SCIENTIFIC REVIEW

SELECTION OF SUPPLIERS IN AN ALTERNATIVE FOOD NETWORK

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ABSTRACT

In this study, the selection of suppliers within an alternative food supply network for fruits and vegetables, specifically Box Schemes, was conducted using multi-criteria decision-making methods. The Entropy-MABAC method was used as the multi-criteria decision-making approach, and the research focused on five suppliers from the city of Novi Sad. Eleven socio-economic criteria were chosen for the research to identify the most favourable supplier. The results indicate that the criterion "product character," i.e., whether the final agricultural product is organic or conventional, was rated the highest, and the first supplier was selected as the most favourable. These results provide a solid foundation for future research, which should focus on further examining the impact of supply methods on end consumers of agricultural products within the alternative food network and developing new methods to aid in selecting the most favourable supplier.

Keywords: *Food, suppliers, multi-criteria decision-making, Entropy method, MABAC method*

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INTRODUCTION

In recent years, alternative methods of food supply have garnered significant professional and scientific attention. Research on this topic has been emerging since the early 2000s, as seen in the works of various authors [23] [24] [22] [13] [25][30][31][32]. These studies emphasized the potential for local rural development, sustainability, and the direct connection between farmers and consumers. Over time, the need for alternative ways to supply end consumers with food became more pronounced compared to the established supply chain channels, which were often characterized by various forms of monopolies held by large food conglomerates, wholesalers, and corporations. The emergence of this type of supply aimed to activate local human potential, further connect individual producers with consumers, and thereby support local agricultural producers, leading to further agricultural and rural development. According to [5], alternative food networks can renew connections between producers by separating political relationships and strengthening sales activities through technical and friendly relationships, thereby encouraging cooperation towards innovation. Additionally, these forms of supply can play a crucial role in linking rural and urban areas, particularly due to their ability to connect economies with the demands of urban consumers living nearby [3]. As noted by [26], the establishment of alternative food networks contributes to the development of sustainable and ecologically responsible production, not only through production approaches but also by reducing transportation distances, energy consumption, and building substantial social capital based on trust, which functions as a mechanism creating coherence and facilitating cooperation among participants in the chain. According to [2], alternative food networks are predominantly oriented from the bottom up in the supply chain, involving customers who operate outside industrial global supply chains [9]. However, some authors argue that their conceptualization is still insufficient due to various organizational parameters [11][27]. Thus, some authors emphasize the simultaneous use of multiple sales markets, the size of the farms participating in the chain, distance, the integration of organic and traditional practices with the use of modern information and communication methods, and so forth. [14] [17] [28] [12].

As consumers increasingly value the quality and traceability of locally produced food, a new profitable market niche has emerged, involving a sales method where farmers directly send products to consumers' homes. These are typically recognizable packages with an emphasis on ecologically produced items. This method of supply, known as Box Schemes, has already become well-established in developed markets of Western Europe, such as Denmark, Austria, and the Netherlands. According to [6], through this supply method, consumers should be aware that purchasing local food impacts biodiversity and landscapes, local employment, trade, and social justice. [4] studied commercial Box Schemes in England and France and found that consumers were motivated by the positive contributions to the ecosystem, quality, and satisfaction.

Based on the previously mentioned context, a selection of such suppliers within the Box Schemes in the territory of Novi Sad was carried out, aiming to choose the most favorable one based on the established criteria. These are fruit and vegetable producers located within a 50-kilometer radius, who have been supplying their end consumers for about ten years. In the continuation of the work and within the methodological framework of the research, the criteria for the selection of these suppliers will be presented. This will be based on the expert group opinions of regular and potential customers of the products, using multi-criteria decision-making methods.

RESEARCH METHODOLOGY

In previous research by various domestic and foreign authors, the emphasis was placed on suppliers and their selection, with criteria based on sustainability and quality. These suppliers provided goods and services in agribusiness from both narrow and broader regions [15] [29] [20] [18] [19]. In all these studies, the application of multi-criteria decision-making proved to be justified.

Additionally, for the purposes of this research, the multi-criteria decision-making method MABAC (*Multi-Attributive Border Approximation Area Comparison*) will be used, while the Entropy method (*entropy weight method*) will be utilized to determine the weights of the criteria. The steps of these methods are presented below:

The first step represents the standardization of the measured values based on the following statement [10] [16]:

$$P_{ij} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}$$

The entropy value of Ei index is defined as [7]:

$$E_i = \frac{\sum_{j=i}^{n} P_{ij} \cdot \ln P_{ij}}{\ln n}$$

While the final weight by the Entropy method is calculated as [1]:

$$w_i = \frac{1 - E_i}{\sum_{i=1}^{m} (1 - E_i)}$$

For selecting the offered alternatives, the MABAC method was used. This method was developed by [21] and is relatively easy to use, thus its utilization will further popularize it. The method defines the distance of the criterion function of each given alternative from the boundary fair value. Its steps are defined as follows:

Step 1: The initial decision matrix (X)

