IMPACT OF UNCERTAINTY WHEN NEGOTIATING WITH SUPPLIERS

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Abstract

Handling the uncertainty in decision-making is always a challenge in practice. This holds also when choosing the most suitable strategy towards suppliers. In this situation, the time when the negotiation is done makes the decision even more difficult. This study builds on Trumić and Zapletal (2023) where the decision-making model has been built. However, this study focusses on the role of variability in opinions in more detail. The goal of this paper is twofold. First, the best strategy is explored with respect to time and uncertainty. Second, it is pointed out how much oversimplifying and distorting the aggregation of opinions using the averaging operator can be. The study works with the results of a large survey conducted in an automotive company. Stochastic multi-criteria acceptability analysis (SMAA) is used to get the results.

Keywords: Suppliers, negotiation, uncertainty, SMAA, AHP

1. INTRODUCTION

Decision-making is intrinsic to many organizations and individuals who utilize methods to assess the impact on the company, themselves, and the environment. Decisions can vary considerably depending on the level of certainty or uncertainty the decision-maker encounters. Also, the framework of the decisions may change over time, so that conditions decided today may be decidedly different in the future. Using an actual example from the automotive industry, we examine how changes in cost management can be influenced before and after a supplier selection.

When looking to the literature, many studies focusing on the supplier management have already been published. However, the most popular is to seek the best (or suitable) suppliers into portfolio [1], negotiation model finding the quantities to order [2], or their combination like, e.g., [3]. In this study, we assume that the selection of suppliers is already done (and cannot be further changed). Then, no precise price bids and quantities are not known yet, thus the model just propose a general strategy which should be adopted before and after a supplier is nominated

A multi-criteria decision model, selecting the most suitable strategy towards suppliers, is presented. This paper builds on the study presented by [4] where the model has been introduced for the first time. This paper also exploits a great survey done at one car manufacturing company, which has already been used in [4]. Unlike this study, the goal is not to do the ranking of the alternatives, but rather to deeply explore the impact of uncertainty which impacts the problem. This uncertainty is two-fold. First, each individual opinion is potentially uncertain (all criteria in the model are nominal). Second, the variability in opinions has potential impact on the final recommendation.

In [4], the fuzzy-AHP method was used to find the best behaviour towards suppliers of a car manufacturer. This paper uses a different method. Namely, the Stochastic Multi-criteria Acceptability Analysis [5] is used. The motivation for this choice is that the optimal strategy obtained by the Fuzzy-AHP in [4] was surprisingly unambiguous. SMAA together with the AHP method will help us to explore whether this unambiguity was caused by the fact that the solution is really absolutely clear, or if it was brought by a simplifying aggregation operator which was used to aggregate individual opinions together.

The remainder of the paper is organized as follows. Section 2 introduces the necessary methodological background of the AHP method and SMAA method. Section 3 recalls the model taken over from Trumić and Zapletal (2023). The core part is Section 4, where the results of SMAA-AHP method are provided, discussed and compared with the results of the Fuzzy-AHP method presented by Trumić and Zapletal (2023).

2. METHODOLOHICAL BACKGROUND

If one has a decision problem where k criteria are used to assess n alternatives, we talk about a multi-criteria decision-making problem (MCDM). A huge number of MCDM methods exist. For this study, we have decided for the combination of the AHP [6] and SMAA [5]. The first one is extremely popular and allows to handle qualitative criteria easily (and this type of criteria is used in this study exclusively). The choice of the AHP is supported also by the possibility to use pair-wise comparisons for evaluation. The SMAA method will help to deeply explore an effect of uncertainty.

In order to keep the length of this paper acceptable, both methods will be rather outlined than completely described. An interested reader can look at many descriptions in the literature.

