotiation results proved that negotiators that operated with more inaccurate scoring systems had a false perception of the negotiation process and their performance. They were convinced that compromises they had achieved were good, while the true ratings of their contracts (obtained by scoring them with an accurate reference scoring system) were significantly lower than their expectations (based on the ratings determined by means of their individual scoring systems).

Another in-class experiment showed that negotiators are inconsistent in evaluating and choosing some predefined SAW-based rankings of offers that fit their preferences (Roszkowska and Wachowicz 2014b). In this research the participants were asked to perform the pre-negotiation preparation in bilateral negotiations, in which the template was defined by means of three issues only. The feasible negotiation space was limited to the set of sixteen exemplary negotiation offers. The negotiators were asked to build the ranking of these offers according to their individual preferences they could define freely after reading the negotiation case. Then they were told that such offer rankings may be generated automatically using the SAW algorithm with a predefined scoring function implemented. Only two of such alternative rankings with the SAW-based ratings were displayed to them and they had to choose the one that fitted best their individual preferences. Surprisingly, most negotiators evaluated as more useful (a better fit) a predefined ranking that was more different from their own subjectively defined one. These findings, different in nature from the previous ones, prove once again that negotiators and individual decision makers may have difficulties in using the simple additive weighting technique correctly (or SMART, if the case is discrete) while trying to build effectively the negotiation/alternative scoring systems.

We do not know the reasons for avoiding numerical scores and making mistakes in quantitative scoring of the negotiation template or the structures of decision problems. The analysis of the potential determinants of accuracy in using the SAW-based scorings systems made for the purpose of the above-mentioned research prove that the scale of misusage of SAW does not depend on some personal, sociological and psychological characteristics of decision makers/negotiators defined by their bargaining profiles. Keeney (2009) also recons that appropriates of using the quantitative evaluations does not depend on the DM's level and type of education. Maybe the reason for avoiding the cardinal utility scores, not operating with numbers and replacing them with the verbal descriptions or linguistic etiquettes may be that the former are simply inadequate measures (Keeney 2002) from the viewpoints of supported DMs. It may also be decision makers' need for cognitive simplification of decision making situations that makes them use more intuitive and subjective scales (Schwenk 1984). No matter what the final grounds are for the problems mentioned above, in view of the fact that DMs prefer operating with verbal evaluation, it seems reasonable and valid to apply the existing or develop new linguistic-based decision support tools for negotiation support. Therefore, in further sections we discuss alternative approaches that may be modified and used in the negotiation context, and develop a novel approach based on the holistic preference elicitation that aims at generating a scoring system *SS* based on the examples of comparisons of some exemplary alternatives, but still assuming the preferences may be aggregated additively (if not some other techniques should be considered such as DEMATEL (Fontela and Gabus 1976) or WINGS (Michnik 2013)). Our focus on holistic preference elicitation results from some earlier results that prove the necessity and usefulness of such an approach as an additional tool for preference verification in negotiation support provided by the Inspire system (Kersten and Noronha 1999). Apart from that, we would also like to free negotiators from the necessity of evaluating some atomic elements of the negotiation template that they may find abstract and out of the context, and in this way may change their perspective of the negotiation process, *i.e.*, make it more competing by suggesting a need for series of distributive bargaining over resolution levels of a single issue at one time only. Similar to other researchers, we believe that instead of analyzing their preferences holistically DMs will gain more insight into their own preferences and knowledge of the problem (Bous et al. 2010).

3 The ZAPROS Approach in the Evaluation of the Negotiation Template

3.1 The Verbal Decision Analysis and the ZAPROS Procedure

The methods from the ZAPROS (the abbreviation of the Russian words: Closed Procedures near Reference Situations) family (Larichev 2001; Larichev and Moshkovich 1995) are very well known within the Verbal Decision Analysis (VDA) paradigm used for solving MCDM problems. The term 'Verbal Decision Analysis' was introduced by Larichev and Moshkovich (1997), though fundamental research within this approach, based on applied mathematics, cognitive psychology, organizational behavior, and computer science, had been started much earlier, in the nineteen eighties of the twentieth century (*e.g.*, Larichev and Moshkovich 1988). The key concept of the VDA approach is to allow DMs to express their evaluations and preferences in a verbal and ordinal form (for instance, using expressions such as: 'more preferable', 'less preferable', or 'equally preferable'), which seems stable and reliable according to the results of psychological experiments. Moreover, judgments provided by DMs are checked to ensure their consistency (Ashikhmin and Furems 2005; Moshkovich and Mechitov 2013). The authors define the key concepts of VDA techniques in the following way: "use language for problem description that is natural to the decision maker, implement psychologically valid measurements and preference elicitation procedures, incorporate procedures for consistency check of decision maker's preferences, procedures should be 'transparent' to the decision maker and provide explanations of the results".

VDA was proposed for unstructured decision-making problems, which are problems with mostly qualitative parameters and no objective model for their aggregation (*e.g.*, the problems of policy making and strategic planning in different fields, as well as in personal decisions). It is especially oriented towards problems with rather large number of alternatives, while the number of criteria is usually relatively small in order to reduce the number of comparisons required (Moshkovich et al. 2005), and it takes into account peculiarities and constraints of the human information processing system. It should be used when there is a need for decision aiding which enables DMs to articulate the evaluations and preferences in a verbal form, and this linguistic, non-numerical form should not be transformed into a quantitative form in any arbitrary way. Techniques based on VDA do not use quantitative information on the importance of criteria, only verbal estimates, and no quantitative operations are made on them. Hence, all operations are clear and understandable to DMs. Methodologically, VDA is based on the same principles as multi-attribute utility theory (MAUT) but it is oriented towards using the verbal form of preference elicitation and evaluating alternatives without resorting to numbers. As in MAUT, the idea is to construct universal decision rules in the criteria space and then use them on any set of real alternatives. The basic underpinnings of VDA are demonstrated by the following three methods (one for each type of decision-making problems): ZAPROS—used for ordering alternatives (Larichev and Moshkovich 1995), ORCLASS—used for classifying alternatives (Larichev and Moshkovich 1994), and PARK—used for selecting the best alternative (Berkeley et al. 1991).

As regards the ZAPROS procedure, preference elicitation consists in comparing pairs of hypothetical alternatives differing in performance with respect to two criteria only; each alternative consists of the best evaluations for all the criteria but one. The results of these comparisons are transformed into the so-called Joint Ordinal Scale (JOS), which is subsequently used to compare real decision-making alternatives. Discussing the details of the ZAPROS procedure in analyzing any MCDM problem we assume that the problem is defined in a form of the negotiation template T described by formula (1).

It is assumed in ZAPROS that the sets X_k are defined in a form of finite sets of possible verbal values on the scale of issue $k = 1, 2, \ldots, n$. Moreover, it is assumed that the DM's preferences are transitive and the pairs of criteria are preferentially independent. In more detail, the ZAPROS procedure consists of four steps presented below (Moshkovich et al. 2005).

Step 1 Building the evaluation scale for each criterion considered in the decision-making problem (*i.e.*, defining the options that will describe various resolution levels within each negotiation issue).

Step 2 Comparing the ideal alternative and the hypothetical alternatives from the set H_{nIRS} pair-wisely, where H_{nIRS} is a subset of vectors from X with the best possible values for all the criteria but one, using the ordinal scale (*e.g.*, more preferable, less preferable, and equally preferable). The DM's comparisons have to be checked for consistency through transitivity of preferences.

Step 3 Constructing on the basis of pairwise comparisons the JOS, which is a complete rank order of the ideal alternative and the hypothetical alternatives from $H_{nIRS} \subset X$, each with the best evaluations for all the criteria but one (built within step 2). The JOS rank for the most preferred alternative (the Ideal Reference Vector) is 1.

Step 4 Comparing the actual decision-making alternatives pair-wisely using the JOS and constructing a partial order on the set of them.

In order to compare the alternatives the following rule is used: alternative a_i is not less preferable than alternative a_j, if for each criterion value of a_i there may be found a not more preferable unique criterion value of alternative a_j. The way to implement this rule is as follows: let us substitute a criterion value in each alternative by the corresponding rank from the Joint Ordinal Scale ($JOS(a_i)$), then rearrange them in the ascending order (from the most preferred to the least preferred one), so that $JOS_1(a_i) \leq JOS_2(a_i) \leq \cdots \leq JOS_n(a_i)$ and apply the following rule: alternative a_i is not less preferable than alternative a_j, if for each $k = 1, 2, \ldots, n \quad JOS_k(a_i) \leq JOS_k(a_j)$.

3.2 Example

The realization of the ZAPROS procedure for the negotiation template evaluation will be illustrated using the negotiation problem described in Sect. 2.2.

Step 1 It is assumed here that the negotiator prefers to evaluate options for negotiation issues using descriptive forms rather than assign the points to the issues and options like in the SAW procedure. Therefore, following the ZAPROS procedure, Fado constructs firstly the evaluation scale for the options for each negotiation issue, taking into account his subjective perception of the negotiation situation. It is worth noting that the same level in the evaluation scale may be assigned to different options. For instance, Fado can maintain that the difference between 5 and 6 concerts is irrelevant to him, and thus, these options are in his opinion equivalent. In the unpublished results of the Inspire experiments we have observed that negotiators actually assigned the same points of scores to different options, even if the available preference information suggested that there were differences between them. Table 2 presents the negotiation template with evaluation scales for options built by the negotiator.

