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Selection of Logistics Distribution Channels for Final Product Delivery: FUCOM-MARCOS Model

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Abstract: An analytical approach was adopted to ascertain the optimal distribution channel for Bingo LLC's final products, deploying a multifaceted decision-making framework that incorporated the Full Consistency Method (FUCOM) and Measurement of Alternatives and Ranking according to the Compromise Solution (MARCOS) methodologies. Weighting coefficients essential for distribution channel selection were derived using FUCOM, informed by responses to a meticulously designed questionnaire administered to experts from distinct Bingo LLC branches in Maglaj and Kraševo. The gathered data, reflecting a range of pertinent criteria, facilitated the computation of weighting coefficients via the FUCOM technique within a Microsoft Excel environment. These coefficients were subsequently employed in the execution of the MARCOS method to determine the hierarchical positioning of the potential alternatives. This process culminated in the identification of the most advantageous distribution channel alternative for the company. The overarching aim of this analysis was to elucidate the most efficacious distribution channel strategy to enhance Bingo LLC's business operations, underpinned by the hypothesis that proficient management of distribution channels is a critical determinant of commercial success. The implications of this research extend to the broader field of trade, highlighting the significance of strategic distribution channel management. This study stands as a testament to the application of decision-making models in operational enhancements and contributes to the existing body of knowledge with empirical evidence from the case of Bingo LLC.

Keywords: Multi-Criteria Decision Making (MCDM); Distribution channels, Full Consistency Method (FUCOM); Measurement of Alternatives and Ranking according to Compromise Solution (MARCOS)

1 Introduction

In the prevailing market milieu, production is increasingly consumer demand-driven, yielding an extensive assortment of product offerings. Products attain their utility for consumers only upon becoming accessible, a function facilitated by logistics. With goods movement being a daily phenomenon, a comprehensive understanding of product characteristics, logistics transport subsystems, and physical distribution channels becomes imperative. Distribution is characterized as an amalgamation of activities, processes, and entities that are essential for bridging the gap between production and consumption [1]. The logistics processes are deemed crucial for ensuring that products reach the marketplace effectively [2]. For organizations immersed in the physical distribution of goods, the articulation of evaluation parameters and an assortment of distribution channels for final products is of significant importance. Extensive literature has been dedicated to the evaluation of physical distribution channels, deploying various Multi-Criteria Decision Making (MCDM) techniques. Reference [3] details the utilization of the Analytic Hierarchy Process (AHP) for a multi-criteria selection of distribution channels, specifically for agricultural outputs of small farms in Serbia. Further research [4] employed an integrated FUCOM-MARCOS model to appraise a firm's physical distribution channels. Within this context, the FUCOM method facilitated the derivation of criteria weighting coefficients, with the MARCOS method being applied to assess the alternatives. The research indicated that considerable cost reductions and business enhancements could be achieved should the subject company expand beyond its singular distribution channel, direct delivery, to involve intermediaries such as wholesalers and retailers in delivering goods to end-users. The necessity of selecting a suitable distribution channel, and the complexities therein, were accentuated in the study of Hatami et al. [5], which also advocated for the application of MCDM in the evaluation and selection of such channels. An integrated AHP-TOPSIS model was implemented, with findings reinforcing the criticality and efficacy of MCDM in the evaluation process for physical distribution channels. In another instance [6], the distribution dilemma within the Iranian oil and gas sector was examined. Experts established a set of pertinent criteria for distribution channel evaluation, with criteria weighting coefficients being determined through the Best Worst Method (BWM). The alternatives, that is, the distribution channels, were evaluated using the AHP method. The study also included a sensitivity analysis to test the dependability of the adopted approach, with the outcomes demonstrating a high degree of robustness, ensuring adaptability to prospective future alterations.

