Nedeljković, M., Puška, A., Pamučar, D., Marinković, D. (2024). Selection of agricultural product sales channels using fuzzy double MEREC and fuzzy RAWEC method. Agriculture and Forestry, 70 (3): 45-58. https://doi.org/10.17707/AgricultForest.70.3.03

DOI: 10.17707/AgricultForest.70.3.03

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SELECTION OF AGRICULTURAL PRODUCT SALES CHANNELS USING FUZZY DOUBLE MEREC AND FUZZY RAWEC METHOD

SUMMARY

When selling food products, it's important to choose the appropriate sales channel. These channels connect producers with consumers. The aim of this study was to select a channel for the sale of cabbage to end customers. In this paper, six different sales channels that are used in the Semberija region for the sale of cabbage were observed. These sales channels were evaluated using 11 different criteria. In order to choose the sales channel that best meets the set objectives, a fuzzy set approach was used. This approach was chosen because qualitative criteria were used and expert ratings were in the form of linguistic values. Based on the input of seven experts who are professors at agricultural faculties in Bijeljina, it was found that consumer habits were the most important criterion, followed by the criterion compliance with environmental standards, while the smallest weight value was given to the criterion delivery method. Using the RAWEC (Ranking of Alternatives with Weights of Criterion) method, it was shown that online sales yield the best results, after that follows Producer-sales agent-consumer, while according to experts, the sales channel is the best rated Producer-wholesaler-retailer-consumer. This is because various tools can be utilized on the Internet for selling agricultural products. Based on the conducted research, the contribution of this study lies in the selection of sales channels using the integration of the MEREC and RAWEC methods.

Keywords: Sales Channels; Agricultural Products; fuzzy set; RAWEC method; MEREC method.

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Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.
Recieved:03/06/2024 *Accepted:19/09/2024*

INTRODUCTION

Agricultural products are food products and have a limited shelf life (Jiuhardi, et al., 2022). In order to maintain their nutritional values, it is necessary to deliver these products to end customers as soon as possible (Ndori Queku, et al., 2024). This is done using sales channels. These sales channels can be different and include all intermediaries from the producer to the buyer (Milford et al., 2021). However, it is also possible to sell products directly from the manufacturer to the customer (Podlevska, and Podlevskyi 2023). With the application of new technologies, the number of these sales channels is increasing (Hartmann and Lussier, 2020). Due to the diversity of sales channels, it is necessary to choose the one that can deliver products to customers in the best way (Volvach, 2023).

To address this decision-making problem, the example of selling cabbage in the Semberija region in North-eastern Bosnia and Herzegovina was used. In this region, agricultural activity constitutes a key element of its development (Nedeljković et al., 2023). In addition, this region is known for the production of cabbage throughout Bosnia and Herzegovina, so it is necessary to develop an efficient system of distribution of these products to final customers. Choosing an adequate sales channel helps farmers to achieve higher revenues and maintain economic stability in their operations (Khan et al., 2022). These channels facilitate connecting agricultural producers with customers, generating revenue through sales, and contributing to the overall development of the region.

The motivation behind this research is to provide suggestions to cabbage farmers regarding which sales channels to use in order to improve their businesses. This is because there are fewer and fewer agricultural producers in Semberija, so it's necessary to enhance this production to improve agricultural output and raise the standard of living for farmers. In this way, the number of agricultural producers will also increase. Solving the choice of sales channels can help in this regard, but it's necessary to strategically work on improving the conditions prevailing in agriculture.

The choice of sales channel falls under the realm of decision-making problems (Zheng et al., 2021), where it's necessary to select from available alternatives the one that best satisfies the established criteria. In this decision-making problem, there are several alternatives considered against multiple criteria, making it a multi-criteria decision-making (MCDM) issue (Rahman, 2023). These decision-making problems are practically addressed using methods for multi-criteria decision-making (MCDM) (Tešić et al., 2024). Based on the foregoing, this study aims to use multi-criteria analysis methods to select a sales channel that will help agricultural producers achieve higher revenues. Additionally, auxiliary objectives of the study are as follows:

- Evaluate various sales channels for agricultural products.
- Examine how specific sales channels can be utilized in selling cabbage to end consumers.
- Assess sales channels based on expert ratings.

- Select a sales channel that will help cabbage producers in Semberija achieve higher revenues.

Based on these set objectives, the following contributions are achieved in this study:

- Providing guidance to cabbage producers on which sales channels to use in order to achieve higher revenues.
- Developing fuzzy RAWEC (Ranking of Alternatives with Weights of Criterion) methods.
- Developing double fuzzy MEREC (Method based on the Removal Effects of Criteria) methods for objectively determining the weight of criteria.
- Developing methodologies based on double normalization.

To achieve the goals of this study, expert decision-making based on linguistic values will be utilized. These values will be employed due to the fact that qualitative criteria have been utilized (Wang et al., 2024; Sahoo et al., 2024). Assessment of these criteria is conducted through the application of linguistic values, as they are more adaptable to human thinking compared to numerical values (Phulara et al., 2024). It is easier to assess whether something is good or not rather than determining the precise value of that alternative (Kannan et al, 2024; Kizielewicz and Sałabun, 2024).