$C_1 \;\; C_2 \;\; \dots \; C_n$

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

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

$C_1 \;\; C_2 \;\; \dots \; C_n$

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

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

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

RESEARCH RESULTS

In comparison to previous experiences, 11 criteria were established based on which ten end consumers, or their families, selected the most favorable supplier. The products included a wide range of fruits and vegetables from this region. The criteria were divided into economic and social categories, aiming for minimization in some and maximization in others. The overview of these criteria is provided in the following Table 1:

Table 1. The criteria used

ID	Criteria	Explanation
C1	Price	Price: The amount paid for the offered product.
C2	Payment terms	Payment terms: The method of payment to the supplier.
C3	Product quality	Product quality: Taste, durability, and resilience of the supplier's products.
C4	Distance	Distance: Proximity of the supplier of the product.
C5	Product characteristics	Product characteristics: Conventional and organic origin of the products.
C6	Farm size	Farm size: Scale and size of the farm from which the products originate.
C7	Variety of offerings	Variety of offerings: Range and types of products offered.
C8	Freshness of products	Freshness of products: Harvesting schedule for products intended for local consumers.
C9	Environmental impact	Environmental impact: Adherence to ecological standards in production and delivery.
C10	Social character of the supplier	Social character of the supplier: Participation of the workforce in supplier activities, respect for labor rights, involvement in local social activities.
C11	Supplier's reputation/brand image	Supplier's reputation/brand image: Past good production practices and experience.

Source: Authors

To convert linguistic values into quantitative ones, we used values from the following Table 2. After assessing the criteria by decision-makers, and in order to determine their weighting values, an initial decision matrix was formed (Table 3). Through its normalization (Table 4) and further calculations, we obtained the necessary weights for the given criteria (Table 5).

Table 2. Linguistic scale of values

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

Source: [8]

Table 3. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	3,9	3,3	4,3	4,1	4,3	3,7	3,8	4	4	4,2	3,5
A2	3,4	3,1	3,5	4	3,5	3,4	3	4	3,4	4,1	3,6
A3	3,6	3,7	3,9	3,8	3,6	3,8	3,4	3,8	3,5	4	3,7
A4	3,7	3,6	3,6	4,1	3,6	3,8	3,8	4,2	4	4	3,8
A5	3,4	2,9	4	4,2	3,2	3,5	3,5	4	3,2	4	3,8
$\sum$	**18**	**16,6**	**19,3**	**20,2**	**18,2**	**18,2**	**17,5**	**20**	**18,1**	**20,3**	**18,4**

Source: Authors

Table 4. Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	0,2166	0,1987	0,2227	0,2029	0,2362	0,2032	0,2171	0,2	0,2209	0,2068	0,1902
A2	0,1888	0,1867	0,1813	0,1980	0,1923	0,1868	0,1714	0,2	0,1878	0,2019	0,1956
A3	0,2	0,2228	0,2020	0,1881	0,1978	0,2087	0,1942	0,19	0,1933	0,1970	0,2010
A4	0,2055	0,2168	0,1865	0,2029	0,1978	0,2087	0,2171	0,21	0,2209	0,1970	0,2065
A5	0,1888	0,1746	0,2072	0,2079	0,1758	0,1923	0,2	0,2	0,1767	0,1970	0,2065

Source: Authors

Table 5. Decision variable (W_i)

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	-0,3313	-0,3211	-0,3345	-0,3236	-0,3408	-0,3238	-0,3316	-0,3218	-0,3336	-0,3259	-0,3156
A2	-0,3148	-0,3133	-0,3096	-0,3206	-0,3170	-0,3134	-0,3023	-0,3218	-0,3141	-0,3230	-0,3191
A3	-0,3218	-0,3345	-0,3231	-0,31428	-0,3205	-0,3270	-0,3183	-0,3155	-0,3177	-0,3200	-0,3225
A4	-0,3251	-0,3314	-0,3132	-0,3236	-0,3205	-0,3270	-0,3316	-0,3277	-0,3336	-0,3200	-0,3257
A5	-0,3148	-0,3048	-0,3261	-0,3265	-0,3056	-0,3170	-0,3218	-0,3218	-0,3063	-0,3200	-0,3257
$\sum$	-1,6080	-1,6053	-1,6066	-1,6088	-1,6046	-1,6084	-1,6057	-1,6089	-1,6054	-1,6092	-1,6089
$\boldsymbol{E_i}$	0,9991	0,9974	0,9982	0,9996	0,9970	0,9993	0,9977	0,9996	0,9975	0,9998	0,9996
$\boldsymbol{1-E_i}$	0,0008	0,0025	0,0017	0,0003	0,0029	0,0006	0,0022	0,0003	0,0024	0,00019	0,0003
$\sum$	0,014580421										
$\boldsymbol{W_i}$	0,0588	0,1738	0,1174	0,02423	0,2046	0,0427	0,1558	0,0213	0,1713	0,0082	0,0214
Rank	6	2	5	8	**1**	7	4	10	3	11	9

Source: Authors

From the previous table, we observed that the ranking order is such that the criterion "product characteristics" received the highest score. Immediately following are the criteria "payment terms" and then "environmental impact." From this, it is clear that consumers in the area of interest consider whether the products are obtained through organic or conventional production methods to be important. Additionally, the payment terms for the products play a significant role for them. It's interesting to note that the environmental impact of a product, i.e., whether certain ecological standards have been adhered to in its production and delivery, is considered more important than the price of the product itself.