The composition of this study is segmented into five sections. The subsequent section delineates the algorithms of the methods employed, namely FUCOM and MARCOS, while the third section elucidates the results alongside detailed calculations. The paper culminates with conclusive observations

2 Methodology

In this section, the methodology adopted for the computation of weighting coefficients via the FUCOM method is elucidated, followed by the delineation of the MARCOS method, which is applied for the ranking of alternatives.

2.1 FUCOM Method

The FUCOM, as posited by researchers [7–10], operates on the paradigm of pairwise comparison and the validation of results by assessing the deviations from an ideal consistency. This recent methodology is utilized for deriving the values of weighting coefficients. It employs a systematic process delineated in Algorithm 1, which is designed to ascertain the relative importance of criteria through a series of pairwise comparisons, with the aim of achieving a fully consistent set of weights.

Algorithm 1 : FUCOM

Input: Expert pairwise comparison of criteria
Output: Optimal values of the weight coefficients of criteria/sub-criteria

Step 1: Expert ranking of criteria/sub-criteria.
Step 2: Determining the vectors of the comparative significance of evaluation criteria.
Step 3: Defining the restrictions of a non-linear optimization model.
Restriction 1: The ratio of the weight coefficients of criteria is equal to the comparative significance among the observed criteria, i.e., $w_k/w_{k+1} = \varphi_{k(k+1)}$.
Restriction 2: The values of weight coefficients should satisfy the condition of mathematical transitivity, i.e., $\varphi_{k(k+1)} \otimes \varphi_{(k+1)(k+2)} = \varphi_{k(k+2)}$.
Step 4: Defining a model for determining the final values of the weight coefficients of evaluation criteria:

$$\min \chi$$

st.

$$\left|\frac{w_{j(k)}}{w_{j(k+1)}} - \varphi_{k/(k+1)}\right| \leq \chi, \forall j$$
$$\left|\frac{w_{j(k)}}{w_{j(k+2)}} - \varphi_{k(k+1)} \otimes \varphi_{(k+1)(k+2)}\right| \leq \chi, \forall j$$
$$\sum_{j=1}^{n} w_j = 1$$
$$w_j \geq 0, \forall j$$

Step 5: Calculating the final values of evaluation criteria/sub-criteria $(w_1, w_2, \ldots, w_n)^T$.

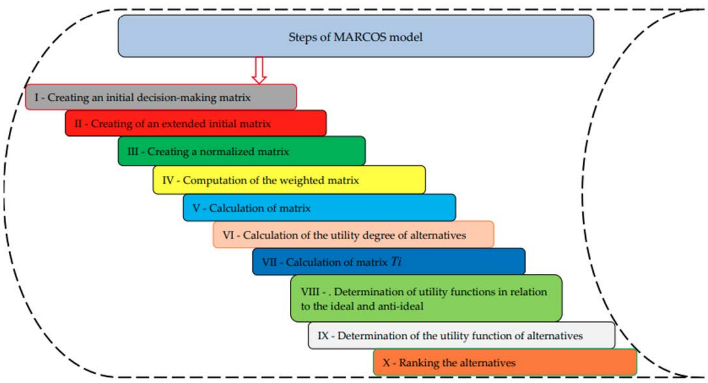

Figure 1. Steps of MARCOS method

2.2 MARCOS Method

The MARCOS method is implemented through the following steps shown in Figure 1 [11–14].

3 Results

In this study, MCDM methodologies were employed to develop a model for selecting the optimal logistics channel for the distribution of final products. The initial phase involved the calculation of weighting coefficients for a sextet of criteria utilizing the FUCOM. The criteria under consideration were product characteristics (C1), the financial situation of the company (C2), consumer habits (C3), costs (C4), geographic concentration (C5), and the breadth of the production program (C6). The ordinal ranking of these criteria was facilitated through the insights provided by two specialists from Bingo LLC, using data collated from questionnaires. These ranked criteria yielded the primary values of the weighting coefficients. To synthesize these values into a definitive set of weights, an averaging process via the geometric mean was undertaken, assimilating the judgments of both decision-makers. The resultant weighting coefficients, thus procured, were subsequently incorporated into the MARCOS method's algorithmic framework, serving as a foundational element in the ranking of potential logistics channels. The geometric mean was selected as the averaging mechanism due to its property of mitigating the impact of outlier judgments, thereby providing a more representative central tendency for the weighting coefficients. This mathematical approach ensures that the resultant criteria weights embody a balanced consensus of the expert evaluations.