Let us observe that in the Inspire system we could actually build and evaluate (using the SAW procedure implemented to the system) $4 \times 5 \times 4 \times 3 = 240$ feasible negotiation offers. The evaluation scales presented in Table 2 have limited the number of packages taken into consideration when building the scoring system to $3 \times 3 \times 2 \times 3 = 54$ only, as, for instance, the following offer: 5 concerts, 13 songs, 2.5 % royalties and 200,000$ contract bonus is worth exactly the same as the offer: 6 concerts, 15 songs, 3 % royalties and 200,000$ contract bonus.

Step 2 The negotiator compares pair-wisely the Ideal Reference Vector [5 or 6; 14; 2.5 or 3; 200] and the hypothetical offers from the set H_{nIRS}, where $H_{nIRS} =$

Table 2 Negotiation issues and evaluation scales for options

No.	Criteria (negotiation issues)	Evaluation scales (options)
f_1	Number of promotional concerts (per year)	Suitable: 5 or 6
		Neutral: 7
		Unsuitable: 8
f_2	Number of new songs (introduced and performed each year)	Favorable: 14
		Neutral: 13 or 15
		Adverse: 11 or 12
f_3	Royalties for CDs (in percent)	High: 2.5 or 3
		Low: 1.5 or 2
f_4	Contract signing bonus (in thousands dollars)	Very favorable: 200
		Favorable: 150
		Not much favorable: 125

{[5 or 6; 14; 1.5 or 2; 200], [5 or 6; 14; 2.5 or 3; 150], [5 or 6; 13 or 15; 2.5 or 3; 200], [7; 14; 2.5 or 3; 200], [5 or 6; 14; 2.5 or 3; 125], [5 or 6; 11 or 12; 2.5 or 3; 200], [8; 14; 2.5 or 3; 200]}. It is assumed that the negotiator is able to evaluate the options by declaring the occurrence of preferences (one alternative is better than another or they are equivalent).

In order to compare the ideal offer and the offers from the set H_{nIRS} the negotiator has to answer a series of questions regarding the comparison of offers that differ in two issues only and each having only one option worse than the ones comprising the Ideal Reference Vector. For instance: "Which offer do you prefer: the offer [5 or 6; 14; 1.5 or 2; 200] with 5 or 6 concerts, 14 songs, 1.5 or 2 percent royalties and 200,000$ contract signing bonus, or the offer [8; 14; 2.5 or 3; 200] with 8 concerts, 14 songs, 2.5 or 3 percent royalties and 200,000$ contract signing bonus?". The possible answers are as follows:

- the first offer [5 or 6; 14; 1.5 or 2; 200] is better (more preferable),
- the second offer [8; 14; 2.5 or 3; 200] is better (more preferable),
- these offers are equivalent (I).

Let us assume that Fado's answer is the following: the first offer [5 or 6; 14; 1,5 or 2; 200] is better. Elicited this way and presented in Table 3, Fado's responses are next checked for consistency through transitivity of preferences.

Step 3 On the basis of the consistent pairwise comparisons made in step 2 the Joint Ordinal Scale (JOS) for the considered negotiation problem is built. The final result in the form of a complete rank order of the ideal offer and the offers from the set H_{nIRS} is presented in Table 4. The JOS rank for the best options for each negotiation issue (5 or 6; 14; 2.5 or 3, and 200) is equal to 1, for option 1.5 or 2 equals 2, for option 150 equals 3, etc.

Step 4 The JOS values determined for all feasible offers within the analyzed negotiation template are presented in "Appendix". For simplicity, we assume here that Fado is interested in the evaluation of only eight packages from the set $A = \{a_2,\ a_4,\ a_{12},\ a_{19},\ a_{28},\ a_{32}, a_{34}, a_{40}\} \subseteq X$, where a_i is chosen from the complete

Table 3 Comparisons of the ideal alternative and the hypothetical alternatives from the set H_{nIRS} made by a negotiator (P—preference, I—indifference)

Hypothetical alternatives from the set H_{nIRS}	[5 or 6; 14; 2.5 or 3; 200]	[5 or 6; 14; 1.5 or 2; 200]	[5 or 6; 14; 2.5 or 3; 150]	[5 or 6; 13 or 15; 2.5 or 3; 200]	[7; 14; 2.5 or 3; 200]	5 or 6; 14; 2.5 or 3; 125]	[5 or 6; 11 or 12; 2.5 or 3; 200]	[8; 14; 2.5 or 3; 200]
[5 or 6; 14; 2.5 or 3; 200]	I	P	P	P	P	P	P	P
[5 or 6; 14; 1.5 or 2; 200]		I	P	P	P	P	P	P
[5 or 6; 14; 2.5 or 3; 150]			I	P	P	P	P	P
[5 or 6; 13 or 15; 2.5 or 3; 200]				I	P	P	P	P
[7; 14; 2.5 or 3; 200]					I	P	P	P
[5 or 6; 14; 2.5 or 3; 125]						I	P	P
[5 or 6; 11 or 12; 2.5 or 3; 200]							I	P
[8; 14; 2.5 or 3; 200]								I

Table 4 Joint Ordinal Scale for the considered negotiation problem

Ideal vector and vectors from the set H_{nIRS}	Evaluations	Rank in JOS
[5 or 6; 14; 2,5 or 3; 200]	5 or 6; 14; 2.5 or 3; 200	1
[5 or 6; 14; 1.5 or 2; 200]	1.5 or 2	2
[5 or 6; 14; 2.5 or 3; 150]	150	3
[5 or 6; 13 or 15; 2.5 or 3; 200]	13 or 15	4
[7; 14; 2.5 or 3; 200]	7	5
[5 or 6; 14; 2.5 or 3; 125]	125	6
[5 or 6; 11 or 12; 2.5 or 3; 200]	11 or 12	7
[8; 14; 2.5 or 3; 200]	8	8

Table 5 Selected negotiation packages and their evaluations by means of the ZAPROS procedure

Offer	Offer specification	Rank from JOS				JOS(a_i)
		f_1	f_2	f_3	f_4	
a_2	[5 or 6; 14; 2.5 or 3; 150]	1	1	1	3	(1,1,1,3)
a_4	[7; 14; 2.5 or 3; 200]	5	1	1	1	(1,1,1,5)
a_{12}	[5 or 6; 13 or 15; 2.5 or 3; 125]	1	4	1	6	(1,1,4,6)
a_{19}	[5 or 6; 11 or 12; 2.5 or 3; 200]	1	7	1	1	(1,1,1,7)
a_{28}	[5 or 6; 14; 1.5 or 2; 200]	1	1	2	1	(1,1,1,2)
a_{32}	[7; 14; 1.5 or 2; 150]	5	1	2	3	(1,2,3,5)
a_{34}	[8; 14; 1.5 or 2; 200]	8	1	2	1	(1,1,2,8)
a_{40}	[7; 13 or 15; 1.5 or 2; 200]	5	4	2	1	(1,2,4,5)

list of feasible offers (see "Appendix"). The selected negotiation packages and their evaluation by means of the ZAPROS procedure are shown in Table 5.

When analyzing the values contained in Table 5 it can be easily shown that, for instance, package a_2 with $JOS(a_2) = (1,1,1,3)$ is preferred to package a_4 with $JOS(a_4) = (1,1,1,5)$, as for each $k = 1, 2, \ldots, n$ $JOS_k(a_2) \leq JOS_k(a_4)$. In turn, the following packages: a_{12} and a_{19}, or a_{12} and a_{32}, or a_{34} and a_{40}, are incomparable. In that way we are able to construct a partial order on the set of the selected offers. The relations between them are depicted in Table 6 and in Fig. 4. As we see, it turned out that some offers are incomparable (a_{12} and a_{19}, a_{12} and a_{32}, a_{12} and a_{34}, a_{12} and a_{40}, a_{19} and a_{32}, a_{19} and a_{40}, a_{32} and a_{34}, and finally a_{34} and a_{40}), therefore the negotiator cannot consider, if moving from one offer to another is profitable for him or not (requires concessions or produces gains). This situation is very inconvenient for the negotiator as establishing the concession strategy is impossible.

3.3 Discussion

The negotiator is involved mainly in the first two steps of the ZAPROS procedure, namely: building the evaluation scale for each issue considered in the negotiation

Table 6 Relations between selected offers determined using ZAPROS (P—preference, I—indifference, R—incomparability)

Relations	a_i	a_2	a_4	a_{12}	a_{19}	a_{28}	a_{32}	a_{34}	a_{40}
a_i	JOS(a_i)	(1,1,1,3)	(1,1,1,5)	(1,1,4,6)	(1,1,1,7)	(1,1,1,2)	(1,2,3,5)	(1,1,2,8)	(1,2,4,5)
a_2	(1,1,1,3)	I	P	P	P		P	P	P
a_4	(1,1,1,5)		I	P	P		P	P	P
a_{12}	(1,1,4,6)			I	R		R	R	R
a_{19}	(1,1,1,7)			R	I		R	P	R
a_{28}	(1,1,1,2)	P	P	P	P	I	P	P	P
a_{32}	(1,2,3,5)			R	R		I	R	P
a_{34}	(1,1,2,8)			R			R	I	R
a_{40}	(1,2,4,5)			R	R			R	I

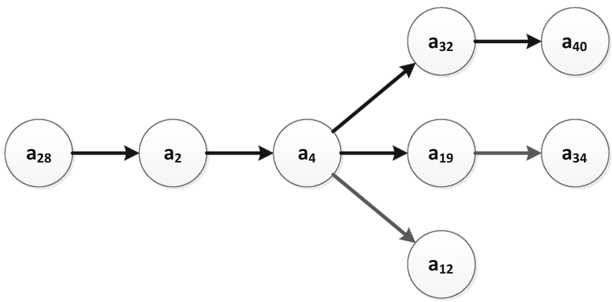


Fig. 4 Partial order obtained by means of the classic ZAPROS approach

problem (*step 1*) and comparing pair-wisely the ideal alternative and the hypothetical alternatives from the set H_{nIRS} using the ordinal scale (*step 2*). The consistency of the negotiator's judgements has to be verified through transitivity of preferences. The construction of the JOS scale (*step 3*) and obtaining a partial order on the set of the offers taken into consideration (*step 4*) do not require the DM's involvement—they run automatically, without any interaction with the negotiator. The whole procedure is straightforward and user-friendly.

