SELECTION OF SUSTAINABLE SUPPLIERS IN AGRICULTURAL ENTERPRISES[1]

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Abstract

The aim of the work was to select sustainable suppliers for the agricultural enterprise according to predetermined criteria. The subject of choice was mineral fertilizer, given that the company is registered for the production and sale of grain wholesale and retail. For the purpose of selection, we used multi-criteria decision-making, that is, the MABAC method of multi-criteria decision-making. The decision makers were employed engineers in the company in question. The work focused on five suppliers and ten criteria, and the criteria "pollution control" and "quality" received the highest value when evaluating the criteria. The results showed that the fifth selected supplier best met the set criteria. Future research should be based on the development of new decision-making methods in order to make rational decisions that are particularly important for this sector of the economy.

Key words: *Suppliers, multi-criteria decision-making, MABAC method, agricultural enterprise, sustainability*

Introduction

Organizational sustainability plays an important role in every company and has attracted a lot of attention in the last thirty years. This certainly includes a rational and sustainable choice of suppliers that would satisfy environmental interests in addition to economic interests. The choice of a sustainable supplier plays a special role in agribusiness, i.e. with economic entities from agriculture, due to the very specificity of the final products, as well as its supply and sales channels.

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With the development of higher stages of processing as well as the use of conventional methods of processing and protection, concern for the environment grows, and the social responsibility of the holders of the organization in production and trade increases. On this occasion, as Puška and Maksimović (2016) point out, among the choice of suppliers, environmental protection is increasingly emphasized. That choice implies the inclusion of quantitative and qualitative criteria, which by their nature can be limited by various restrictions, and very often contradict each other. For this purpose, multi-criteria decision-making methods have a logical use.

The choice of suppliers, i.e. the acquisition of a certain necessary means of production, represents the primary function of every organization, so choosing the best supplier is one of the most important issues in a competitive environment (Kannan et al., 2013).

Considering the previous statement, the goal of the work would be the selection of a sustainable supplier for an agricultural company. The company, which is the subject of the work in this case, is located in the wider area of the city of Novi Sad and is engaged in primary agricultural production and trade in agricultural products. The goal of the work is to choose a supplier of seed goods for the upcoming sowing with an emphasis on environmental protection and a higher degree of sustainability in the phase of supplying the necessary goods.

In recent research, we have found numerous examples of domestic and foreign authors of supplier selection in agriculture and agribusiness, precisely using multi-criteria decision-making methods. (Qureschi et al., 2018; Alaoui et al., 2019; Balezentis et al., 2020; Maksimović et al., 2021; Kieu et al., 2021; Nedeljković et al., 2021; Nedeljković et al., 2022; Nedeljković et al., 2023; Puška et al., 2022; Puška et al., 2022a) When it comes to the sustainability of suppliers in agribusiness, some authors also apply multi-criteria decision-making methods. (Miranda-Ackerman, 2019; Ramakrishnan and Chakraborty, 2020; Kazemitash et al., 2021; Tirkolaee et al., 2021; Puška et al., 2021; Ecer, 2022) Thus Nedeljković (2022a) by applying fuzzy logic of multi-criteria decision making in one agricultural company in the area of the municipality of Bijeljina selects the supplier that best meets 13 set criteria, some of which related exclusively to sustainability and environmental protection (Safety and health, Pollution control, Waste management, Recycling, Green product). Also, the same author, in his work (Nedeljković, 2022b), using the DEMATEL method of multi-criteria decision-making, ranks the criteria important for choosing the most favorable supplier. For this purpose, it considers criteria related to environmental management system, green product, pollution control, recycling, eco design. Puška et al. (2023) in their study on the example of agribusiness companies choose a sustainable supplier and for this purpose use the new fuzzy multi-criteria decision-making method TRUST CRADIS. Choosing the most favorable supplier strengthened the sustainable strategy of the company in question, as well as demonstrated the successful application of the multi-criteria decision-making method used.

Certainly, increasing sustainability in procurement must be accompanied by legal regulations at the state level, that is, encouraged within its formal framework. As concluded by Vasiljević et al. (2015), in the period after 2000 until today, agriculture has not been characterized by a clear strategy for development, so it would be necessary to do more in that field as well.

