EVALUATION OF SUPPLIERS' QUALITY AND SIGNIFICANCE BY METHODS BASED ON WEIGHTED ORDER

Jan Bezecný
VSB - Technical University of Ostrava, 17. listopanu 21/1572, 708 33 Ostrava-Poruba,
Czech Republic, EU, jan.bezecny@vsb.cz (corresponding author)

Petr Besta
VSB - Technical University of Ostrava, 17. listopanu 21/1572, 708 33 Ostrava-Poruba,
Czech Republic, EU, petr.besta@vsb.cz

Tomáš Sezima
T. G. Masaryk Water Research Institute, Department of Water and Waste Management, Macharova 5,
702 00 Ostrava, Czech Republic, EU, tomas.sezima@vuv.cz

Dominika Stoch
VSB - Technical University of Ostrava, 17. listopanu 21/1572, 708 33 Ostrava-Poruba,
Czech Republic, EU, dominika.stoch@vsb.cz

Kamila Janovská
VSB - Technical University of Ostrava, 17. listopanu 21/1572, 708 33 Ostrava-Poruba,
Czech Republic, EU, kamila.janovska@vsb.cz

Tomáš Malčic
VSB - Technical University of Ostrava, 17. listopanu 21/1572, 708 33 Ostrava-Poruba,
Czech Republic, EU, tomas.malcic@vsb.cz

Adam Drastich
VSB - Technical University of Ostrava, 17. listopanu 21/1572, 708 33 Ostrava-Poruba,
Czech Republic, EU, adam.drastih@vsb.cz

Abstract: The efficiency of the purchasing process co-decides on the success of the production organization. One of the basic tools for quality purchasing management is the selection and evaluation of suppliers. We can use a wide range of tools to evaluate suppliers, and this evaluation can be based on a large and diverse set of criteria. In the case of evaluating many potential suppliers according to a number of criteria, it is not possible to rely solely on the intuitive nature of the evaluation. Therefore, managerial tools based on the mathematical principles of multi-criteria decision-making have been increasingly important. The article deals with the analysis of the realized research focused on the use of mathematical methods in the evaluation of suppliers in an industrial enterprise. This article aims to analyse the possibility to use tools based on determining weighted order when evaluating suppliers. Data obtained from the research in a selected industrial enterprise in the Czech Republic was used for evaluation.

1 Introduction

Purchasing can be defined as the management of the organization's activities related to ensuring inputs for efficient work within the following processes. Given that the quality of the products that the organization can provide for its customers depends on the quality of the products it can get from its suppliers, purchasing is considered to be the core of business activities. Employees responsible for the implementation of purchasing activities must meet a wide range of knowledge in different areas (technical product specifications, legislative requirements, organization, language skills) and must have extraordinary personal abilities (communication, creation and maintenance of interpersonal relationships, high morale and loyalty to the organization) [1].

A prerequisite for efficient purchasing process is perfect knowledge of organization needs, flexible market analysis, effective management of the process following the vision, strategy and goals of the organization, effective work with suppliers [1].

Purchasing strongly affects the competitiveness of the organization. The purchase of low-quality or high-cost raw materials can negatively affect asserting the product on the market even before it is launched. Improving the quality of the purchasing process is fundamentally related to effective cooperation with suppliers [2]. It is also essential to collect and evaluate information about suppliers and compare their offers. We can use a variety of different procedures and methods to evaluate suppliers. One way of evaluating suppliers is to use multi-criteria decision-making methods [3,4]. These tools allow the synthesis of a broader range of criteria, and the resulting evaluation is then based on a multidimensional basis. The aim of the article is the experimental use of multicriteria decision-making tools for

supplier evaluation. The evaluation is carried out for a selected manufacturing company in the Czech Republic. Three major long-term suppliers were included in the evaluation.

2 Evaluation tools

Evaluation of suppliers using multi-criteria decision-making methods is based on the quantification of a broader range of criteria. Manufacturing companies prefer primarily the criteria that affect the economic or business results of the enterprise. These criteria also affect the final product quality. In general terms, we can classify criteria for supplier evaluation into the following groups:

- criteria relating to products,
- criteria relating to the services provided,
- criteria relating to price and contractual conditions,
- criteria evaluating supplier behaviour and approach [1].