3.1 Calculation of the Weighting Coefficients of the Criteria Using the FUCOM Method

The criteria, as prioritized by the first decision-maker through questionnaire 1, were sequenced in the following descending order of importance:

$$C4 > C3 > C5 > C6 > C1 > C2$$

Costs (C4) was identified as the paramount criterion, succeeded by consumer habits (C3), geographic concentration (C5), the breadth of the production program (C6), product characteristics (C1), with the company's financial situation (C2) being deemed the least significant.

Subsequent to this ranking, a pairwise comparison of the established criteria was undertaken, with each criterion being compared against the criterion of highest priority (costs, C4) on a scale ranging from 1 to 5. This procedure facilitated the derivation of the relative importance ($\omega_{\mathrm{Cj(k)}}$) of the aforementioned criteria, the results of which are detailed in Table 1.

Table 1. Significance of the criteria by decision-maker 1

C4	C3	C5	C6	C1	C2
1	2	3	3.4	3.8	4

After determining the significance of the criteria, the comparative importance of the criteria ($\varphi_{\mathrm{k/(k+1)}}$) is calculated. The calculation is performed as follows:

$$\varphi_{\mathrm{C4/C3}} = 2.0/1.0 = 2.00; \varphi_{\mathrm{C3/C5}} = 3.0/2.0 = 1.50; \varphi_{\mathrm{C5/C6}} = 3.4/3.0 = 1.13;$$
$$\varphi_{\mathrm{C6/Cl}} = 3.8/3.4 = 1.12; \varphi_{\mathrm{Cl/C2}} = 4.0/3.8 = 1.05.$$

The first condition that the final values of the weighting coefficients should fulfill is the condition defined:

$$W_4/W_3 = 2.00; W_3/W_5 = 1.50; W_5/W_6 = 1.13; W_6/W_1 = 1.12; W_1/W_2 = 1.05.$$

Another condition that the final values of the weighting coefficients should fulfill is the condition of mathematical transitivity:

$$\frac{W_4}{W_5} = \varphi_{C_4/C_3} \times \varphi_{C_3/C_5} = 2.0 \times 1.50 = 3.00; \frac{W_3}{W_6} = \varphi_{C_3/C_5} \times \varphi_{C_5/C_6} = 1.50 \times 1.13 = 1.69;$$
$$\frac{W_5}{W_1} = \varphi_{C_5/C_6} \times \varphi_{C_6/C_1} = 1.13 \times 1.12 = 1.26; \frac{W_6}{W_2} = \varphi_{C_6/C_1} \times \varphi_{C_1/C_2} = 1.12 \times 1.05 = 1.18.$$

The final model for determining the weighting coefficients of the criteria is as follows:

$$\min \chi$$
$$\left|\frac{W_4}{W_3}-2.0\right| \le \chi; \left|\frac{W_3}{W_5}-1.50\right| \le \chi; \left|\frac{W_5}{W_6}-1.13\right| \le \chi; \left|\frac{W_6}{W_1}-1.12\right| \le \chi; \left|\frac{W_1}{W_2}-1.05\right| \le \chi;$$
$$\left|\frac{W_4}{W_5}-3.0\right| \le \chi; \left|\frac{W_3}{W_6}-1.69\right| \le \chi; \left|\frac{W_5}{W_1}-1.26\right| \le \chi; \left|\frac{W_6}{W_2}-1.18\right| \le \chi.$$

Using the FUCOM solver, the final values of the weighting coefficients, shown in Table 2, are obtained.