From the viewpoint of negotiation analysis, ZAPROS has three major advantages. Firstly, it allows comparing complete packages (offers), which is a natural way of evaluating the concessions between the offers by negotiators. Secondly, it does not require determining the weights of negotiation issues, since it seeks and uses preferences in an ordinal form (as an indirect comparison of trade-offs between issues). Finally, it compares quasi-ideal packages, which are close to aspiration levels defined usually by negotiators. The aspiration levels play a key role in defining negotiation goals and, by opening negotiators to a framing effect (Neale and Bazerman 1985), they may highly influence the negotiation process and its outcome.

Unfortunately, there are also two serious drawbacks that do not allow applying an original ZAPROS algorithm into the process of the negotiation template evaluation. These are: (1) a relatively low comparison power, which makes the occurrence of incomparability of the offers almost unavoidable, and (2) a specific representation of the results obtained within the ZAPROS procedure, displayed in a form of graph showing the preference relations and ranking only. Such a global preference information might be insufficient for negotiators and, especially, for analysts who rather expect the numerical information on differences between the global attractiveness of the offers. There are only numerical and cardinal scores that are of use to evaluate the concessions made by the parties in the subsequent negotiation rounds or to determine the efficient improvements of the negotiated agreement according to some notions of fairness (Nash 1950).

4 The MACBETH Approach in the Evaluation of the Negotiation Template

4.1 The MACBETH Procedure

The MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) approach was developed in the nineteen nighties of the twentieth century (Bana e Costa and Vansnick 1997, 1999) and is somewhat in line with similar ideas previously proposed by Saaty in AHP (Saaty 1980). It was devised as a response to the question, very important from both the methodological and pragmatic viewpoints: how to build a value scale on a finite set of elements, in a way both qualitatively and quantitatively meaningful, without forcing a DM to give direct numerical representations of preferences and involving only two elements of the set for each judgement required from the DM? Therefore, using the MACBETH method, a DM provides information about two elements (alternatives, criteria) of the analyzed set at a time, first by giving an ordinal judgement as to their relative attractiveness/importance and second—if they are not deemed to be equally attractive/important—by expressing a qualitative judgement about the difference between their attractiveness/importance using six semantic categories: ‘very weak’, ‘weak’, ‘moderate’, ‘strong’, ‘very strong’ and ‘extreme’ or—if the DM is unsure of the size of the difference—a succession of them. The judgements provided by DMs are verified to eliminate possible inconsistencies. Next, numerical, cardinal value scales for the considered alternatives with respect to each criterion (as well as a weighting scale) are built on the basis of the DM’s semantic judgements using linear programming. The overall value scores of the alternatives that reflect their attractiveness with respect to all of the criteria are calculated by additively aggregating the single-criterion value scores. The MACBETH technique is very popular worldwide, in particular in Portugal, Brazil, France, and Spain. It has been used in many public and private applications such as environmental management, evaluation of bids, management of European structural programs, strategic town planning, human resources management, resource allocation, suppliers performance evaluation, risk management, prioritization of projects, credit scoring, etc. The MACBETH procedure consists of the following four steps (Bana e Costa et al. 2005):

Step 1 Building the evaluation scale for each criterion considered in the decision-making problem (*i.e.*, defining the options that will describe various resolution levels within each criterion).
Step 2 Comparing pair-wisely the differences between the importance of the criteria, as well as between the attractiveness of alternatives according to each criterion using seven semantic categories: 'no', 'very weak' (d_1), 'weak' (d_2), 'moderate' (d_3), 'strong' (d_4), 'very strong' (d_5) and 'extreme' (d_6). The description of the difference is provided in the form 'd_i to d'_j, $i \leq j$.
Step 3 Solving the linear programs corresponding to all the comparisons conducted, *i.e.*, separately for the criteria and separately for the alternatives with respect to each criterion:

$$\min v(y_1) \tag{7}$$

subject to the following constraints S_{mac}:

$$v(y_p) - v(y_r) = 0 \quad \forall y_p, y_r \in I, \text{ where } I \text{ is indifference relation, } p < r, \tag{8}$$

$$d_i + 0.5 \leq v\left(y_p\right) - v\left(y_r\right) \quad \forall i, j \in \{1, \ldots, 6\}, \; i \leq j, \quad \forall y_p, y_r \in C_{ij}, \tag{9}$$

where C_{ij} is a preference relation,

$$v(y_p) - v(y_r) \leq d_{j+1} - 0.5 \quad \forall i, j \in \{1, \ldots, 5\}, \quad i \leq j, \quad \forall y_p, y_r \in C_{ij}, \tag{10}$$

$$d_1 = 0.5 \tag{11}$$

$$d_{i-1} + 1 \leq d_i \quad \forall i \in \{2, \ldots, 6\}, \tag{12}$$

$$v\left(y_i\right) \geq 0 \qquad \forall i \in \{1, \ldots, n\}, \tag{13}$$

$$d_i \geq 0 \qquad \forall i \in \{1, \ldots, 6\}. \tag{14}$$

As a result, the optimal solution is obtained:

$$v\left(y_1\right), v\left(y_2\right), \ldots, v\left(y_n\right); \; v\left(y_1\right) = \mu\left(y_1\right), v\left(y_n\right) = \mu\left(y_n\right) = 0 \tag{15}$$

Solving (in order to guarantee the uniqueness of the MACBETH scales) for $i =$ 2 to $n - 1$:

$$\max v(y_i) \tag{16}$$

subject to:

$$S_{mac} \tag{17}$$

$$v\left(y_1\right) = \mu\left(y_1\right), \ldots, v\left(y_{i-1}\right) = \mu\left(y_{i-1}\right) \tag{18}$$

obtaining the optimal solution:

$$v\left(y_1\right), v\left(y_2\right), \ldots, v\left(y_n\right), \text{ where } y \max = v\left(y_i\right), \tag{19}$$

$$\min v\left(y_i\right) \tag{20}$$

subject to:

$$S_{mac} \tag{21}$$

$$v\left(y_1\right)=\mu\left(y_1\right),\ldots,v\left(y_{i-1}\right)=\mu\left(y_{i-1}\right) \tag{22}$$

obtaining the optimal solution:

$$v\left(y_1\right),v\left(y_2\right),\ldots,v\left(y_n\right),\text{ where } y\min=v\left(y_i\right), \tag{23}$$

$$\mu\left(y_i\right)=\frac{y\min+y\max}{2}. \tag{24}$$

Transforming the scales obtained for the alternatives and the scale constructed for the weights into 0–100 scales and assigning the scores 0 and 100 to the two end points of the scales. In the case of the criterion weights, values from the 0–100 scale should be normalized so that their sum is equal to 1.
Step 4 Calculating the weighted sum of the scores of the alternatives with respect to each criterion.
For any alternative $a_j \in X$ the overall score is determined by the following formula:

$$V(a_j)=\sum_{k=1}^{n} w_k u_k(a_j), \tag{25}$$

where w_k is a weight of kth criterion and $u_k(a_j)$ is a partial score of the alternative a_j according to criterion f_k.

4.2 Example

The application of the MACBETH procedure for negotiation template evaluation will be shown using the negotiation problem described in Sect. 2.2.

Step 1 Negotiation issues and evaluation scales for options determined by the negotiator within the analyzed negotiation problem are presented in Table 2.
Step 2 When using MACBETH the negotiation problem needs to be decomposed and Fado's preferences have to be analyzed separately for the negotiation issues (in order to obtain the vector of weights) and for the salient reference options within each issue (in order to obtain partial scores for them). It is assumed that the negotiator is able not only to provide ordinal preferential information about compared elements, but also to express a qualitative judgement about the difference between their importance or attractiveness (using the seven semantic categories). Thus, Fado, instead of assigning score points to the issues and options, makes verbal comparisons between them. For instance, let us assume that his judgments regarding the relative attractiveness of the options for the issue 'Number of promotional concerts' are like these presented in Table 7.