This paper also develops a new decision-making model based on double normalization. The RAWEC method, in its original form, employs two normalizations to obtain the ranking order of alternatives: normalization where all criteria are transformed into maximum criteria and normalization where all criteria are transformed into minimum criteria. The MEREC method utilizes minimum normalization, transforming all criteria into minimum criteria. Therefore, in this study, the fuzzy MEREC method will be applied twice, using both of these normalizations. This approach will involve employing two different sets of criteria weights in ranking the alternatives.

MATERIAL AND METHODS

When evaluating different cabbage sales channels, using the example of Semberija, the methodology presented in Figure 1 will be applied. In practice, there are numerous criteria and alternatives, so the study encompasses 6 alternatives and 11criteria.

When selecting alternatives, the focus was on identifying cabbage sales channels currently available in the Semberija region. Therefore, six different sales channels were considered:

- Producer-consumer (SC1). Represents a direct sales format where there are no intermediaries involved in the sale.
- Producer-wholesaler-retailer-consumer (SC2). This sales channel involves the insertion of a wholesaler between the producer and the consumer.

- Producer-wholesaler-retailer-consumer (SC3). In this sales channel format, there are two intermediaries involved: the wholesaler and the retailer.
- Producer-sales agent-consumer (SC4). This sales channel involves a sales agent who acts as an intermediary between the producer and the consumer.
- Online sales (SC5). This channel involves various online tools to connect producers with consumers.
- Sales through brokers (SC6). Involves a broker as an intermediary who sells products from the producer to the consumers.

To evaluate these sales channels, the following criteria are used:

- Product characteristics (C1). Represent the basic properties of the product being sold (Nedeljković et al., 2023; Thilmany et al., 2021).
- Sales reliability (C2). Reflects the consistency and reliability in fulfilling orders (Simms et al., 2022).
- Financial situation (C3). Reflects the liquidity and profitability of a specific sales channel (Nedeljković et al., 2023; Đalić et al., 2020).
- Consumer habits (C4). Relates to preferences and patterns in purchasing agricultural products (Đalić et al., 2020; Pang and Chen, 2024).
- Sales costs/commissions (C5). This criterion pertains to all costs associated with product distribution and promotion, which may include transportation, storage, marketing, and sales activities (Dong et al., 2021; Wang et al., 2024).
- Geographic concentration (C6). This criterion relates to focusing sales activities on a specific geographical area to sell products more efficiently and reduce logistics costs (Nedeljković et al., 2023; Đalić et al., 2020).
- Product range (C7). This criterion pertains to the ability to sell a variety of products through sales channels, allowing the producer to adapt to customer needs (Milford et al., 2021; Fałkowski and Chlebicka, 2021).
- Delivery method (C8). Refers to how products are delivered from the producer to the consumer, including the choice of transportation, delivery routes, and logistics management (Prashar et al., 2020; Markowska et al., 2023).
- Delivery volume (C9). This criterion concerns the quantity of products that can be conveyed through a specific sales channel within a certain time frame. The greater the quantity, the more efficient the sales channel (Tadić and Veljović, 2021; Erfurth and Bendul, 2018).
- Sales sustainability (C10). Relates to the application of sustainability strategies in the sales channel, considering ecology and future generations (Raimbekov et al., 2023; Mannarelli Filho, 2020).
- Compliance with environmental standards (C11). This criterion pertains to the adoption of ecological practices to preserve the environment and reduce the negative impacts of sales channels (Mihailović et al., 2017; Millet et al., 2020).