Research methodology

We used the MABAC (Multi-Attributive Border Approximation area Comparison) method of multi-criteria decision-making as a working method. The method was developed by Pamučar and Ćirović (2015) and actually defines the distance of the criterion function of each of the observed alternatives from the marginal fair value. The reason for using this method lies in the fact that it is relatively new, easy to use and currently less popular in this subject area in our country. Its authors define the following steps of this method:

Step 1: Formation of the initial decision matrix (X)

$$= \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_m \end{matrix} \overset{\begin{matrix} C_1 & C_2 & \dots & C_n \end{matrix}}{\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}}$$

Step 2: Normalization of the element of the initial decision matrix (X)

$$N = \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_m \end{matrix} \overset{\begin{matrix} C_1 & C_2 & \dots & C_n \end{matrix}}{\begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1n} \\ n_{21} & n_{22} & \cdots & n_{2n} \\ \dots & \dots & \dots & \dots \\ n_{m1} & n_{m2} & \cdots & n_{mn} \end{bmatrix}}$$

a) For benefits type criteria

$$n_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-}$$

b) For cost type criteria

$$n_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+}$$

Step 3: Calculation of the weight matrix element (V)

$$V_{ij} = w_i g(n_{ij} + 1)$$

Step 4: Determination of the matrix of boundary approximate surfaces (G)

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{\frac{1}{m}}$$

Step 5: Calculation of elements of alternative distance matrices from the limit approximate domain (Q)

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix}$$

Step 6: Ranking of alternatives

$$S_i = \sum_{j=1}^{n} q_{ij} \quad j = 1,2,\dots,n \quad i = 1,2,\dots,m$$

In this case, the joint decision-makers were five employed engineers in the company, which normally has around 60 employees of various profiles. The weights of the given criteria in the paper were determined by the popular AHP method of multi-criteria decision making.

Results

Table 1 provides an overview of the criteria used (assigned) in the work. The criteria were obtained using a review of the relevant literature that was discussed in the previous chapters of the paper, and were informally divided into criteria related to the economic-technical aspect of business, as well as criteria related to their sustainability. Each of these criteria should meet its maximum or minimum.

Table 1. Research Criteria

Criterion label (C)	Criterion	Criteria Type
C1	Price	Minimum
C2	Quality	Maximum
C3	Costs of transport	Minimum
C4	Delivery time	Minimum
C5	Techological capacities	Maximum
C6	Sustainable management standards	Maximum
C7	Pollution control	Maximum
C8	Ecological production design	Maximum
C9	Environmentally acceptable materials	Maximum
C10	Reducing resource consump-tion	Maximum

Source: Authors

To evaluate the linguistic statements of the decision makers, we used the values shown in the following table 2. Based on the linguistic scale, the decision makers in this case, experts (engineers) from the subject area gave a summary assessment of the given criteria.

Table 2. Linguistic scale of values

Evaluation of criteria	Linguistic scale
1	VP-Very Poor
2	P-Poor
3	M-Medium
4	G-Good
5	VG-Very Good

Source: Đalić et al., 2020

After calculating the weights of the criteria, we notice that the greatest importance is given to the criteria “quality” as “pollution control”. Immediately afterwards, “price” and “delivery time” were evaluated as important criteria. The weighting coefficients ranged from 0.03 to 0.22. The next steps in the work concerned the normalization of the decision-making matrix (table 4), as well as the weighting of the normalized decision-making matrix (table 5).

Table 3. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	2	4	3	5	4	3	2	2	5	4
A2	3	2	4	4	3	3	3	2	4	3
A3	4	3	3	2	3	3	3	4	4	4
A4	3	3	4	3	3	2	3	3	3	2
A5	5	4	5	4	4	4	4	4	5	5
Weight	**0,12**	**0,22**	**0,09**	**0,12**	**0,07**	**0,09**	**0,18**	**0,05**	**0,03**	**0,03**
Max.	5	4	5	5	4	4	4	4	5	5
Min.	2	2	3	2	3	2	2	2	3	2

Source: Authors

Table 4. Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	1	1	1	0	1	0,5	0	0	1	0,66
A2	0,66	0	0,5	0,33	0	0,5	0,5	0	0,5	0,5
A3	0,33	0,5	1	1	0	0,5	0,5	1	0,5	0,66
A4	0,66	0,5	0,5	0,66	0	0	0,5	0,5	0	0
A5	0	1	0	0,33	1	1	1	1	1	1