Table 7 Comparisons of the attractiveness of the options for the issue 'Number of promotional concerts' made by the negotiator

Option	5 or 6	7	8
5 or 6	No	Weak	Strong
7		No	Moderate
8			No

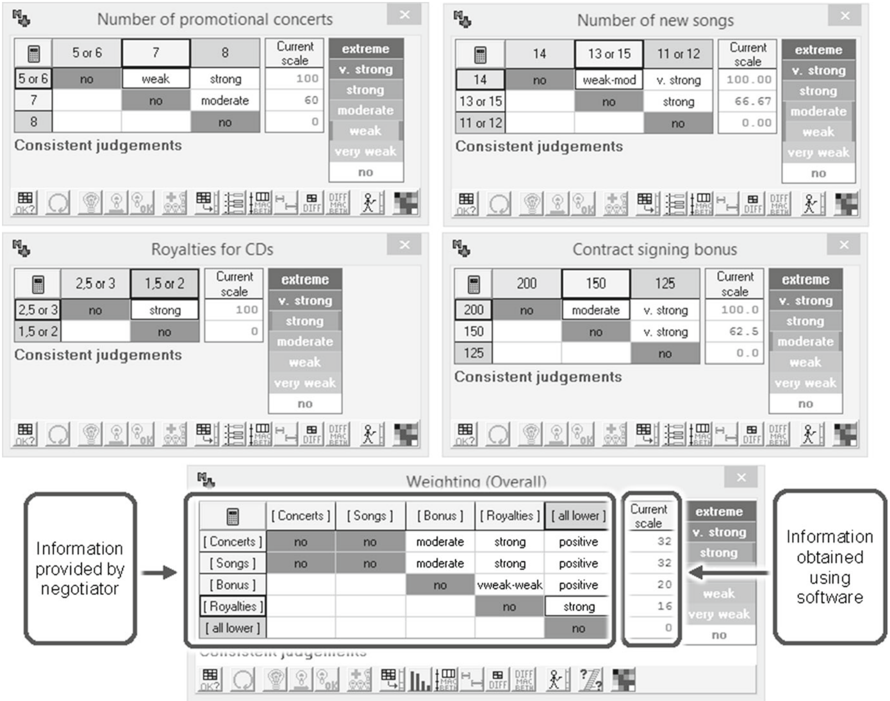


Fig. 5 Pair-wise comparisons conducted by the negotiator (step 2) and the 0–100 scales obtained using M-MACBETH software (step 3)

As we see, Fado claims that the difference in attractiveness between 5 or 6 concerts and 7 concerts is weak, between 5 or 6 concerts and 8 concerts—strong, and between 7 concerts and 8 concerts—moderate.

Pair-wise comparisons may be conducted by the negotiator using M-MACBETH software. It is worth noting that they have to be checked for consistency, but in the M-MACBETH software it is done automatically.

For the analyzed negotiation problem five comparison matrices have to be built: four for comparing the options according to each negotiation issue, and the fifth one—for comparing the relative importance of the issues.

Step 3 The matrices with pairwise comparisons made by the negotiator in step 2 as well as 0–100 scales obtained for the analyzed negotiation problem using the M-MACBETH software are presented in Fig. 5.

Let us observe that building a comparison matrix in the case of the issue 'Royalties for CDs' is pointless. Since we compare two elements only, the better one will

Table 8 Scores from the scale 0–100 for the issue ‘Number of promotional concerts’

Resolution level	5 or 6	7	8
Value	100.00	60.0	0.00

Table 9 Scores from the scale 0–100 for the issue ‘Number of new songs’

Resolution level	14	13 or 15	11 or 12
Value	100.00	66.67	0.00

Table 10 Scores from the scale 0–100 for the issue ‘Royalties for CDs’

Resolution level	2.5 or 3	1.5 or 2
Value	100.00	0.00

Table 11 Scores from the scale 0–100 for the issue ‘Contract signing bonus’

Resolution level	200	150	125
Value	100.00	62.5	0.00

Table 12 Weights for the negotiation issues totaling 1

Issue	Number of promotional concerts	Number of new songs	Royalties for CDs	Contract signing bonus
Value	0.32	0.32	0.20	0.16

always obtain 100 points, and the worse one—0 points (for whatever judgement as to their relative attractiveness). Moreover, it should be emphasized that all the scores in the scales presented in Fig. 5 may be adjusted to the negotiator’s subjective opinions without violating the preferential information provided by him or her. Accordingly, if the negotiator wants to redefine the suggested score, he or she may use the value from the interval calculated by the M-MACBETH software that seems the most appropriate for him or her. In our example we assume that the scores suggested by the M-MACBETH software were accepted by the negotiator without changes.

Tables 8, 9, 10, 11 and 12 present the partial scores on the 0–100 scale for the options for each negotiation issue and the one-sum weights for the issues obtained as a result of applying the MACBETH procedure.

Step 4 The weighted sums determined for all feasible offers within the analyzed negotiation template as well as their ranking are presented in “Appendix”. In turn, eight selected negotiation packages and their evaluation by means of the MACBETH procedure are shown in Fig. 6.

For instance, the overall score for option a_2 is calculated as follows:

$$V(a_2) = 0.32 \cdot 100 + 0.32 \cdot 100 + 0.20 \cdot 62.5 + 0.16 \cdot 100 = 92.50 \qquad (26)$$

Table of scores

Options	Overall	Concerts	Songs	Bonus	Royalties
[all upper]	100.00	100.00	100.00	100.00	100.00
a2	92.50	100.00	100.00	62.50	100.00
a4	87.20	60.00	100.00	100.00	100.00
a28	84.00	100.00	100.00	100.00	0.00
a12	69.33	100.00	66.67	0.00	100.00
a19	68.00	100.00	0.00	100.00	100.00
a32	63.70	60.00	100.00	62.50	0.00
a40	60.53	60.00	66.67	100.00	0.00
a34	52.00	0.00	100.00	100.00	0.00
[all lower]	0.00	0.00	0.00	0.00	0.00
Weights :		0.3200	0.3200	0.2000	0.1600

Fig. 6 Selected negotiation packages and their evaluations by means of the MACBETH procedure obtained using the M-MACBETH software

4.3 Discussion

The negotiator is involved in the first two steps of the MACBETH procedure, namely, in building the evaluation scale for each issue considered in the negotiation problem (*step 1*) and comparing pair-wisely the differences between the attractiveness/importance of the options/issues using seven semantic categories (*step 2*). The scores for options and weights for issues (*step 3*) as well as overall evaluations for the offers (*step 4*) can be obtained automatically using the M-MACBETH software without any interaction with the negotiator. The M-MACBETH software is a straightforward and user-friendly tool, allowing the useful visualization of the results obtained. It automatically verifies the consistency of judgements when they are entered into the software and propose—in the form of simple discussion with the user—a solution in the case of their inconsistency.

From the viewpoint of negotiation analysis MACBETH has two major advantages: (1) it allows us to compare verbally the elements of the negotiation template using an intuitive linguistic scale, and (2) results in a cardinal scoring system that allows measuring the scale of concessions, making quantitative comparisons of successive negotiation offers, etc.

However, it has one minor drawback, *i.e.*, it decomposes the problem and requires pair-wise comparisons of the negotiation issues, while negotiators demonstrate their inability to score the issues effectively, and mistakes made at this level may influence negatively the whole scoring system. Here the negotiator has to evaluate issues separately (at the beginning of the preference elicitation process), which we would prefer to avoid, taking into account the authors' own recent research proving the problems and inconsistencies that accompany the process of issue rating (see Sect. 2.3). Moreover, let us notice that it is necessary to perform $s(s-1)/2$ pair-wise comparisons in the case of each comparison matrix where $s \times s$ is a dimension of the matrix. Such comparisons may be time-consuming and can be even difficult for negotiators who may prefer package-to-package comparisons, which are more natural for them, since when conducting actual negotiation they face full packages submitted to the negotiation table.

5 MARS—The Preference Elicitation Algorithm Based on the ZAPROS and MACBETH Methods

5.1 The MARS Procedure

Taking into account the advantages and disadvantages of the ZAPROS and MACBETH procedures presented above, we propose a new approach called MARS. The acronym MARS stands for: Measuring Attractiveness near Reference Situations. The reference situations can be twofold:

- Ideal Reference Situation described by the vector with the best evaluations (*resolution levels*) for all criteria,
- Anti-Ideal Reference Situation expressed by the vector with the worst evaluations (*resolution levels*) for all criteria.

Based on ZAPROS and MACBETH, MARS allows us to obtain a complete ranking of the alternatives considered with scores measured on an interval scale. The MARS procedure consists then of the following five steps, whose execution will be illustrated in the next section.

Step 1 Determination of the evaluation scale (resolution levels) for each criterion considered in the decision-making problem.
Step 2 Defining the Reference Situations:

- Ideal Reference Vector with the best evaluations (resolution levels) for all criteria, or
- Anti-Ideal Reference Vector with the worst evaluations (resolution levels) for all criteria.

Building a set of hypothetical alternatives from $H_{nIRS} \subset X$or $H_{nAIRS} \subset X$, where:

- H_{nIRS} is a set of all hypothetical alternatives with the best evaluation for all criteria but one (the set of alternatives being near to the Ideal Reference Situation),
- H_{nAIRS} is a set of all hypothetical alternatives with the worst evaluation for all criteria but one (the set of alternatives being near to the Anti-Ideal Reference Situation).

Step 3 Pairwise comparison of the hypothetical alternatives from $H_{nIRS} \subset X$ and the Ideal Reference Vector, or the hypothetical alternatives from $H_{nAIRS} \subset X$ and the Anti-Ideal Reference Vector, using the ordinal scale: more preferable, less preferable, and equally preferable, or the following semantic categories: 'no', 'very weak' (d_1), 'weak' (d_2), 'moderate' (d_3), 'strong' (d_4) 'very strong' (d_5) and 'extreme' (d_6). In the latter case, the difference in attractiveness between vectors is expressed by 'd_i to d_j', $i \leq j$. The choice of the scale depends on DMs' expectations, experience, and skills as well as their willingness and ability to devote adequate time and effort to conducting comparisons. Comparisons can be performed using the M-MACBETH software, which automatically verifies their consistency and offers suggestions to resolve possible inconsistencies.