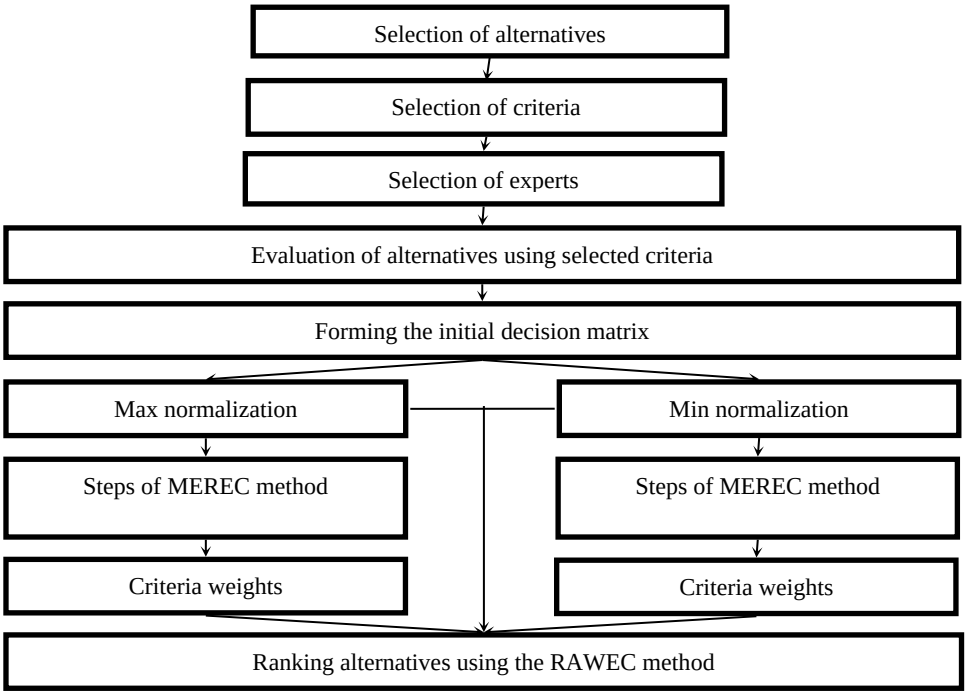

Figure 1. Research Methodology

After certain alternatives and criteria have been determined, it is necessary to evaluate these channels using these criteria. A total of 15 professors from agricultural faculties in Bijeljina were contacted to participate in this research. Out of these 15, seven professors agreed to participate.

After selecting the experts, the next step is to assess the listed sales channels based on the selected criteria. This assessment is done using linguistic values. It is easier to use linguistic values (good, bad, few, many) when evaluating rather than precisely determining how well a sales channel meets the set criteria. Based on this, they will provide ratings ranging from "very bad" to "very good" with seven levels of values (Table 1). To use these values in the evaluation of sales channels, fuzzy numbers need to be used. These numbers are formed by assigning certain fuzzy numbers to certain linguistic values using a membership function (Stević et al., 2022).

Table 1. Linguistic values and membership functions

Linguistic values	Membership function
Very bad (VB)	(0, 0, 1)
Bad (B)	(0, 1, 3)
Medium bad (MB)	(1, 3, 5)
Medium (M)	(3, 5, 7)
Medium good (MG)	(5, 7, 9)
Good (G)	(7, 9, 10)
Very good (VG)	(9, 10, 10)

Next follows the formation of the initial decision matrix. This matrix is the basis for conducting the steps of the MCDM method. It is formed by experts providing ratings for sales channels based on the established criteria. Since the experts' ratings are in the form of linguistic values, an initial linguistic decision matrix is formed, which is then transformed into a fuzzy initial decision matrix.

This research aims to reduce the subjective influence of experts on the importance of criteria, so the fuzzy MEREC method is used to objectively determine the criterion weights. The ranking of alternatives will be performed using the fuzzy RAWEC method, which employs two normalizations: maximum normalization and minimum normalization. Therefore, the next step after forming the fuzzy initial decision matrix is normalization. In this case, two normalizations will be performed, and for each of these normalizations, the fuzzy MEREC method will determine the criterion weights. Using this approach, two different criterion weights will be used in the fuzzy RAWEC method, representing an innovation in the previous application of MCDM methods.

The fuzzy MEREC method

The MEREC method was developed by Keshavarz-Ghorabaee et al., (2021). The steps of this method are as follows:

Step 1. Formation of the initial decision matrix.

Step 2. Normalization of the initial decision matrix.

Step 3. Calculation of the overall performance of alternatives. (S_i) (Ristić et al., 2024):

$$\tilde{S}_i = \ln\left(1 + \left(\frac{1}{m}\sum_j \left|\ln\left(\tilde{n}_{ij}^{x}\right)\right|\right)\right) \quad (1)$$

Step 4. Calculating the effects of alternatives for each criterion.

$$\tilde{S}'_{ij} = \ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} \left|\ln\left(\tilde{n}_{ik}^{x}\right)\right|\right)\right) \quad (2)$$

Step 5. Calculating the sum of absolute deviation values.

$$\tilde{E}_j = \sum_i \left|\tilde{S}'_{ij} - \tilde{S}_i\right| \quad (3)$$

Step 6. Calculating the final weights of criteria.

$$\widetilde{w}_j = \frac{\tilde{E}_j}{\sum_k \tilde{E}_k} \quad (4)$$

The fuzzy RAWEC method

The RAWEC method was developed to facilitate decision-making, as in its original form, this method consists of only four steps (Puška et al., 2024). The steps of this method are as follows:

Step 1. Formation of the linguistic decision matrix. It is necessary to transform linguistic values into fuzzy numbers (l, m, u) in order to proceed with the other steps of the fuzzy RAWEC method.

Step 2. Normalization of the decision matrix. When using normalization, two types of normalization are employed:

Maximum normalization

$$n_{ij} = \frac{x_{ij}^{l}}{\max x_j^u}, \frac{x_{ij}^{m}}{\max x_j^u}, \frac{x_{ij}^{u}}{\max x_j^u} \text{ ; for benefit criteria} \quad (5)$$

$$n_{ij} = \frac{\min x_j^{l}}{x_{ij}^{u}}, \frac{\min x_j^{l}}{x_{ij}^{m}}, \frac{\min x_j^{l}}{x_{ij}^{l}} \text{; for cost criteria} \quad (6)$$

Minimum normalization

$$n'_{ij} = \frac{\min x_j^{l}}{x_{ij}^{u}}, \frac{\min x_j^{l}}{x_{ij}^{m}}, \frac{\min x_j^{l}}{x_{ij}^{l}} \text{; for benefit criteria} \quad (7)$$

$$n'_{ij} = \frac{x_{ij}^{l}}{\max x_j^u}, \frac{x_{ij}^{m}}{\max x_j^u}, \frac{x_{ij}^{u}}{\max x_j^u} \text{ ; for cost criteria} \quad (8)$$

Where $x_{j\,min}$ – minimal value of each criterion, and $x_{j\,max}$ – maximum value of each criterion.