The specific form and number of criteria naturally affects the nature of the product but also the specifics of the given industrial area. In the application of multi-criteria decision-making tools, the first step, following the determination of the criteria being evaluated, is to determine their significance (weights). One of the ways to determine the weight is to use the scoring method. This method is one computationally less-demanding methods. However, the quality of the results is subject to the subjective nature of decision-making. The method is also referred to as 100 point allocation. The problem is that the solver needs to be able to perform a quantitative evaluation of the criteria importance. However, this is often very difficult due to the variety of criteria being followed with the value of bi in the given scale. The more important the criterion is, the higher the score. The solver does not have to choose only integers from a given scale but can assign the same value to even more criteria. The scoring method requires a quantitative evaluation of the criteria by the solver but allows a more differentiated expression of subjective preferences. Criteria weigh is determined according to formula (1).

$$v_i = \frac{b_i}{\sum_{i=1}^{k} b_i}, i = 1,2,...,k \qquad (1)$$

where: v_i - criterion weight.
b_i - value of the respondent's preferences

After determining weighs of the individual criteria, it is possible to use the multi-criteria decision-making tool for the analysis of specific suppliers (variants). For example, we can use the weighted order method [5]. This method is based on the weighted average of partial variants according to the individual criteria. The optimal variant is the one with the largest total weight. The principle of the method is that, for all criteria, their ranking is determined in terms of the degree of fulfilment of the individual criteria. Criteria values are therefore translated into their order in view of the quality for the given criterion [5]. This order then enters the overall rating, which also takes into account the weighting of individual criteria. In the first step, we first determine a partial evaluation of variants in terms of each criterion (h_{ij}), according to the relation (2).

$$h_{ij} = m + 1 - p_{ij} \qquad (2)$$

where: h_{ij} - evaluation of the variance according to each criterion,
m - the total number of variants,
p_{ij} - order value.

The calculation of the total value of the individual variants (H_j) is performed according to the relation (3).

$$H_j = \sum_{i=1}^{n} v_i \times h_{ij} \qquad (3)$$

where: n – the total number of criteria
v_i – criterion weight.
h_{ij} - evaluation of the variance according to each criterion,

The cumulative value thus determined represents the quality of a particular variant (supplier). We then rank the evaluated suppliers in descending order according to this value.

3 Experimental work

In the framework of the research carried out, three suppliers were also compared in a selected industrial enterprise. Seven key criteria were selected for the evaluation. All criteria, together with specific values for individual suppliers, are given in Table 1.

Criteria selection was made by purchasing department staff. In the first step, the 15 criteria used were selected. Within the framework of the workshop, the seven most important ones were selected. Using assembled descending order.

In the first step, the normalized weights of the individual criteria ⟨0.1⟩ were determined. Weights were determined using the scoring method. The individual criteria were evaluated on a point-rated basis, and a specific weight was determined using the relationship (1).

The scales were determined by a group of 20 experts. Everyone has expressed their preferences. Point values are determined as an arithmetic mean (rounded).

Table 1 Input values for the criteria for three selected suppliers

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	Criteria	Supplier 1	Supplier 2	Supplier 3
K_1	Price ($)	840	790	920
K_2	Maturity (days)	45	30	90
K_3	Quality (1-10)	9	8	10
K_4	Service (%)	85	90	89
K_6	Consignment (1-3)	1	1	2
K_6	Delivery date (days)	1	3	2
K_7	Supplier benefits (1-10)	7	8	9

The determined weights are shown in Table 2. The highest importance was assigned to criterion 1, i.e. the price of the product. In the second place, criterion 4 (service) was placed. The determined weights were further used in the evaluation of the individual suppliers.

Table 2 Criteria point rating

Criterion	K_1	K_2	K_3	K_4	K_5	K_6	K_7	$\sum$
Number of points	20	11	16	19	18	14	2	100
Weight	0.20	0.06	0.16	0.19	0.18	0.19	0.02	1

The input values of the criteria as listed in Table 1 were subsequently transformed into descending order. For criterion 1 (prices), for example, the values were ranked according to the advantage of individual suppliers. The lowest price quotation was marked as best (supplier 2). In the same way, a ranking of the values for all other criteria was performed. Specific information on the order of the criteria for the monitored suppliers is given in Table 3.