Step 4 Solution of the linear program corresponding to the comparisons performed (using the MACBETH approach and, for example, the M-MACBETH software) to obtain the scores from the 0–100 scale for the elements compared, *i.e.*, to form the JCS—Joint Cardinal Scale:

$$\min v(h_1) \tag{27}$$

subject to the following constraints S_{mac}:

$$v\left(h_p\right) - v\left(h_r\right) = 0 \; \forall \; h_p, h_r \in I, \text{ where } I \text{ is an indifference relation, } p < r, \tag{28}$$

$$d_i + 0.5 \leq v\left(h_p\right) - v\left(h_r\right) \quad \forall i, j \in \{1, \ldots, 6\}, \quad i \leq j, \quad \forall h_p, h_r \in C_{ij}, \tag{29}$$

where C_{ij} is a preference relation,

$$v\left(h_p\right) - v\left(h_r\right) \leq d_{j+1} - 0.5 \quad \forall i, j \in \{1, \ldots, 5\}, \quad i \leq j, \forall h_p, h_r \in C_{ij}, \tag{30}$$

$$d_1 = 0.5 \tag{31}$$

$$d_{i-1} + 1 \leq d_i \quad \forall i \in \{2, \ldots, 6\}, \tag{32}$$

$$v\left(h_i\right) \geq 0 \qquad \forall i \in \{1, \ldots, n\}, \tag{33}$$

$$d_i \geq 0 \qquad \forall i \in \{1, \ldots, 6\}. \tag{34}$$

As a result, the optimal solution is obtained:

$$v\left(h_1\right), v\left(h_2\right), \ldots, v\left(h_n\right); \; v\left(h_1\right) = \mu\left(h_1\right), v\left(h_n\right) = \mu\left(h_n\right) = 0 \tag{35}$$

Solving (in order to guarantee the uniqueness of the MACBETH scales) for $i = 2$ to $n - 1$:

$$\max \quad v(h_i) \tag{36}$$

subject to:

$$S_{mac} \tag{37}$$

$$v(h_1) = \mu\left(h_1\right), \ldots, v\left(h_{i-1}\right) = \mu\left(h_{i-1}\right) \tag{38}$$

obtaining the optimal solution:

$$v\left(h_1\right), v\left(h_2\right), \ldots, v\left(h_n\right), \text{ where } h \max = v\left(h_i\right), \tag{39}$$

$$\min v\left(h_i\right) \tag{40}$$

subject to:

$$S_{mac} \tag{41}$$

$$v\left(h_1\right)=\mu\left(h_1\right),\ldots,v\left(h_{i-1}\right)=\mu\left(h_{i-1}\right) \tag{42}$$

obtaining the optimal solution:

$$v\left(h_1\right),v\left(h_2\right),\ldots,v\left(h_n\right),\text{ where } h\min=v\left(h_i\right), \tag{43}$$

$$\mu\left(h_i\right)=\frac{h\min+h\max}{2}. \tag{44}$$

Transforming the scale obtained into 0–100 scale and assigning the scores 0 and 100 to the two end points of the scale.

Step 5 Ordering the alternatives with respect to the Reference Situation, which, depending on the reference vector selected in step 2, may require one of these two following orderings:

- Ordering the alternatives with respect to the Ideal Reference Vector: Let us substitute the resolution levels in each vector describing the alternative considered in the decision-making problem by the corresponding scores from the 0–100 JCS. For each alternative the distance $L(a_i)$from the ideal alternative is defined by the following formula:

$$L(a_i)=\sum_{k=1}^{n}(100-JCS_{ik}), \tag{45}$$

where JCS_{ik} is the score from the 0–100 JCS substituting the assessment of alternative $a_i$according to criterion f_k. The final complete ranking of the alternatives is constructed according to the distance values $L(a_i)$ in ascending order.

- Ordering the alternatives with respect to the Anti-Ideal Reference Vector: Let us substitute the resolution levels in each vector describing the alternative considered in the decision-making problem by the corresponding scores from the 0–100 JCS. For each alternative the distance $L(a_i)$ from the anti-ideal alternative is defined by the formula:

$$L(a_i)=\sum_{k=1}^{n}JCS_{ik}, \tag{46}$$

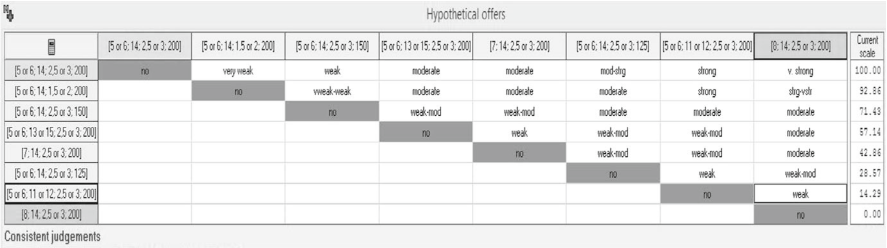
where JCS_{ik} is the score from the 0–100 JCS substituting the assessment of alternative a_i according to criterion f_k. The final complete ranking of the alternatives is constructed according to the distance values $L(a_i)$ in descending order.

5.2 Example

The application of the MARS procedure for negotiation template evaluation will be shown using the negotiation problem described in Sect. 2.2.

Table 13 Reference Situations and the hypothetical alternatives from the set H_{nIRS} and H_{nAIRS}

Ideal Reference Vector and the hypothetical alternatives from the set H_{nIRS}	Anti-Ideal Reference Vector and the hypothetical alternatives from the set H_{nAIRS}
[5 or 6; 14; 2.5 or 3; 200]	[8; 11 or 12; 1.5 or 2; 125]
[5 or 6; 14; 1.5 or 2; 200]	[8; 11 or 12; 2.5 or 3; 125]
[5 or 6; 14; 2.5 or 3; 150]	[8; 11 or 12; 1.5 or 2; 150]
[5 or 6; 13 or 15; 2.5 or 3; 200]	[8; 13 or 15; 1.5 or 2; 125]
[7; 14; 2.5 or 3; 200]	[7; 11 or 12; 1.5 or 2; 125]
[5 or 6; 14; 2.5 or 3; 125]	[8; 11 or 12; 1.5 or 2; 200]
[5 or 6; 11 or 12; 2.5 or 3; 200]	[8; 14; 1.5 or 2; 125]
[8; 14; 2.5 or 3; 200]	[5 or 6; 11 or 12; 1.5 or 2; 125]

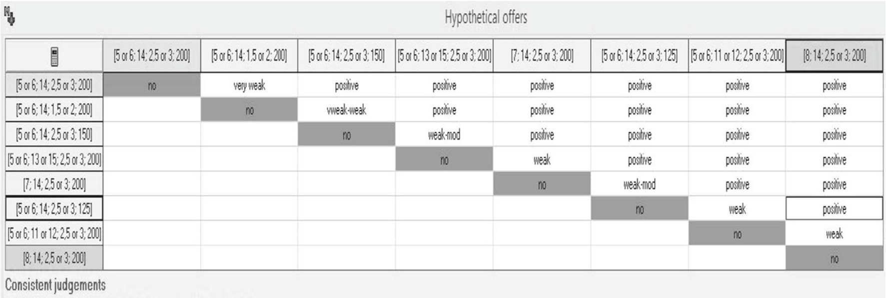

Hypothetical offers

	[5 or 6; 14; 2,5 or 3; 200]	[5 or 6; 14; 1,5 or 2; 200]	[5 or 6; 14; 2,5 or 3; 150]	[5 or 6; 13 or 15; 2,5 or 3; 200]	[7; 14; 2,5 or 3; 200]	[5 or 6; 14; 2,5 or 3; 125]	[5 or 6; 11 or 12; 2,5 or 3; 200]	[8; 14; 2,5 or 3; 200]	Current scale
[5 or 6; 14; 2,5 or 3; 200]	no	very weak	weak	moderate	moderate	mod-strg	strong	v. strong	100.00
[5 or 6; 14; 1,5 or 2; 200]		no	vweak-weak	moderate	moderate	moderate	strong	strg-vstr	92.86
[5 or 6; 14; 2,5 or 3; 150]			no	weak-mod	weak-mod	moderate	moderate	moderate	71.43
[5 or 6; 13 or 15; 2,5 or 3; 200]				no	weak	weak-mod	weak-mod	moderate	57.14
[7; 14; 2,5 or 3; 200]					no	weak-mod	weak-mod	moderate	42.86
[5 or 6; 14; 2,5 or 3; 125]						no	weak	weak-mod	28.57
[5 or 6; 11 or 12; 2,5 or 3; 200]							no	weak	14.29
[8; 14; 2,5 or 3; 200]								no	0.00

Consistent judgements

Fig. 7 Comparisons of the ideal alternative and the hypothetical alternatives from the set H_{nIRS} made by a negotiator (step 3) and the 0–100 scale obtained using the M-MACBETH software (step 4)

Step 1 Negotiation issues and evaluation scales for options determined by the negotiator within the analyzed negotiation problem are presented in Table 2.
Step 2 The Ideal Reference Vector and the alternatives from the set H_{nIRS} as well as the Anti-Ideal Reference Vector and the alternatives from the set H_{nAIRS} for the considered negotiation problem look like it is presented in Table 13.
Step 3 Let us assume that Fado wants to compare complete packages with respect to the Ideal Reference Vector and using the seven semantic categories defined in the classic MACBETH approach. The pair-wise comparisons required by the MARS procedure (made by the negotiator using the M-MACBETH software) are presented in Fig. 7. When analyzing the preferential information, it can be easily noticed that the hesitation between two or more consecutive semantic categories (except indifference) is allowed.
Let us observe that it is not necessary to perform all $s(s-1)/2$ pair-wise comparisons using the seven semantic categories, where $s \times s$—is a dimension of the comparison matrix, but rather focus on the minimal acceptable number of judgements equal to $s-1$, and precisely define the preferences for all the cells placed just above the main diagonal of the matrix (see Fig. 8). All the remaining cells can be filled with the linguistic evaluation 'positive', which means that for the pair considered only ordinal preferential information is available. For the purpose of our example, we use the comparisons taken from Fig. 7.