Table 2. Final values of weighting coefficients based on DM1 ranking

C1	C2	C3	C4	C5	C6
0.100	0.095	0.189	0.379	0.126	0.111

The prioritization of criteria as determined by the second decision-maker via questionnaire 2 was established as follows:

$$C4 > C1 > C2 > C3 > C5 > C6$$

Costs (C4) was accorded the highest priority, followed by product characteristics (C1), the company's financial situation(C2), consumer habits (C3), geographic concentration (C5), with the breadth of the production program (C6) being assigned the lowest level of importance.

A subsequent comparative analysis was conducted with the foremost criterion, costs (C4), serving as a reference point. This comparative exercise yielded the relative importance values ($\omega_{\mathrm{Cj(k)}}$) for the criteria as they were ranked in the antecedent step, detailed in Table 3.

Table 3. Significance of the criteria by decision-maker 2

C4	C1	C2	C3	C5	C6
1	1.5	2	3	3.5	4.5

In the next step, the comparative importance of the criteria ($\varphi_{\mathrm{k/(k+1)}}$) is calculated as follows:

$$\varphi_{C_4/C_1} = 1.5/1.0 = 1.50; \varphi_{C_1/C_2} = 2.0/1.5 = 1.33; \varphi_{C_2/C_3} = 3.0/2.0 = 1.50;$$
$$\varphi_{C_3/C_5} = 3.5/3.0 = 1.17; \varphi_{C_5/C_6} = 4.5/3.5 = 1.28.$$

The first condition that the final values of the weighting coefficients should fulfill is the condition defined by:

$$W_4/W_1 = 1.50; W_1/W_2 = 1.33; W_2/W_3 = 1.50; W_3/W_5 = 1.17; W_5/W_6 = 1.28.$$

Another condition that the final values of the weighting coefficients should fulfill is the condition of mathematical transitivity, defined:

$$\frac{W_4}{W_2} = \varphi_{C_4/C_1} \times \varphi_{C_1/C_2} = 1.50 \times 1.33 = 1.99; \frac{W_1}{W_3} = \varphi_{C_1/C_2} \times \varphi_{C_2/C_3} = 1.33 \times 1.50 = 1.99;$$
$$\frac{W_2}{W_5} = \varphi_{C_2/C_3} \times \varphi_{C_3/C_5} = 1.50 \times 1.17 = 1.75; \frac{W_3}{W_6} = \varphi_{C_3/C_5} \times \varphi_{C_5/C_6} = 1.17 \times 1.28 = 1.50.$$

The final model for determining the weighting coefficients of the criteria is as follows:

$$\min \chi$$
$$\left|\frac{W_4}{W_1}-1.50\right| \le \chi; \left|\frac{W_1}{W_2}-1.33\right| \le \chi; \left|\frac{W_2}{W_3}-1.50\right| \le \chi; \left|\frac{W_3}{W_5}-1.17\right| \le \chi; \left|\frac{W_5}{W_6}-1.28\right| \le \chi;$$
$$\left|\frac{W_4}{W_2}-1.99\right| \le \chi; \left|\frac{W_1}{W_3}-1.99\right| \le \chi; \left|\frac{W_2}{W_5}-1.75\right| \le \chi; \left|\frac{W_3}{W_6}-1.50\right| \le \chi.$$

By applying the FUCOM solver, the final values of the weighting coefficients (Table 4) of the criteria are obtained, taking into account the ranking by decision-maker 2.

Based on the values of the weighting coefficients shown in Table 2 and Table 4, the values were averaged using the geometric mean. The final values obtained are shown in Table 5.