Step 3. Calculating the deviation from the criterion weight.

$$\tilde{v}_{ij} = \sum_{i=1}^{n} \tilde{w}_j \cdot \left(1 - \tilde{n}_{ij}\right) \quad (9)$$

$$\tilde{v}'_{ij} = \sum_{i=1}^{n} \tilde{w}_j \cdot \left(1 - \tilde{n}'_{ij}\right) \quad (10)$$

Where $\tilde{w}_j$ represents the weights obtained using the fuzzy MEREC method.

Step 4. Defuzzification of deviation from the criterion weight

$$v_{ij\,def} = \frac{v_i^{l} + 4v_i^{m} + v_i^{u}}{6} \quad (11)$$

$$v'_{ij\,def} = \frac{v'_i{}^{l} + 4v'_i{}^{m} + v'_i{}^{u}}{6} \quad (12)$$

Step 5. Calculating the value of the RAWEC method.

$$Q_i = \frac{v'_{ij} - v_{ij}}{v'_{ij} + v_{ij}} \quad (13)$$

Further details about the steps of these methods will be explained in the results of this research.

RESULTS AND DISCUSSION

The first step in both methods involves determining the initial decision matrix. This matrix is formed by evaluating the observed channels based on set criteria according to expert opinions. Experts have provided ratings in the form of linguistic values, thus forming the initial linguistic decision matrix (Table 2).

The next step is to transform these linguistic values into fuzzy numbers. This is done by applying the membership function (Table 1). Each linguistic value is thus transformed into the corresponding fuzzy number. By transforming linguistic values into fuzzy numbers, the initial fuzzy decision matrix is formed. Since seven initial decision matrices have been formed, one for each expert, it is necessary to form an aggregate decision matrix. This decision matrix is formed by calculating the average value. This way, each expert is given equal importance in the choice of sales channels.

Table 2. The initial linguistic decision matrix

E1	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
SC1	M	MB	MB	M	MB	B	MB	VB	B	MB	MB
SC2	MB	MB	MB	M	MB	MB	MB	MB	M	MB	M
SC3	MB	B	MB	M	VB	B	M	B	MB	MB	M
SC4	B	B	VB	MB	VB	M	MB	MB	MB	MB	M
SC5	VB	VB	B	B	B	M	MB	M	MB	MB	MB
SC6	MB	M	MB	M	M	MB	MB	B	M	B	MB
E2	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
SC1	M	MB	MB	MB	MB	B	MB	VB	VB	MB	MB
SC2	M	MB	MB	M	M	MB	B	MB	M	MB	MG
SC3	MB	B	M	MG	B	MB	M	MB	B	B	M
SC4	M	MB	VB	MB	MB	M	M	MB	MB	MB	MB
SC5	VB	VB	MB	B	B	MB	MB	MB	B	B	MB
SC6	MB	M	M	M	M	MB	MB	B	M	B	MB
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
E7	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
SC1	MB	MB	MB	MB	MB	B	MB	B	MB	M	MB
SC2	B	M	B	G	M	M	B	VB	M	VB	MB
SC3	B	MB	B	M	VB	B	B	VB	B	MB	B
SC4	M	MB	VB	B	MB	MB	VB	M	M	MB	B
SC5	VB	VB	B	B	VB	M	MB	MB	VB	MB	B
SC6	MB	M	M	M	B	MG	VB	B	M	B	MB

The next step is the normalization of the aggregate decision matrix. This normalization will be applied to both methods. Since the linguistic values are formed from 'very bad' to 'very good' and all criteria used are in the form of benefit criteria, expressions 5 and 7 are applied. For example, for the first criterion and the first alternative and the fourth alternative, the calculation of the normalized decision matrix is done as follows:

$$n_{11} = \frac{3.29}{10} = 0.33;\ \frac{5.29}{10} = 0.53;\ \frac{7.29}{10} = 0.73$$

$$n'_{11} = \frac{3.29}{7.29} = 0.45;\ \frac{3.29}{5.29} = 0.62;\ \frac{3.29}{3.29} = 1.00$$

$$n_{41} = \frac{5.29}{10} = 0.53;\ \frac{7.00}{10} = 0.70;\ \frac{8.29}{10} = 0.83$$

$$n'_{41} = \frac{3.29}{8.29} = 0.40;\ \frac{3.29}{7.00} = 0.47;\ \frac{3.29}{5.29} = 0.62$$

In maximum normalization of fuzzy values, they are divided by the highest value of the fuzzy number of the given criterion, while in minimum normalization; all fuzzy numbers are divided by the lowest value of the fuzzy number of the given criterion. It is necessary to emphasize that care must be taken so that the first fuzzy number is less than or equal to the second fuzzy number, while the second fuzzy number must be less than or equal to the third fuzzy number. Therefore, in minimum normalization, for the first fuzzy normalized number, the lowest value

is divided by the third fuzzy number, for the second fuzzy normalized number, the lowest value is divided by the second fuzzy number, while for the third fuzzy normalized number, the lowest value is divided by the first fuzzy number (expression 7). In this way, the normalized decision matrix is formed, and the steps of the selected methods are applied.