Hypothetical offers

	[5 or 6; 14; 2,5 or 3; 200]	[5 or 6; 14; 1,5 or 2; 200]	[5 or 6; 14; 2,5 or 3; 150]	[5 or 6; 13 or 15; 2,5 or 3; 200]	[7; 14; 2,5 or 3; 200]	[5 or 6; 14; 2,5 or 3; 125]	[5 or 6; 11 or 12; 2,5 or 3; 200]	[8; 14; 2,5 or 3; 200]
[5 or 6; 14; 2,5 or 3; 200]	no	very weak	positive	positive	positive	positive	positive	positive
[5 or 6; 14; 1,5 or 2; 200]		no	vweak-weak	positive	positive	positive	positive	positive
[5 or 6; 14; 2,5 or 3; 150]			no	weak-mod	positive	positive	positive	positive
[5 or 6; 13 or 15; 2,5 or 3; 200]				no	weak	positive	positive	positive
[7; 14; 2,5 or 3; 200]					no	weak-mod	positive	positive
[5 or 6; 14; 2,5 or 3; 125]						no	weak	positive
[5 or 6; 11 or 12; 2,5 or 3; 200]							no	weak
[8; 14; 2,5 or 3; 200]								no

Consistent judgements

Fig. 8 The minimum possible number of comparisons made by the negotiator in MARS using the M-MACBETH software

Table 14 The Joint Cardinal Scale for the considered negotiation problem

Ideal Reference Vector and vectors from the set H_{nIRS}	Evaluations	Score in JCS
[5 or 6; 14; 2.5 or 3; 200]	5 or 6; 14; 2.5 or 3; 200	100.00
[5 or 6; 14; 1.5 or 2; 200]	1.5 or 2	92.86
[5 or 6; 14; 2.5 or 3; 150]	150	71.43
[5 or 6; 13 or 15; 2.5 or 3; 200]	13 or 15	57.14
[7; 14; 2.5 or 3; 200]	7	42.86
[5 or 6; 14; 2.5 or 3; 125]	125	28.57
[5 or 6; 11 or 12; 2.5 or 3; 200]	11 or 12	14.29
[8; 14; 2.5 or 3; 200]	8	0.00

Note that in Fig. 7 only the hypothetical offers (each with the best resolution level for all issues but one) and the ideal offer (with the best resolution levels for all issues) are compared. According to the fundamental assumptions of ZAPROS, based on these comparisons, the basic options are ranked according to the increasing concessions their require. Applying the MACBETH's linguistic scale allows us to assign (within step 4) cardinal score to each option, which reflects the scale of concession required, when the ideal option in the package is replaced by the option under consideration.

Step 4 On the basis of the consistent pairwise comparisons made in step 3 the Joint Cardinal Scale (JCS) for the considered negotiation problem is built. Table 14 presents the scores on the 0–100 scale obtained as a result of applying step 4 of the MARS procedure with the help of the M-MACBETH software.

Let us note that all of the scores presented in Table 14 can be adjusted to the negotiator's opinions and beliefs without violating the preferential information provided by him or her in the matrix presented in Fig. 7. Accordingly, if the negotiator wants to redefine the suggested score, he or she is free to use the value from the interval computed by the M-MACBETH software that seems the most appropriate for him or her. In our example we assume that the scores suggested by the M-MACBETH software were accepted by the negotiator without any modification.

Table 15 Selected negotiation packages and their evaluations by means of the MARS procedure

Offer	Offer specification	JCS_{i1}	JCS_{i2}	JCS_{i3}	JCS_{i4}	$L(a_i)$
a_{28}	[5 or 6; 14; 1.5 or 2; 200]	100	100	92.86	100	7.14
a_2	[5 or 6; 14; 2.5 or 3; 150]	100	100	100	71.43	28.57
a_4	[7; 14; 2.5 or 3; 200]	42.86	100	100	100	57.14
a_{19}	[5 or 6; 11 or 12; 2.5 or 3; 200]	100	14.29	100	100	85.71
a_{32}	[7; 14; 1.5 or 2; 150]	42.86	100	92.86	71.43	92.85
a_{34}	[8; 14; 1.5 or 2; 200]	0	100	92.86	100	107.14
a_{40}	[7; 13 or 15; 1.5 or 2; 200]	42.86	57.14	92.86	100	107.14
a_{12}	[5 or 6; 13 or 15; 2.5 or 3; 125]	100	57.14	100	28.57	114.29

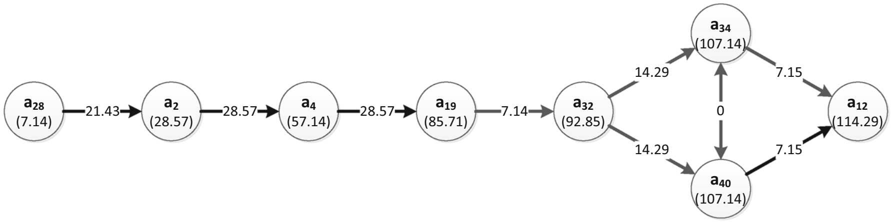


Fig. 9 The order of the offers obtained by means of the MARS approach

Step 5 Assuming that the negotiator orders the alternatives with respect to the Ideal Reference Vector, the distance values determined for all feasible offers within the analyzed negotiation template as well as their ranking are presented in "Appendix". In turn, eight selected negotiation packages and their evaluation by the MARS procedure are contained in Table 15.

For instance, the distance value for option a_2 is calculated as follows:

$$L(a_2) = (100 - 100) + (100 - 100) + (100 - 100) + (100 - 71.43) = 28.57 \quad (47)$$

The final ranking of the selected offers is presented in Fig. 9. Moreover, it shows the overall scores of the offers (in brackets) and the concessions, which are necessary to make when moving from one offer to another (expressed on the arcs).

Let us emphasize that all of the feasible offers from the negotiation template are fully comparable. The scores obtained within the MARS procedure provide the negotiator with all relevant cardinal data sufficient to decide which of any two packages (offers) is better and by how much. They may also be used to perform the symmetric analysis to determine the fair solution for both parties during the mediation or arbitration process or to visualize the negotiation progress and the concession paths.

5.3 Discussion

The negotiator is involved in the first three steps of the MARS procedure: building the evaluation scale for each issue considered in the negotiation problem (*step 1*), choosing the reference situation (*step 2*) and comparing pair-wisely the differences between the attractiveness of the packages from the reference set using the ordinal scale or the seven semantic categories (*step 3*). The construction of the Joint Cardinal Scale (*step 4*) and obtaining distance values for the considered offers (*step 5*) do not require the DM's involvement—they run automatically, without any interaction with the negotiator. Similarly as in the MACBETH approach, the M-MACBETH software can be useful here (*in steps 3 and 4*).

Note that from the viewpoint of the negotiation analysis and further negotiation support the scoring systems obtained by means of the classic MACBETH approach and the MARS procedure are similar. In MARS the scores reflect the distances to the Ideal Solution, therefore, the smaller the score, the better the alternative is. However, the scores received using MARS may be easily transformed into 0–100 scale and adjusted to the requirements of the value maximizing problem by applying one of the normalization formulas.

Please note, that the first two steps of the algorithm presented above are in fact the modifications of the ZAPROS original procedure. Step 3 combines the elements of both the ZAPROS and MACBETH methods. The pairwise comparisons of the hypothetical alternatives with the selected reference vector are ZAPROS-specific, while the sematic categories used for these comparisons are derived from the MACBETH original algorithm. The procedure of determining the Joint Cardinal Scale in step 4 is MACBETH-specific, however, the very notion of joint scale was taken from ZAPROS. Step 5 is MARS-specific and allows building a cardinal rating system that may be used for sophisticated negotiation support and analysis (similarly to the one obtained by means of SAW).

The ZAPROS procedure allows DMs to define their preferences verbally and provides a straightforward but effective method for analyzing the trade-offs between the alternatives using few reference alternatives only (Larichev and Moshkovich 1995). Unfortunately, it results in the ordinal ranking and allows the occurrence of the incomparability relation between the alternatives, thus it cannot be directly applied to build a negotiation offers scoring system. With a view to overcoming these limitations we apply the elements of the MACBETH algorithm, which allows us to determine the cardinal scores for the alternatives and to identify the potential inconsistencies that may occur when defining preferences by negotiators within the classic ZAPROS approach. It also extends the classic ZAPROS functionality allowing DMs to declare not only if one alternative is preferable over another, but also to specify verbally how much it is better or worse. The scoring system obtained this way makes it possible to conduct a more sophisticated symmetric and asymmetric negotiation analysis, such as measuring the scale of concessions, randomizing between two different alternatives or determining the arbitration solution.

6 Conclusions

In the paper a framework for the negotiation offers evaluation based on a new technique called MARS, hybridizing the ZAPROS and MACBETH approaches, has been proposed. To show the differences in scoring procedures, workload required and results obtained, the example was presented by means of which we could compare ZAPROS, MACBETH and MARS from the point of view of the evaluation of negotiation packages. To justify the usability of the MARS procedure we compared it also with the SAW method, which is very frequently applied in the evaluation of negotiation offers. The MARS algorithm can be used to structure negotiation problems by defining numerical values based on verbal statements, which allows the construction of the value function derived from qualitative judgements about the differences in attractiveness between packages from the reference set. Such an approach allows us to quantify preferences arising from a verbal evaluation of the quality of negotiation packages and calculate the attractiveness (scores) for them in a numerical way.