Table 3 Order of the criteria according to the input values

	Criteria	Supplier 1	Supplier 2	Supplier 3
		Ranking		
K_1	Price	2.	1.	3.
K_2	Maturity	2.	3.	1.
K_3	Quality	2.	3.	1.
K_4	Service	2.	1.	3.
K_6	Consignment	2.	2.	1.
K_6	Delivery date	1.	3.	2.
K_7	Supplier benefits	3.	2.	1.

An assembled order of criteria is the basis for using the weighted order method. This method was applied to the monitored suppliers. Table 4 shows the process, solution and final evaluation.

Table 4 Comparison of suppliers using the weighted order method

Criterion	V_i	Supplier 1			Supplier 2			Supplier 3		
		p_{i1}	h_{i1}	V_ih_{i1}	p_{i2}	h_{i2}	V_ih_{i2}	p_{i3}	h_{i3}	V_ih_{i3}
K_1	0.20	2.	2	0.40	1.	3	0.60	3.	1	0.20
K_2	0.06	2.	2	0.12	3.	1	0.06	1.	3	0.18
K_3	0.16	2.	2	0.32	3.	1	0.16	1.	3	0.48
K_4	0.19	2.	2	0.38	1.	3	0.57	3.	1	0.19
K_5	0.18	2.	2	0.36	2.	2	0.36	1.	3	0.54
K_6	0.19	1.	3	0.57	3.	1	0.19	2.	2	0.38
K_7	0.02	3.	1	0.02	2.	2	0.04	1.	3	0.06
$\sum$				2.17			1.98			2.03
Order of suppliers				1.			3.			2.

Table 4 shows decompositionally the solution process for all three suppliers. Column V_i indicates the specified weights for each criterion. For each rated supplier, the order of the given criterion (p_i), the supplier's rating for each criterion (h_i) and the finite value calculation for a particular criterion (V_ih_i) are listed in Table 4. The sum of

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the final values of all the criteria is a crucial parameter for the evaluation. Based on this value, suppliers are then ranked in descending order. The formula (2) and (3) were used to calculate the values. The last row of Table 4 lists the final ranking of suppliers.

4 Results and discussion

Rating providers were analysed on the basis of seven relevant criteria. For all criteria, their weight was first determined. For the comparison of the suppliers, the weighted order method was used experimentally. The final order is shown in Table 4. Supplier 1 was determined as the most appropriate supplier based on the quantifiable criteria values. Here it is possible to mention that, from the point of view of the assembled order of criteria, this supplier ranked first only with one criterion (K6). In other cases, the values of all the criteria were ranked second (except for K7, which was ranked third). In general, however, this supplier's offer is the best one on the basis of the applied process. The second was Supplier No. 3 (2.03) and Third Supplier 2 (1.98), according to Table 4. The order of the individual criteria for these suppliers was largely inhomogeneous. In many cases, providers were evaluated as the best according to the selected criteria, but according to other criteria, they were assessed as the worst. If we were to make a strategic choice of a supplier, it is possible to recommend using supplier No. 1 on the basis of the analysed data and the applied procedure. However, it will always be crucial to take into account all the specifics of the given industrial area.

5 Conclusions

In the framework of the realized research, we used the principle of weighted order for the suppliers' evaluation, and for the weighting of the criteria, we used the method of evaluating on a point-rated basis. Both tools offer an interesting alternative for supplier ratings. A significant advantage is the low algorithmic requirements of both methods. At the same time, it is possible to synthesise a larger number of categorically different criteria in one indicator. Based on the above procedure, it is possible to identify the best variant (supplier), but also to assemble their order. In the case of difficult decision-making, one or more suppliers can be selected. It is often preferable to buy from multiple sources, eliminating dependence on only one supplier and making it possible to compare. This can make a significant contribution to improving the quality of the purchasing process. The efficiency of purchasing raw materials thus clearly promotes the competitiveness of the product and the organization.

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