Source: Authors

Table 5. Weighted Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0,24	0,44	0,18	0,12	0,14	0,135	0,18	0,05	0,06	0,0498
A2	0,1992	0,22	0,135	0,1596	0,07	0,135	0,27	0,05	0,045	0,045
A3	0,1596	0,33	0,18	0,24	0,07	0,135	0,27	0,1	0,045	0,0498
A4	0,1992	0,33	0,135	0,1992	0,07	0,09	0,27	0,075	0,03	0,03
A5	0,12	0,44	0,09	0,1596	0,14	0,18	0,36	0,1	0,06	0,06
Gi	0,1787	0,3414	0,1396	0,1709	0,092	0,1318	0,2637	0,0715	0,0465	0,0457

Source: Authors

In the following, the distance of the alternatives from the approximate range of limit values was calculated (table 6), and finally the suppliers (alternatives) were ranked (table 7). As we can see, the fifth supplier performed best, that is, it is the supplier that best meets the set criteria and was therefore selected.

Table 6. Distance of the Alternatives from the BBA

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0,0613	0,0986	0,0404	-0,0509	0,0477	0,0032	-0,0837	-0,0215	0,0135	0,0041
A2	0,0205	-0,1214	-0,0046	-0,0113	-0,0223	0,0032	0,0063	-0,0215	-0,0015	-0,0007
A3	-0,0191	-0,0114	0,0404	0,0691	-0,0223	0,0032	0,0063	0,0285	-0,0015	0,0041
A4	0,0205	-0,0114	-0,0046	0,0283	-0,0223	-0,0418	0,0063	0,0035	-0,0165	-0,0157
A5	-0,0587	0,0986	-0,0496	-0,0113	0,0477	0,0482	0,0963	0,0285	0,0135	0,0143

Source: Authors

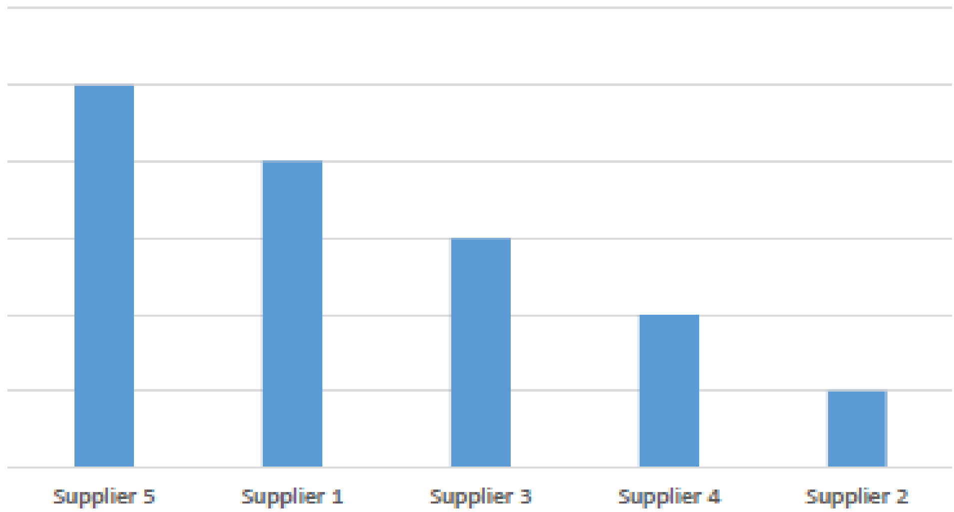
Table 7. Ranking alternatives (Suppliers)

Si	**Rank**
0,1127	**2**
-0,1533	**5**
0,0973	**3**
-0,0537	**4**
0,2275	**1**

Source: Authors

A visual representation of the order (ranking) of suppliers after the necessary calculations is given in the following chart 1.

Graph 1. Supplier ranking



Conclusion

The choice of suppliers, that is, the supply chain, represents a complex process for every company in today's market economy. For this reason, and according to pre-defined standards, it is necessary to satisfy certain criteria of an economic and technical nature, as well as recently increasingly authentic standards of sustainability. In the previous example, the selection of the most favorable supplier for seed goods in an agricultural company was made in the paper, and the fifth supplier proved to be the best supplier. For the purpose of selection, the multi-criteria decision-making method (MABAC) was used, which proved to be a real solution for such situations, given that certain criteria are in conflict with each other. The most highly rated criterion was the quality of the goods, and the fact that the pollution control criterion was recognized as one of the most important criteria is also pleasing. The work represents a realistic basis for future research in this area, as well as an opportunity to improve existing and introduce new multi-criteria research methods, especially when it comes to the procurement sector in agriculture and agribusiness.

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