The MARS approach, proposed in this paper, combines some elements of ZAPROS and MACBETH to provide negotiators with a straightforward tool that requires of them the basic preferential information only and simple offer-to-offer comparisons in order to evaluate the negotiation template and build the cardinal negotiation offer scoring system. We tried to derive from the advantages of both methods, eliminating, at the same time, their major drawbacks that may be cumbersome for users and result in typical mistakes and inconsistencies, as discussed in Sect. 2.3. Using ZAPROS we are able to operate with the intuitively interpreted linguistic scale while defining the preferences. If the negotiator is not sure regarding the strength of his preferences, he may only declare that one offer is simply better or worse than another (not specifying by how much it is better). The ZAPROS algorithm also allows us to identify a small set of reference alternatives that need to be evaluated by the negotiator, and these alternatives consist of the best resolution levels for all the negotiation issues but one (see Sects. 3 and 5). It makes the preference elicitation process easier and faster, since when comparing the offers pair-wisely negotiators need to evaluate simple trade-offs only, considering, in fact, which concession is better for him/her to make. This trade-off based preference elicitation process seems to be quite natural for negotiators, since it is close to the real decision making analysis that negotiators face during actual negotiations, while comparing various offers from subsequent negotiation rounds. On the other hand, however, by applying the elements of MACBETH analysis we are able to determine the strong interval scale out of the verbal judgements defined by negotiators at the beginning of the preference elicitation process. Using MACBETH allows us also to eliminate the major drawbacks of the classic ZAPROS approach, namely: (1) any two alternatives will no longer appear to be incomparable, and (2) the potential inconsistencies in preferences can be easily tracked and eliminated from the preference elicitation process. By hybridizing the ZAPROS and MACBETH algorithms, MARS eliminates the major disadvantages of VDA-based approaches but also the classic quantitative approaches (like SAW- or TOPSIS-based ones). It allows a verbal definition of the preferences over the potential trade-offs (negotiation concessions) releasing DMs from unintuitive assigning of abstract scoring points to options and issues, which may be meaningless or misinterpreted. It should be mentioned that the MARS approach is not limited to negotiation support only but can also be used to any MCDM problem for which the DM decides to use the notion of reference points and is willing to compare close-to-ideal alternatives that differ in trade-offs on two criteria only.

The key advantages of the MARS approach are the following:

(1) This technique allows the verbal preference elicitation of the attractiveness of the packages within procedure that transforms *ordinal* information into *cardinal information* by a non-numerical *pairwise comparison* questioning mode. It is a very useful approach, especially when the problem is poorly defined, in the context of qualitative issues that often appear in negotiation templates, as well as in the case of the occurrence of imprecise information.
(2) The negotiator preference information is collected in a very easy way and concerns a small subset of negotiations offers, playing the role of a training sample. Elicitation of the holistic pairwise comparisons of the negotiation packages from the Reference Set requires from the negotiator making a relatively small cognitive effort. From the negotiator's perspective, the set represents the offers, which are near to the Ideal Reference Situation, so those ones that can be easily accepted by him/her. However, the set with the offers closed to the Anti-Ideal Reference Situation represents the offers that can be definitely rejected by the negotiator.
(3) The MARS technique does not require evaluating the weights for negotiation issues separately, but derives them from package-to-package comparisons. It is especially convenient in negotiation situations where it is very difficult for the negotiator to elicit exact criteria weights. The process involved to assess an overall preference, using a decomposed analytical procedure, may not be natural for him/her. The negotiator may only be able to say that one criterion is more important than another, but most aggregation methods require a more precise information, so the negotiator may reject any model based on weights that are not meaningful to him/her. Taking this into account, the MARS technique allows negotiators to evaluate trade-offs by comparing complete packages, which seems more natural for the them, since it is close to the actual decision making analysis conducted during real-life negotiations.
(4) The computation processes for determining the scoring function take into account the negotiation space for each issue as well as the concepts of reservation and aspiration levels.
(5) The verbal expressions of the negotiator could be vague sometimes, thus the representative score generated by the MACBETH technique is accompanied by the bounds of the interval within which it is located. The M-MACBETH software proposes the *exact score*, however, the negotiator can modify *preference scale* using points from the interval scale, if it is needed.

However, despite its simplicity, the MARS approach may appear to be tiresome in analyzing big negotiation problems. The number of negotiation issues and options significantly influences the number of potential comparisons that have to be conducted in the decision matrix. This problem may be partially solved by using the notion of predefined verbal categories limited in number for each negotiation issue (as it is recommended in the classic ZAPROS algorithm). Furthermore, the MARS ratings are obtained by solving the MACBETH-specific linear program that usually finds more alternative solutions. Using one of them will result in a particular scoring system that may be very different from another one, determined for other alternative solution of LP-program. The rankings of the offers may be different then as well as the interpretation of trade-offs and concessions. Therefore, it is quite vital to verify empirically whether negotiators: (1) are aware of obtaining various ratings, (2) modify the initial scores within the 'free ranges' proposed by the MACBETH algorithm or accept the first one shown; (3) are interested in obtaining the precise rankings and define their preferences using the whole matrix of comparisons or provide the minimum required information in above-diagonal cells only. Therefore, our future work will focus on building a software tool for supporting the MARS algorithm and verifying its use and usefulness by organizing experimental research regarding both negotiation and a pure MCDM problem.

Acknowledgments This research was supported by the grant obtained from the Polish National Science Centre (2015/17/B/HS4/00941).

Appendix

See Tables 16 and 17.

Table 16 Negotiation offers from the template and their evaluations with the application of the ZAPROS and MACBETH procedures

a_i	Resolution levels of issues				ZAPROS Rank from JOS scale				MACBETH		
	f_1	f_2	f_3	f_4	f_1	f_2	f_3	f_4	JOS(a_i)	Score	Rank
a_1^*	5 or 6	14	2.5 or 3	200	1	1	1	1	(1,1,1,1)	100	1
a_2^*	*5 or 6*	*14*	*2.5 or 3*	*150*	*1*	*1*	*1*	*3*	*(1,1,1,3)*	92.5	*2*
a_3^*	5 or 6	14	2.5 or 3	125	1	1	1	6	(1,1,1,6)	80	7
a_4^*	*7*	*14*	*2.5 or 3*	*200*	*5*	*1*	*1*	*1*	*(1,1,1,5)*	87.2	*4*
a_5	7	14	2.5 or 3	150	5	1	1	3	(1,1,3,5)	79.7	8
a_6	7	14	2.5 or 3	125	5	1	1	6	(1,1,5,6)	67.2	16
a_7^*	8	14	2.5 or 3	200	8	1	1	1	(1,1,1,8)	68	15
a_8	8	14	2.5 or 3	150	8	1	1	3	(1,1,3,8)	60.5	21
a_9	8	14	2.5 or 3	125	8	1	1	6	(1,1,6,8)	48	30
a_{10}^*	5 or 6	13 or 15	2.5 or 3	200	1	4	1	1	(1,1,1,4)	89.33	3
a_{11}	5 or 6	13 or 15	2.5 or 3	150	1	4	1	3	(1,1,3,4)	81.83	6
a_{12}	*5 or 6*	*13 or 15*	*2.5 or 3*	*125*	*1*	*4*	*1*	*6*	*(1,1,4,6)*	69.33	*13*
a_{13}	7	13 or 15	2.5 or 3	200	5	4	1	1	(1,1,4,5)	76.53	9
a_{14}	7	13 or 15	2.5 or 3	150	5	4	1	3	(1,3,4,5)	69.03	14
a_{15}	7	13 or 15	2.5 or 3	125	5	4	1	6	(1,4,5,6)	56.53	23
a_{16}	8	13 or 15	2.5 or 3	200	8	4	1	1	(1,1,4,8)	57.33	22
a_{17}	8	13 or 15	2.5 or 3	150	8	4	1	3	(1,3,4,8)	49.83	29
a_{18}	8	13 or 15	2.5 or 3	125	8	4	1	6	(1,4,6,8)	37.33	36
a_{19}^*	*5 or 6*	*11 or 12*	*2.5 or 3*	*200*	*1*	*7*	*1*	*1*	*(1,1,1,7)*	*68*	*15*