Since it is necessary to possess criterion weights for ranking, the calculation of criterion weights using the fuzzy MEREC method is performed first. Since this method has already been applied in many studies (Narang et al., 2023; Kousar et al., 2024; Wan et al., 2023), the steps of this method will not be further elaborated.

The next step of this method is to calculate the total performance of alternatives ($\tilde{S}_i$). This is done by first calculating the natural logarithms (ln) for all values, then computing the absolute values of these numbers, summing these values for the corresponding fuzzy numbers, dividing the obtained value by the number of criteria, adding one (1) to that value, and finally taking the natural logarithm of the resulting value. The calculation of the effects of alternative ($\tilde{S}'_{ij}$) is done in the same way, except that the value of the alternative for which this indicator is calculated is not included. This way, the effects are calculated without that value. Then, the sum of the deviations from the absolute values is calculated, where the values of the total performance of alternatives are subtracted from the values of the effects of alternatives, forming the absolute value of that value. Finally, the criterion weights are calculated. This procedure is applied to both normalized decision matrices, resulting in two weight values (Table 3). Based on the results of the fuzzy MEREC method, criterion C4 has the highest weight, indicating the highest importance in both calculations, while criterion C8 has the lowest weight. Based on these weight values, it can be said that the importance of criteria remains the same but the weight values have changed.

Table 3. The values of criterion weights

	w_j	w'_j
C1	(0.03, 0.09, 0.31)	(0.07, 0.15, 0.37)
C2	(0.03, 0.09, 0.30)	(0.08, 0.17, 0.41)
C3	(0.02, 0.08, 0.29)	(0.07, 0.16, 0.38)
C4	(0.06, 0.16, 0.52)	(0.14, 0.28, 0.68)
C5	(0.02, 0.08, 0.27)	(0.05, 0.13, 0.32)
C6	(0.03, 0.10, 0.33)	(0.06, 0.15, 0.37)
C7	(0.02, 0.08, 0.30)	(0.08, 0.16, 0.38)
C8	(0.01, 0.06, 0.23)	(0.04, 0.11, 0.27)
C9	(0.03, 0.09, 0.30)	(0.08, 0.17, 0.41)
C10	(0.02, 0.07, 0.28)	(0.07, 0.15, 0.36)
C11	(0.02, 0.10, 0.36)	(0.14, 0.26, 0.62)

After calculating the values of the weights, the selected sales channels are ranked using the fuzzy RAWEC method. After calculating the normalized decision

matrices, the deviations from the values of the criterion weights are calculated. For example, for the first alternative, this is done as follows:

$v_1 = [0.03 \cdot (1 - 0.73) + 0.03 \cdot (1 - 0.90) + 0.02 \cdot (1 - 0.91) + \cdots + 0.02 \cdot (1 - 0.95)] = 0.03;\ [0.09 \cdot (1 - 0.53) + 0.09 \cdot (1 - 0.70) + 0.08 \cdot (1 - 0.71) + \cdots + 0.10 \cdot (1 - 0.74)] = 0.47;\ [0.31 \cdot (1 - 0.33) + 0.30 \cdot (1 - 0.50) + 0.29 \cdot (1 - 0.51) + \cdots + 0.36 \cdot (1 - 0.53)] = 1.64$

$v'_1 = [0.07 \cdot (1 - 1.00) + 0.08 \cdot (1 - 0.60) + 0.07 \cdot (1 - 0.66) + \cdots + 0.14 \cdot (1 - 0.34)] = 0.37;\ [0.15 \cdot (1 - 0.62) + 0.17 \cdot (1 - 0.43) + 0.16 \cdot (1 - 0.47) + \cdots + 0.26 \cdot (1 - 0.24)] = 1.11;\ [0.37 \cdot (1 - 0.45) + 0.41 \cdot (1 - 0.33) + 0.38 \cdot (1 - 0.37) + \cdots + 0.62 \cdot (1 - 0.19)] = 3.08$

This way, values are calculated for all sales channels (Table 4). After calculating the deviations from the criterion weights, defuzzification of these values is performed to determine the final value of the fuzzy RAWEC method. For example, for the first sales channel, this is calculated as follows:

$$\mathrm{def}\, v_1 = \frac{0.03 + 4 \cdot 0.47 + 1.64}{6} = 0.592$$

$$\mathrm{def}\, v'_1 = \frac{0.37 + 4 \cdot 1.11 + 3.08}{6} = 1.313$$

By calculating the defuzzified value, the value of the fuzzy RAWEC method is computed. For example, for the first alternative, this is done as follows:

$$Q_1 = \frac{1.313 - 0.592}{1.313 + 0.592} = 0.379$$

Based on these results, according to expert opinions, the distribution channel SC5 (Online Sales) demonstrates the best performance, followed by SC4 (Manufacturer-Agent-Consumer), while SC2 (Manufacturer-Retailer-Consumer) achieved the poorest results.