Table 4. Final values of weighting coefficients based on DM2 ranking

C1	C2	C3	C4	C5	C6
0.222	0.166	0.111	0.332	0.095	0.074

Table 5. The final values of the weighting coefficients of the criteria

C1	C2	C3	C4	C5	C6
0.149	0.126	0.145	0.349	0.109	0.091

The analysis of the weighted coefficients reveals that the criterion of costs (C4) holds paramount significance, bearing a weight of 0.349. Following in importance is the product characteristics criterion (C1), with a weight of 0.149. Consumer habits (C3) are identified next with a coefficient of 0.145, while the financial situation of the company (C2) is ascribed a weight of 0.126. The criteria pertaining to geographical concentration (C5) and the breadth of the production program (C6) conclude the ranking, possessing weights of 0.109 and 0.091 respectively, indicating their lesser influence relative to the other criteria assessed.

3.2 Application of the MARCOS Method for Ranking Alternatives

The first step means the creation of an initial decision matrix (Table 6).

Table 6. Initial decision matrix

Alternative	C1	C2	C3	C4	C5	C6
Manuf.-consumer	1	2.828	2.236	2	3	3.162
Man.-retail-con.	3	1	3.464	4.472	2	4.472
Man.-wholesale-r.-con.	3.162	3	3.873	3.162	5	1.732
Man.-agent-con.	2.828	2.828	2	1.732	2	2.449
Man.-broker-con.	4.472	5	2	2.449	2	2

The second step of the MARCOS method is the formation of an extended initial decision matrix. In the extended initial matrix, ideal (AI) and anti-ideal (AAI) solutions are defined. The extended initial decision matrix is shown in Table 7.

Table 7. Extended initial decision matrix

Alternative	C1	C2	C3	C4	C5	C6
AAI	1	1	2	1.732	2	1.732
Manufacturer-consumer	1	2.828	2.236	2	3	3.162
Man.-retail-con.	3	1	3.464	4.472	2	4.472
Man.-wholesale-r.-con.	3.162	3	3.873	3.162	5	1.732
Man.-agent-con.	2.828	2.828	2	1.732	2	2.449
Man.-broker-con.	4.472	5	2	2.449	2	2
AI	4.472	5	3.873	4.472	5	4.472

The third step of the MARCOS method involves the normalization of the extended initial decision matrix. Therefore, the elements of the normalized extended decision matrix are obtained. The matrix values are shown in Table 8.

Table 8. Normalized extended matrix

Alternative	C1	C2	C3	C4	C5	C6
AAI	0.224	0.200	0.516	0.387	0.400	0.387
Manufacturer-consumer	0.224	0.566	0.577	0.447	0.600	0.707
Man.-retail-con.	0.671	0.200	0.894	1.000	0.400	1.000
Man.-wholesale-r.-con.	0.707	0.600	1.000	0.707	1.000	0.387
Man.-agent-con.	0.632	0.566	0.516	0.387	0.400	0.548
Man.-broker-con.	1.000	1.000	0.516	0.548	0.400	0.447
AI	1.000	1.000	1.000	1.000	1.000	1.000

In the fourth step, it is necessary to form a weighted normalized matrix. The values of the weighted matrix are shown in Table 9.

Table 9. Weighted normalized decision matrix

Alternative	C1	C2	C3	C4	C5	C6
AAI	0.033	0.025	0.075	0.135	0.044	0.035
Manufacturer-consumer	0.033	0.071	0.084	0.156	0.065	0.064
Man.-retail-con.	0.100	0.025	0.130	0.349	0.044	0.091
Man.-wholesale-r.-con.	0.105	0.076	0.145	0.247	0.109	0.035
Man.-agent-con.	0.094	0.071	0.075	0.135	0.044	0.050
Man.-broker-con.	0.149	0.126	0.075	0.191	0.044	0.041
AI	0.149	0.126	0.145	0.349	0.109	0.091

In the fifth step, it is necessary to calculate the utility degree of alternatives K_i in relation to the ideal and anti-ideal solution. First, it is necessary to obtain the sum of the elements of the weighted matrix *V*. The values of the sum are as follows:

$$AI = 0.347; A_1 = 0.474; A_2 = 0.738; A_3 = 0.717; A_4 = 0.469; A_5 = 0.625; AI = 0.969.$$

The values for the utility degree of alternatives (K_i) in relation to the AAI and AI solutions are obtained (Table 10).