AHP

The AHP is based on Saaty's matrices. The Saaty's matrix pair wisely compare either the importance between two criteria, or performance between two alternatives in terms of a given criterion. The matrix for weights' determination will be of size $k \times k$ and each of k matrices comparing the alternatives will be of size $n \times n$. Each Saaty's matrix must be reciprocal and its elements must belong to the Saaty's scale (the values from 2 to 9 to express the preferences in favour of an entity in a row over an entity in the column, and their reciprocals to express the opposite preference; 1 is used for equal preferences). Before the priorities are derived, each Saaty's matrix should be checked for the consistency, e.g., using the consistency ratio, see [6]. The weights w_i from the Saaty's matrix are calculated using (1), the utilities u_{ij}, revealing the performance of the *j*-th alternative in terms of the criterion *i*, would be analogical.

$$w_i = \frac{\prod_{j=1}^{k} s_{ij}}{\sum_{m=1}^{k} \prod_{j=1}^{k} s_{mj}}. \quad (1)$$

The ranking is determined according to the value of total utilities of alternatives:

$$U_i = \sum_{j=1}^{k} w_j \cdot u_{ij}, i = 1, \ldots, n. \quad (2)$$

SMAA

In SMAA, all evaluations are considered stochastic. Thus, it is necessary to start with the definition of all random variables. In the next step, the Monte Carlo simulation is done to get a large number of scenarios revealing all possible combinations of evaluations which can possible occur based on the random input data. Using these scenarios, many useful results can be derived using some of MCDM methods, like, e.g., the acceptability index (the probability that an alternative is ranked the first or at other positions), the central weight vector (the mean values of the criteria weights of the favourable first rank), or the confidence factor (the probability that an alternative with the preferences, corresponding to the central weight vector, would be ranked the first). For more details about the method, see, e.g., [7].

3. DECISION MODEL

This section recalls the decision model introduced by [4]. The criteria as well as the alternatives (strategies) have been defined expertly based on the interviews done at the same car manufacturing company where the survey for the case study was performed. The structure of the model is supported by [8]. Despite the model has been proposed based on the expert opinions from the automotive company, it does not use any criterion, nor strategy, which could not be reasonably expectable in case of any industrial company.

CRITERIA

The following criteria for evaluations are considered:

- Speed of implementation,
- Complexity,
- Capacity effort,
- Setting of premises,
- Internal know-how,
- Output.

The **speed** of implementation is a very important factor in the selection of the tools. It is very important how fast each topic can be implemented in practice; how **complex** the topics are in the preparation and how much **capacity** must be used in terms of man power and time. Furthermore, it is also very important whether **premises** can be set for the respective topic. For example, if premises are kept too coarse and generous in a change catalogue, the costs cannot be precisely defined. A precise and detailed definition of the premises also enables a detailed statement of costs for a specific measure. It is also important to ask whether the **know-how** is available internally. The employees and their experience are essential. Employees from development and purchasing can bring the topics into the tools from Lessons Learned. These topics have to be evaluated by the supplier. Finally, **output** is the last also very important criteria. It may be that everything can be implemented very fast, with low capacity and high know-how, but if the output is small or it brings little savings, the focus is usually placed on another topic. All six criteria are considered categorial (qualitative).

ALTERNATIVES

Alternatives in the presented model are three particular strategies which can be adopted by a company. These strategies can rarely be applied separatelly, but their combination with different “power” is expected to be used:

- Change catalogue or pre-negotiation of possible changes in the future,
- Improvement of the technical requirements and specifications,
- A decrease of the overhead and profit surcharge or a question whether the used „Surcharge calculation” by many OEMs, is future oriented.

The use of a **change catalogue** after nomination can be useful for example, to negotiate changes better and more effectively. A high-quality change catalogue is developed in close cooperation between the purchasing and development teams.

When specifying the details and **quality of the specifications**, the company can avoid many changes through the development of the product in the future, so that the change catalogue can be made redundant or at least greatly reduced in complexity.

The third main strategy, when trying to reduce the costs of product development and its delivery, is a decrease of **overhead** and profit surcharges. Many OEMs use a surcharge calculation as a calculation base. The calculation uses the bottom-up approach to calculate the cost components and then add the overhead and profit surcharges as a percentage of the material and production costs. This is primarily determined during the nomination and agreed with the supplier. [4]

4. CASE STUDY

In this section begins with the introduction of the input data. Then, the results obtained by [4] of the implementation of the fuzzy-AHP approach to the presented model. The core part of this section focuses on the results of the application of the hybrid AHP-SMAA method. The results of both methods are carefully compared and the recommendations are provided.

Input data

In this paper, we present the implementation of the model on the data brought by the survey in a single car-manufacturing company. Namely, 113 managers (out of approximately 500) from the fields of purchase and logistics have been asked (in the autumn, 2022) to evaluate the importance of criteria and performance of the alternatives using the Saaty's scale with the possibility to express their hesitance using the interval within the scale. All evaluations have had to be done twice – first for the period before nomination (before the contract is signed) and second after nomination.