In the continuation of the work, the selection of the actual supplier of agricultural products was carried out using the MABAC method. In the initial steps, the decision matrix was calculated (Table 6), followed by its normalization (Table 7).

Table 6. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	3,9	3,3	4,3	4,1	4,3	3,7	3,8	4	4	4,2	3,5
A2	3,4	3,1	3,5	4	3,5	3,4	3	4	3,4	4,1	3,6
A3	3,6	3,7	3,9	3,8	3,6	3,8	3,4	3,8	3,5	4	3,7
A4	3,7	3,6	3,6	4,1	3,6	3,8	3,8	4,2	4	4	3,8
A5	3,4	2,9	4	4,2	3,2	3,5	3,5	4	3,2	4	3,8
Max.	3,4	3,7	4,3	3,8	4,3	3,8	3,8	4,2	4	4,2	3,8
Min.	3,9	2,9	3,5	4,2	3,2	3,4	3	3,8	3,2	4	3,5

Source: Authors

Table 7. Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	1	0,5	1	0,75	1	0,75	1	0,5	1	1	0
A2	0	0,25	0	0,5	0,2727	0	0	0,5	0,25	0,5	0,3333
A3	0,4	1	0,5	0	0,3636	1	0,5	0	0,375	0	0,6666
A4	0,6	0,875	0,125	0,75	0,3636	1	1	1	1	0	1
A5	0	0	0,625	1	0	0,25	0,625	0,5	0	0	1

Source: Authors

After the normalization of the decision matrix, the obtained values were multiplied by the weights of all criteria (Table 8), and the deviation from the given alternatives was calculated (Table 9), resulting in the final ranking of the suppliers (Table 10).

Table 8. Weight Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
W_i	0,0588	0,1738	0,1174	0,0242	0,2046	0,0427	0,1558	0,0213	0,1713	0,0082	0,0214
A1	0,1177	0,2608	0,2348	0,0424	0,4093	0,0747	0,3116	0,0319	0,3426	0,0164	0,0214
A2	0,0588	0,2173	0,1174	0,0363	0,2605	0,0427	0,1558	0,0319	0,2141	0,0123	0,0286
A3	0,0824	0,3477	0,1761	0,0242	0,2791	0,0854	0,2337	0,0213	0,2355	0,0082	0,0358
A4	0,0941	0,3260	0,1321	0,0424	0,2791	0,0854	0,3116	0,0426	0,3426	0,0082	0,0429
A5	0,0588	0,1738	0,1908	0,0484	0,2046	0,0533	0,2532	0,03197	0,1713	0,0082	0,0429
g_i	0,0794	0,2568	0,1649	0,0377	0,2793	0,06589	0,2457	0,0312	0,2519	0,0102	0,0335

Source: Authors

Table 9. Distance of the Alternatives from the BAA

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
A1	0,0383	0,0040	0,0699	0,0046	0,1300	0,0088	0,0659	0,0007	0,0907	0,006	-0,0117
A2	-0,0205	-0,0394	-0,0474	-0,0014	-0,0188	-0,0231	-0,0898	0,0007	-0,0377	0,0020	-0,0046
A3	0,0029	0,0909	0,0112	-0,0135	-0,0002	0,0195	-0,0119	-0,0099	-0,0163	-0,0020	0,0025
A4	0,0147	0,0692	-0,0328	0,0046	-0,0002	0,0195	0,0659	0,0114	0,0907	-0,0020	0,0097
A5	-0,0205	-0,0829	0,0259	0,0107	-0,0746	-0,0124	0,0075	0,0007	-0,080	-0,0020	0,009

Source: Authors

The ranking order of suppliers in the given Box Schemes is such that according to the specified criteria, the most favourable supplier is the first one. Immediately after them is the fourth supplier, followed by the third, fifth, and finally, the second supplier, which was rated the lowest. (Table 10).

Table 10. Ranking of the suppliers

S_i	Rank
0,407668	**1**
-0,28034	**5**
0,073258	**3**
0,250908	**2**
-0,21866	**4**

Source: Authors

CONCLUSION

From the foregoing, it can be concluded that alternative food supply networks are increasingly gaining importance, with one of its variants being Box Schemes. These alternative networks present opportunities for local development in economic and social terms. In support of this, the study attempted to derive some guidelines for further development of this supply method using a sample of 10 consumers and 5 suppliers. It was observed that the product characteristics (organic and conventional) play a crucial role in selecting the supplier, as well as the payment terms for end-users. The application of multi-criteria decision-making has proven to be a useful tool for this type of research, where further development of these methods would contribute to a more successful analysis of decision factors among users and future development of local activities.

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