In the sixth step, the utility function of alternatives $f(K_i)$ is determined. The utility functions are determined and shown in Table 10.

The seventh step involves ranking of the alternatives. The ranking of the alternatives is shown in Table 10.

Table 10. Ranking results using the MARCOS method

Alternative	S_i	K_i -	K_i +	fK -	fK +	fK_i	RANK
AAI	0.347	1					
Manufacturer-consumer	0.474	1.366	0.489	0.264	0.736	0.447	4
Man.-retail-con.	0.738	2.127	0.762	0.264	0.736	0.696	1
Man.-wholesale-r.-con.	0.717	2.066	0.740	0.264	0.736	0.676	2
Man.-agent-con.	0.469	1.352	0.484	0.264	0.736	0.442	5
Man.-broker-con.	0.625	1.801	0.645	0.264	0.736	0.590	3
AI	0.969		1.000				

The analysis of results presented in Table 10 reveals that the distribution channel represented by alternative 2, delineated as manufacturer-retail-consumer, emerges as the foremost option with a utility function value of 0.696. The subsequent rank is accorded to alternative 3, the manufacturer-wholesale-retail-consumer pathway, registering a value of 0.676. Proceeding in the hierarchy, alternative 5, characterized as manufacturer-broker-consumer, is ascribed a value of 0.590. Succeeding in order is the direct manufacturer-consumer model, bearing a utility function value of 0.447. Conclusively, the sequence is anchored by alternative 4, the manufacturer-agent-consumer route, which is attributed the terminal utility function value of 0.442.

4 Conclusion

In the realm of strategic enterprise management, the articulation of distribution channels emerges as a pivotal determinant in establishing market presence and competitive supremacy. It is imperative for organizations to comprehend the potency of judiciously organized distribution networks in the valorization of market offerings.

The multidisciplinary nature of decision-making necessitates the consideration of multiple criteria, underpinned by the attribution of weights to these criteria, thereby facilitating the evaluative process of objective attainment. Expertise, informed by extensive knowledge and professional experience, remains paramount in the adjudication of criteria and their consequential weightings—arguably the most nuanced facet of MCDM. Within this context, numerical values, synthesized from decision-making elements across potential solutions, are computed and arrayed to form a hierarchy of alternatives.

The current investigation elucidates the most apt distribution channel for Bingo LLC, identified via a systematic application of methodological calculations. Predicated on the responses of company experts through a structured questionnaire, the FUCOM method was utilized to calculate the weighting coefficients of six designated criteria: product characteristics (C1), company's financial situation (C2), consumer habits (C3), costs (C4), geographical concentration (C5), and breadth of the production program (C6). Consequently, the coefficients were discerned as follows: for C1 a weight of 0.149, for C2 a weight of 0.126, C3 a weight of 0.145, C4 a predominant weight of 0.349, C5 a weight of 0.109, and C6 with the least influence, a weight of 0.091. The prominence of cost (C4) as the criterion of paramount significance was established, while the breadth of the production program (C6) was deemed to be of minimal consequence.

Subsequent to the determination of weighting coefficients, the MARCOS method was applied to ascertain the hierarchical ranking of potential distribution alternatives, namely: Manufacturer-consumer (A1), Manufacturer-retail-consumer (A2), Manufacturer-wholesale-retail-consumer (A3), Manufacturer-agent-consumer (A4), and Manufacturer-broker-consumer (A5). The comprehensive analysis culminated in the preeminence of the Manufacturer-retail-consumer (A2) model, endorsed by a utility function value of 0.696. In contrast, the Manufacturer-agent-consumer (A4) paradigm was adjudged as the least favourable, with a utility function value of 0.442.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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