Results

The authors of [4] applied the fuzzy-AHP method to the same dataset and get an unambiguous ranking of the alternatives, see **Fig. 1** and **Fig. 2**.

Leading up to the supplier decision before nomination, it is crucial to prioritize the development of a cost catalogue, while defining highly detailed technical specifications is of lesser importance. This is reasonable because negotiating the list of changes with the best conditions is only possible before the contract is signed. Good prices for the future changes after signing a contract cannot be expected. The reason why these future changes should be negotiated before the contract is signed is the better power position of purchasing and the leverage to be able to place the order with another supplier.

For the period after nomination, the ranking obtained by [4] is also unambiguous, but it differs substantially. The most important tool is the overhead, followed by the technical requirements and the catalogue of changes. After the nomination, the lever towards the suppliers is gone and purchasing loses its position of power. For this reason, the prioritization of the change catalogue slipped to third place after a nomination, which is also understandable, because negotiating the change costs after the nomination makes little sense.

The results seem to be absolutely clear at the first glance, since the triangular fuzzy sets in the figure do not overlap anywhere. However, these results were based on the aggregation of the individual uncertain opinions using the (fuzzy-) geometric mean, and as for any other use of an aggregation operator, a part of information is potentially lost.

The results of the application of the hybrid AHP-SMAA method are provided in **Fig. 3**. Namely the acceptability indices for all three positions of the strategies before and after the nomination are provided there. For the situation after nomination, the results are not so surprising. Despite each strategy can potentially be ranked at all positions, 3% of cases are omittable for both, the first position of "Change catalogue" and the last position of "Overhead". These results were expectable under knowledge of the Fuzzy-AHP results in **Fig. 2**. The results before nomination are much more interesting. It can be seen that the most frequent individual ranking need not necessarily correspond with the aggregated ranking. Technical requirements are ranked in almost 50% as the second one, however, according to aggregated results, this alternative is clearly the last one. "Overhead" was ranked using the aggregated opinion as clearly second but the AHP-SMAA analysis revealed that this position is the least frequent at all. The results show how much simplifying the aggregation can be, despite the included uncertainty.

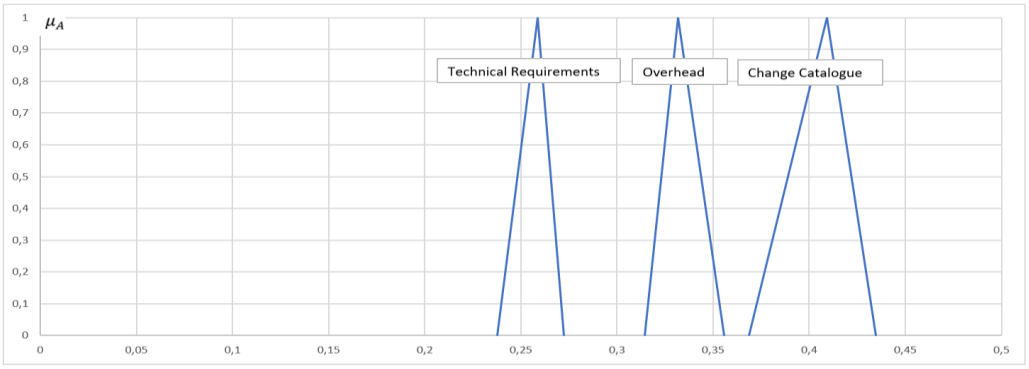

Figure 1 Final results of alternatives before the nomination [Trumić and Zapletal (2023)]

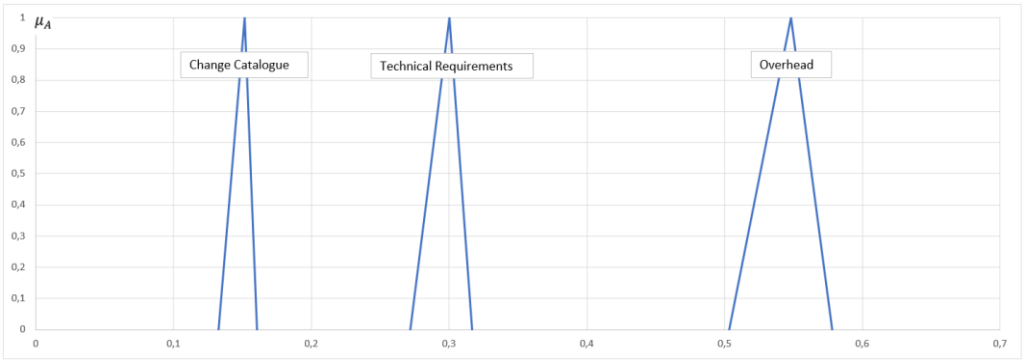

Figure 2 Final results of alternatives after the nomination [Trumić and Zapletal (2023)]