Table 4. The results of the fuzzy RAWEC method

Id	$\tilde{v}$	$def\ v$	$\tilde{v}'$	$def\ v'$	Q_i	Rank
SC1	(0.03, 0.47, 1.64)	0.592	(0.37, 1.11, 3.08)	1.313	0.379	4
SC2	(0.06, 0.55, 1.89)	0.690	(0.22, 1.01, 2.95)	1.200	0.270	6
SC3	(0.04, 0.47, 1.60)	0.585	(0.39, 1.14, 3.09)	1.338	0.392	3
SC4	(0.03, 0.45, 1.55)	0.560	(0.42, 1.14, 3.09)	1.341	0.411	2
SC5	(0.02, 0.34, 1.21)	0.432	(0.46, 1.19, 3.14)	1.395	0.527	1
SC6	(0.05, 0.54, 1.86)	0.678	(0.30, 1.04, 2.98)	1.242	0.294	5

The obtained results show that online sales are the best channel for selling cabbage, and they confirm the results of Sheng and Lu (2020), who found that rural settlements must use Internet connectivity more in order to have better sales channels. However, Smoluk-Sikorska (2019) says in her research that online sales are only in fourth place among the sales of organic agricultural products, and that direct sales are the most widely used. This is because these products are more prone to rotting and must be stored in a prescribed manner in order to stay fresh longer, while this is not the case with cabbage. Cabbage is less susceptible to rotting than any other agricultural product, so it is possible to find buyers through online sales.

Also, Milford et al. (2021) considered the problem of selling organic production, and found that the use of specialized stores is most common in Norway. Nedeljković et al. (2023) said that the best sales channel for the agri-food sector in Semberija is producer - seller (retailer) - consumer, but they did not consider the online sales channel in their work. However, online sales can include different types of sales channels, i.e. cabbage is sold directly to consumers or feeders or even agents, and that is why it is the most expedient and that is why it was rated the best by experts.

CONCLUSIONS

This study focused on selecting sales channels for cabbage sales in the Semberija region. Expert opinions and fuzzy set theory were used in the process, yielding the following results:

- The most significant criterion was consumer habits.
- Online sales showed the best results.

Furthermore, the contributions of this research are as follows:

- Providing guidelines to cabbage producers regarding which sales channels to use to increase revenue
- Integrating the fuzzy MEREC and RAWEC methods into a unified methodology for selecting sales channels.
- Applying double normalization in the MEREC method.
- Developing the fuzzy RAWEC method which hasn’t been used in the previous research.

In addition to these contributions, this research also has certain limitations. These limitations include the selection of experts, as there could be other experts whose knowledge could further enhance agricultural product sales. However, efforts were made to avoid subjectivity among agricultural producers by selecting professors from agricultural faculties in Bijeljina.

Furthermore, future research could involve interviewing these producers to understand why they use specific sales channels and the advantages they derive from them. Another limitation is the number of experts involved in the research. Increasing the number of experts complicates the decision-making process, so it's essential to maintain a balance in the number of experts involved. Additionally, the criteria used for ranking sales channels could be a limitation. While other criteria could be considered, it's not feasible to include all possible criteria in the ranking process. Therefore, future research should explore other criteria and compare the results with those obtained in this study.

ACKNOWLEDGMENTS

Paper is a part of research financed by the MSTDI RS, agreed in decision no. 451-03-66/2024-03/200009 from 5.2.2024.

REFERENCES

Đalić, I., Stević, Ž., Erceg, Ž., Macura, P., and Terzić, S. (2020). Selection of a distribution channel using the integrated FUCOM-MARCOS model. *International Review*, 3-4, 80-96. https://doi.org/10.5937/intrev2003080Q

Dong, S., Yang, L., Shao, X., Zhong, Y., Li, Y., and Qiao, P. (2021). How can channel information strategy promote sales by combining ICT and blockchain? Evidence from the agricultural sector. *Journal of Cleaner Production*, 299, 126857. https://doi.org/10.1016/j.jclepro.2021.126857

Erfurth, T., and Bendul, J. (2018). Integration of global manufacturing networks and supply chains: a cross case comparison of six global automotive manufacturers. *International Journal of Production Research*, 56(22), 7008-7030. https://doi.org/10.1080/00207543.2018.1424370

Fałkowski, J., and Chlebicka, A. (2021). What product mix do they offer and what marketing channels do they use? – Exploring agricultural producer organisations' heterogeneity. *Journal of Rural Studies*, 85, 1-12. https://doi.org/10.1016/j.jrurstud.2021.05.002