Table 16 continued

a_i	Resolution levels of issues				ZAPROS				MACBETH		
					Rank from JOS scale						
	f_1	f_2	f_3	f_4	f_1	f_2	f_3	f_4	JOS(a_i)	Score	Rank
a_{20}	5 or 6	11 or 12	2.5 or 3	150	1	7	1	3	(1,1,3,7)	60.5	21
a_{21}	5 or 6	11 or 12	2.5 or 3	125	1	7	1	6	(1,1,6,7)	48	30
a_{22}	7	11 or 12	2.5 or 3	200	5	7	1	1	(1,1,5,7)	55.2	24
a_{23}	7	11 or 12	2.5 or 3	150	5	7	1	3	(1,3,5,7)	47.7	31
a_{24}	7	11 or 12	2.5 or 3	125	5	7	1	6	(1,5,6,7)	35.2	38
a_{25}	8	11 or 12	2.5 or 3	200	8	7	1	1	(1,1,7,8)	36	37
a_{26}	8	11 or 12	2.5 or 3	150	8	7	1	3	(1,3,7,8)	28.5	42
a_{27}	8	11 or 12	2.5 or 3	125	8	7	1	6	(1,6,7,8)	16	46
a_{28}^*	*5 or 6*	*14*	*1.5 or 2*	*200*	*1*	*1*	*2*	*1*	*(1,1,1,2)*	*84*	*5*
a_{29}	5 or 6	14	1.5 or 2	150	1	1	2	3	(1,1,2,3)	76.5	10
a_{30}	5 or 6	14	1.5 or 2	125	1	1	2	6	(1,1,2,6)	64	18
a_{31}	7	14	1.5 or 2	200	5	1	2	1	(1,1,2,5)	71.2	12
a_{32}	*7*	*14*	*1.5 or 2*	*150*	*5*	*1*	*2*	*3*	*(1,2,3,5)*	63.7	*19*
a_{33}	7	14	1.5 or 2	125	5	1	2	6	(1,2,5,6)	51.2	28
a_{34}	*8*	*14*	*1.5 or 2*	*200*	*8*	*1*	*2*	*1*	*(1,1,2,8)*	*52*	*27*
a_{35}	8	14	1.5 or 2	150	8	1	2	3	(1,2,3,8)	44.5	32
a_{36}	8	14	1.5 or 2	125	8	1	2	6	(1,2,6,8)	32	40
a_{37}	5 or 6	13 or 15	1.5 or 2	200	1	4	2	1	(1,1,2,4)	73.33	11
a_{38}	5 or 6	13 or 15	1.5 or 2	150	1	4	2	3	(1,2,3,4)	65.83	17
a_{39}	5 or 6	13 or 15	1.5 or 2	125	1	4	2	6	(1,2,4,6)	53.33	25
a_{40}	*7*	*13 or 15*	*1.5 or 2*	*200*	*5*	*4*	*2*	*1*	*(1,2,4,5)*	60.53	*20*
a_{41}	7	13 or 15	1.5 or 2	150	5	4	2	3	(2,3,4,5)	53.03	26
a_{42}	7	13 or 15	1.5 or 2	125	5	4	2	6	(2,4,5,6)	40.53	34
a_{43}	8	13 or 15	1,5 or 2	200	8	4	2	1	(1,2,4,8)	41.33	33
a_{44}	8	13 or 15	1.5 or 2	150	8	4	2	3	(2,3,4,8)	33.83	39
a_{45}	8	13 or 15	1.5 or 2	125	8	4	2	6	(2,4,6,8)	21.33	43
a_{46}	5 or 6	11 or 12	1.5 or 2	200	1	7	2	1	(1,1,2,7)	52	27
a_{47}	5 or 6	11 or 12	1.5 or 2	150	1	7	2	3	(1,2,3,7)	44.5	32
a_{48}	5 or 6	11 or 12	1.5 or 2	125	1	7	2	6	(1,2,6,7)	32	40
a_{49}	7	11 or 12	1.5 or 2	200	5	7	2	1	(1,2,5,7)	39.2	35
a_{50}	7	11 or 12	1.5 or 2	150	5	7	2	3	(2,3,5,7)	31.7	41
a_{51}	7	11 or 12	1.5 or 2	125	5	7	2	6	(2,5,6,7)	19.2	45
a_{52}	8	11 or 12	1.5 or 2	200	8	7	2	1	(1,2,7,8)	20	44
a_{53}	8	11 or 12	1.5 or 2	150	8	7	2	3	(2,3,7,8)	12.5	47
a_{54}	8	11 or 12	1.5 or 2	125	8	7	2	6	(2,6,7,8)	0	48

* Offers from the Reference Set
Italicized offers used in the example

Table 17 Negotiation offers from the template and their evaluations with the application of the MARS procedure

a_i	Resolution levels of issues				MARS				$L(a_i)$	Rank
					Score from 0–100 scale					
	f_1	f_2	f_3	f_4	JCS_{i1}	JCS_{i2}	JCS_{i3}	JCS_{i4}		
a_1^*	5 or 6	14	2.5 or 3	200	100	100	100	100	0.00	1
a_2^*	*5 or 6*	*14*	*2.5 or 3*	*150*	*100*	*100*	*100*	71.43	28.57	*3*
a_3^*	5 or 6	14	2.5 or 3	125	100	100	100	28.57	71.43	9
a_4^*	*7*	*14*	*2.5 or 3*	*200*	42.86	*100*	*100*	*100*	57.14	*7*
a_5	7	14	2.5 or 3	150	42.86	100	100	71.43	85.71	11
a_6	7	14	2.5 or 3	125	42.86	100	100	28.57	128.57	18
a_7^*	8	14	2.5 or 3	200	0	100	100	100	100.00	13
a_8	8	14	2.5 or 3	150	0	100	100	71.43	128.57	18
a_9	8	14	2.5 or 3	125	0	100	100	28.57	171.43	27
a_{10}^*	5 or 6	13 or 15	2.5 or 3	200	100	57.14	100	100	42.86	5
a_{11}	5 or 6	13 or 15	2.5 or 3	150	100	57.14	100	71.43	71.43	9
a_{12}	*5 or 6*	*13 or 15*	*2.5 or 3*	*125*	*100*	57.14	*100*	28.57	114.29	*15*
a_{13}	7	13 or 15	2.5 or 3	200	42.86	57.14	100	100	100.00	13
a_{14}	7	13 or 15	2.5 or 3	150	42.86	57.14	100	71.43	128.57	18
a_{15}	7	13 or 15	2.5 or 3	125	42.86	57.14	100	28.57	171.43	27
a_{16}	8	13 or 15	2.5 or 3	200	0	57.14	100	100	142.86	21
a_{17}	8	13 or 15	2.5 or 3	150	0	57.14	100	71.43	171.43	27
a_{18}	8	13 or 15	2.5 or 3	125	0	57.14	100	28.57	214.29	33
a_{19}^*	*5 or 6*	*11 or 12*	*2.5 or 3*	*200*	*100*	14.29	*100*	*100*	85.71	*11*
a_{20}	5 or 6	11 or 12	2.5 or 3	150	100	14.29	100	71.43	114.28	15
a_{21}	5 or 6	11 or 12	2.5 or 3	125	100	14.29	100	28.57	157.14	24
a_{22}	7	11 or 12	2.5 or 3	200	42.86	14.29	100	100	142.85	20
a_{23}	7	11 or 12	2.5 or 3	150	42.86	14.29	100	71.43	171.42	26
a_{24}	7	11 or 12	2.5 or 3	125	42.86	14.29	100	28.57	214.28	32
a_{25}	8	11 or 12	2.5 or 3	200	0	14.29	100	100	185.71	30
a_{26}	8	11 or 12	2.5 or 3	150	0	14.29	100	71.43	214.28	32
a_{27}	8	11 or 12	2.5 or 3	125	0	14.29	100	28.57	257.14	36
a_{28}^*	*5 or 6*	*14*	*1.5 or 2*	*200*	*100*	*100*	92.86	*100*	7.14	*2*
a_{29}	5 or 6	14	1.5 or 2	150	100	100	92.86	71.43	35.71	4
a_{30}	5 or 6	14	1.5 or 2	125	100	100	92.86	28.57	78.57	10
a_{31}	7	14	1.5 or 2	200	42.86	100	92.86	100	64.28	8
a_{32}	*7*	*14*	*1.5 or 2*	*150*	42.86	*100*	92.86	71.43	92.85	*12*
a_{33}	7	14	1.5 or 2	125	42.86	100	92.86	28.57	135.71	19
a_{34}	*8*	*14*	*1.5 or 2*	*200*	*0*	*100*	92.86	*100*	107.14	*14*
a_{35}	8	14	1.5 or 2	150	0	100	92.86	71.43	135.71	19

Table 17 continued

a_i	Resolution levels of issues				MARS Score from 0–100 scale				L(a_i)	Rank
	f_1	f_2	f_3	f_4	JCS_{i1}	JCS_{i2}	JCS_{i3}	JCS_{i4}		
a_{36}	8	14	1.5 or 2	125	0	100	92.86	28.57	178.57	29
a_{37}	5 or 6	13 or 15	1.5 or 2	200	100	57.14	92.86	100	50.00	6
a_{38}	5 or 6	13 or 15	1.5 or 2	150	100	57.14	92.86	71.43	78.57	10
a_{39}	5 or 6	13 or 15	1.5 or 2	125	100	57.14	92.86	28.57	121.43	17
a_{40}	*7*	*13 or 15*	*1.5 or 2*	*200*	42.86	57.14	92.86	*100*	107.14	*14*
a_{41}	7	13 or 15	1.5 or 2	150	42.86	57.14	92.86	71.43	135.71	19
a_{42}	7	13 or 15	1.5 or 2	125	42,86	57.14	92.86	28.57	178.57	29
a_{43}	8	13 or 15	1,5 or 2	200	0	57.14	92.86	100	150.00	23
a_{44}	8	13 or 15	1.5 or 2	150	0	57.14	92.86	71.43	178.57	29
a_{45}	8	13 or 15	1.5 or 2	125	0	57.14	92.86	28.57	221.43	35
a_{46}	5 or 6	11 or 12	1.5 or 2	200	100	14.29	92.86	100	92.85	12
a_{47}	5 or 6	11 or 12	1.5 or 2	150	100	14.29	92.86	71.43	121.42	16
a_{48}	5 or 6	11 or 12	1.5 or 2	125	100	14.29	92.86	28.57	164.28	25
a_{49}	7	11 or 12	1.5 or 2	200	42.86	14.29	92.86	100	149.99	22
a_{50}	7	11 or 12	1.5 or 2	150	42.86	14.29	92.86	71.43	178.56	28
a_{51}	7	11 or 12	1.5 or 2	125	42.86	14.29	92.86	28.57	221.42	34
a_{52}	8	11 or 12	1.5 or 2	200	0	14.29	92.86	100	192.85	31
a_{53}	8	11 or 12	1.5 or 2	150	0	14.29	92.86	71.43	221.42	34
a_{54}	8	11 or 12	1.5 or 2	125	0	14.29	92.86	28.57	264.28	37

* Offers from the Reference Set
Italicized offers used in the example

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