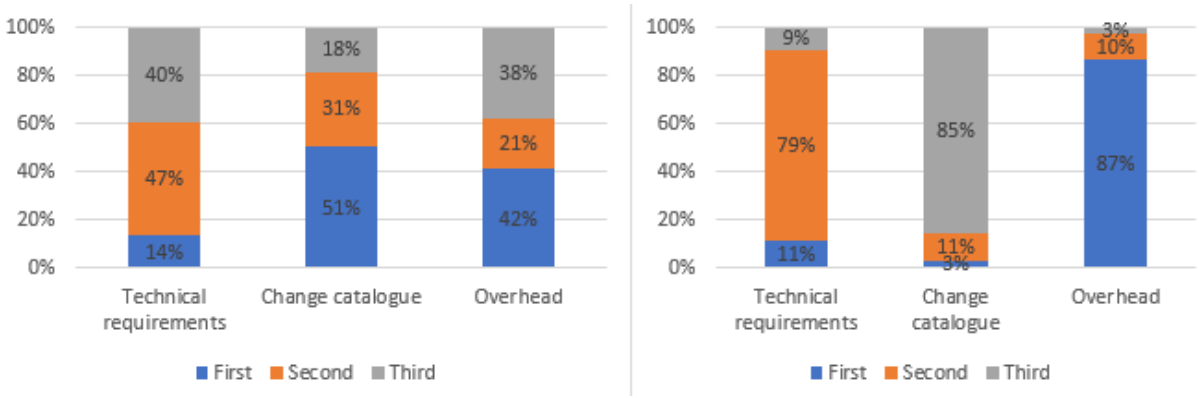

Figure 3 Final results of alternatives before (left) and after (right) the nomination

Table 1 Central weight vector for the results before nomination

Top ranked/criterion	Speed	Complexity	Capacity	Premises	Know-how	Output
Change catalogue	0.32	0.20	0.09	0.05	0.07	0.27
Technical requirements	0.29	0.22	0.12	0.06	0.08	0.23
Overhead	0.30	0.19	0.13	0.06	0.07	0.26

The results of the AHP-SMAA method pointed out how unwise would be to focus only on the “winning” strategy and ignore the remaining two strategies.

Since the ranking of the strategies before the nomination is by far more ambiguous, the central weight vector for this situation was calculated, see the results in **Tab. 1**. The weights in this table represent the mean value

of weights when one of the strategies is ranked the first. This analysis reveals to what extent the first position depends on the weights of criteria. It can be seen that the average weights of some criteria are the same or very similar, regardless the winning strategy (premises, know-how). On the other hand, the mean weights differ significantly (the statistical significance has been checked using the Mann-Whitney test in IBM SPSS statistics), like in the case of speed (the highest priority if change catalogue wins), complexity (the highest priority if technical requirements wins), and output (the highest priority is assigned to this criterion if change catalogue or overhead are ranked the first).

5. CONCLUSIONS

In this paper, the model deciding on the best strategy towards the suppliers, presented by [4] was solved using absolutely different approach. Instead of the aggregation of the individual opinions to get a single result, all individual opinions are taken into account, including the hesitance of the individuals. The results showed that despite the aggregated ranking can seems to be clear and unambiguous, the analysis of the individual evaluations can possibly reveal a completely different picture. The study showed that, based on the data gathered in the survey, the choice of the best strategy before nomination is done is more difficult in comparison with the situation after nomination. A disadvantage of the detailed results is that there are not so easy to interpret as the aggregated results. If the proportions for alternatives are too similar, some additional analysis would be necessary. For example, the individuals could be more segmented to understand the variability of the rankings, the average values of the criteria weights for each ranking could be explored, etc. The further research will be focused on better understanding of highly variable rankings of the alternatives and exploring the impact of various product types.

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