Hartmann, N. N., and Lussier, B. (2020). Managing the sales force through the unexpected exogenous COVID-19 crisis. *Industrial Marketing Management*, 88, 101-111. https://doi.org/10.1016/j.indmarman.2020.05.005

Jiuhardi, J., Hasid, Z., Darma, S., and Darma, D. C. (2022). Sustaining Agricultural Growth: Traps of Socio–Demographics in Emerging Markets. *Opportunities and Challenges in Sustainability*, 1(1), 13-28. https://doi.org/10.56578/ocs010103

Kannan, J., Jayakumar, V., & Pethaperumal, M. (2024). Advanced Fuzzy-Based Decision-Making: The Linear Diophantine Fuzzy CODAS Method for Logistic Specialist Selection. *Spectrum of Operational Research*, *2*(1), 41-60. https://doi.org/10.31181/sor2120259

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E. K., Turskis, Z., and Antucheviciene, J. (2021). Determination of objective weights using a new method based on the Removal Effects of criteria (MEREC). *Symmetry*, 13(4), 525. https://doi.org/10.3390/sym13040525

Khan, N., Ray, R. L., Zhang, S., Osabuohien, E., and Ihtisham, M. (2022). Influence of mobile phone and internet technology on income of rural farmers: Evidence from Khyber Pakhtunkhwa Province, Pakistan. *Technology in Society*, 68, 101866. https://doi.org/10.1016/j.techsoc.2022.101866

Kizielewicz, B., & Sałabun, W. (2024). SITW Method: A New Approach to Re-identifying Multi-criteria Weights in Complex Decision Analysis. *Spectrum of Mechanical Engineering and Operational Research*, *1*(1), 215-226. https://doi.org/10.31181/smeor11202419

Kousar, S., Ansar, A., Kausar, N., & Freen, G. (2024). Multi-Criteria Decision-Making for Smog Mitigation: A Comprehensive Analysis of Health, Economic, and Ecological Impacts. *Spectrum of Decision Making and Applications*, *2*(1), 53-67. https://doi.org/10.31181/sdmap2120258

Mannarelli Filho, T. (2020). A model for strategic analysis in wood treatment companies. *Research, Society and Development*, 9(11), e53191110206. https://doi.org/10.33448/rsd-v9i11.10206

Markowska, M., Marcinkowski, J., Kiba-Janiak, M., and Strahl, D. (2023). Rural E-Customers' Preferences for Last Mile Delivery and Products Purchased via the Internet before and after the COVID-19 Pandemic. *Journal of Theoretical and Applied Electronic Commerce Research*, 18(1), 597-614. https://doi.org/10.3390/jtaer18010030

Mihailović, B., Simonović, Z., and Ćurčić, N. (2017). Agricultural resources and development priorities of the municipality of Stara Pazova. *Ekonomika poljoprivrede*, 64(1), 259-274. https://doi.org/10.5937/ekoPolj1701259M

Milford, A. B., Lien, G., and Reed, M. (2021). Different sales channels for different farmers: Local and mainstream marketing of organic fruits and vegetables in Norway. *Journal of Rural Studies*, 88, 279-288. https://doi.org/10.1016/j.jrurstud.2021.08.018

Millet, M., Keast, V., Gonano, S., and Casabianca, F. (2020). Product qualification as a means of identifying sustainability pathways for place-based agri-food systems: The case of the GI Corsican grapefruit (France). *Sustainability*, 12(17), 7148. https://doi.org/10.3390/su12177148

Narang, M., Kumar, A., and Dhawan, R. (2023). A fuzzy extension of MEREC method using parabolic measure and its applications. *Journal of Decision Analytics and Intelligent Computing*, 3(1), 33-46. https://doi.org/10.31181/jdaic10020042023n

Ndori Queku, Y., Adibura Seidu, B., Ayine Adaane, L., Carsamer, E., Kofi Sobre Frimpong, F., and Ndori Queku, D. (2024). Market Synchronicity Among African Markets: is IFRS Adoption an Augmentor or Inhibitor? *Economics - innovative and economics research journal*, 12(1), 29-49. https://doi.org/10.2478/eoik-2024-0006

Nedeljković, M., Nastić, L., and Puška, A. (2023). Selection of sales distribution channel in agricultural enterprise. *Western Balkan Journal of Agricultural Economics and Rural Development*, 5(2), 121-131. https://doi.org/10.5937/WBJAE2302121N

Pang, S., and Chen, M.-C. (2024). Investigating the impact of consumer environmental consciousness on food supply chain: The case of plant-based meat alternatives. *Technological Forecasting and Social Change*, 201, 123190. https://doi.org/10.1016/j.techfore.2023.123190

Phulara, S., Kumar, A., Narang, M., and Bisht, K. (2024). A novel hybrid grey-BCM approach in multi-criteria decision making: An application in OTT platform. *Journal of Decision Analytics and Intelligent Computing*, 4(1), 1–15. https://doi.org/10.31181/jdaic10016012024p

Podlevska, O., and Podlevskyi, A. (2023). Development of Circular Economy in Modern Conditions. *Economics - innovative and economics research journal*, 11(2), 97–112. https://doi.org/10.2478/eoik-2023-0025

Prashar, D., Jha, N., Jha, S., Lee, Y., and Joshi, G. P. (2020). Blockchain-based traceability and visibility for agricultural products: A decentralized way of ensuring food safety in India. *Sustainability*, 12(8), 3497. https://doi.org/10.3390/su12083497

Puška, A., Štilić, A., Pamučar, D., Božanić, D., and Nedeljković, M. (2024). Introducing a Novel multi-criteria Ranking of Alternatives with Weights of Criterion (RAWEC) model. *MethodsX*, 12, 102628. https://doi.org/10.1016/j.mex.2024.102628

Rahman, K. (2023). Application of Complex Polytopic Fuzzy Information Systems in Knowledge Engineering: Decision Support for COVID-19 Vaccine Selection. International *Journal of Knowledge and Innovation Studies*, 1(1), 60-72. https://doi.org/10.56578/ijkis010105

Raimbekov, Z., Syzdykbayeva, B., Rakhmetulina, A., Rakhmetulina, Z., Abylaikhanova, T., Ordabayeva, M., and Doltes, L. (2023). The impact of agri-food supply channels on the efficiency and links in supply chains. *Economies*, 11(8), 206. https://doi.org/10.3390/economies11080206

Ristić, B., Bogdanović, V., and Stević, Ž. (2024). Urban Evaluation of Pedestrian Crossings Based on Start-Up Time Using the MEREC-MARCOS Model. *Journal of Urban Development and Management*, 3(1), 34-42. https://doi.org/10.56578/judm030103

Sahoo, S. K., Choudhury, B. B., & Dhal, P. R. (2024). A Bibliometric Analysis of Material Selection Using MCDM Methods: Trends and Insights. *Spectrum of Mechanical Engineering and Operational Research*, *1*(1), 189-205. https://doi.org/10.31181/smeor11202417

Sheng, J., and Lu, Q. (2020). The influence of information communication technology on farmers' sales channels in environmentally affected areas of China. *Environmental Science and Pollution Research International*, 27(34), 42513-42529. https://doi.org/10.1007/s11356-020-10203-6

Simms, C., McGowan, P., Pickernell, D., Vazquez-Brust, D., and Williams, A. (2022). Uncovering the effectual-causal resilience nexus in the era of Covid-19: A case of a food sector SME's resilience in the face of the global pandemic. *Industrial Marketing Management*, 106, 166-182. https://doi.org/10.1016/j.indmarman.2022.08.012

Smoluk-Sikorska, J. (2019). Sales channels from organic food processing companies. *Annals PAAAE*, 21(4), 436-445. https://doi.org/10.22004/AG.ECON.302855

Stević, Ž., Subotić, M., Softić, E., and Božić, B. (2022). Multi-Criteria Decision-Making Model for Evaluating Safety of Road Sections. *Journal of Intelligent Management Decision*, 1(2), 78-87. https://doi.org/10.56578/jimd010201

Tadić, S., Veljović, M. (2021). Home delivery: A framework for structuring. *International Journal for Traffic and Transport Engineering*, 11(1), 30-74. https://doi.org/10.7708/ijtte.2021.11(1).03

Tešić, D., Božanić, D., and Khalilzadeh, M. (2024). Enhancing Multi-Criteria Decision-Making with Fuzzy Logic: An Advanced Defining Interrelationships Between Ranked II Method Incorporating Triangular Fuzzy Numbers. *Journal of Intelligent Management Decision*, 3(1), 56-67. https://doi.org/10.56578/jimd030105

Thilmany, D., Canales, E., Low, S. A., and Boys, K. (2021). Local food supply chain dynamics and resilience during COVID-19. *Applied Economic Perspectives and Policy*, 43(1), 86-104. https://doi.org/10.1002/aepp.13121

Volvach, O. (2023). Assessment of The Efficiency of use of EPS by Business. *Economics - innovative and economics research journal*, 11(1), 233-249. https://doi.org/10.2478/eoik-2023-0003

Wan, G., Rong, Y., and Garg, H. (2023). An efficient spherical fuzzy MEREC–CoCoSo approach based on novel score function and aggregation operators for group decision making. *Granular Computing*, 8(6), 1481-1503. https://doi.org/10.1007/s41066-023-00381-2

Wang, C., Cheng, K., and Wang, Z. (2024). Navigating High-Quality Economic Growth: An Examination of Regional Innovation Ecosystems in China Through Fuzzy-Set Qualitative Comparative Analysis. *Opportunities and Challenges in Sustainability*, 3(1), 20-34. https://doi.org/10.56578/ocs030102

Zheng, B., Chu, J., and Jin, L. (2021). Recycling channel selection and coordination in dual sales channel closed-loop supply chains. *Applied Mathematical Modelling*, 95, 484-502. https://doi.org/10.1016/j.apm.2021.02.022