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METHODS

A New FullEX Decision-Making Technique for Criteria Importance Assessment: An Application to the Sustainable Last-Mile Delivery Courier Selection

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ABSTRACT Last-Mile Delivery (LMD) phase is essential issue in city logistics. However, it presents challenges due to the increasing number of vehicles and negative transportation effects. Sustainable city development requires smart LMD courier selection based on various criteria. This paper introduces a new subjective technique, called FullEX, for the criteria importance assessment. FullEX incorporates experts' opinions and their influence on the final decision, considering their reputation determined by education degree and experience. The application of FullEX focuses on assessing the importance of criteria for LMD courier selection. Such criteria are *delivery service cost, on-time delivery, air and noise pollution, brand,* and *safety*. Five experts participate in the evaluation procedure. However, this number can be adjusted depending on a certain problem. The FullEX method ranks *on-time delivery* as the most important criterion for sustainable LMD courier selection. In addition, the comparative analysis with the Best-Worst Method (BWM) confirms the results obtained by the FullEX method. Nevertheless, the sensitivity analyses demonstrate the stability of the FullEX and justify its introduction. Measuring the consistency index of the experts' judgment has also the advantage of this method. This proposed criterion weighting method is versatile, user-friendly, and applicable to any MCDM problem involving expert opinions on criteria.

INDEX TERMS Last-mile delivery, multi-criteria group decision-making, criteria weighting method, FullEX, BWM.

I. INTRODUCTION

In recent years, there has been an increasing number of populations worldwide, especially in urban areas. By 2050, approximately 70 % of the population will live in cities [1]. More and more people move to the cities due to a better lifestyle, accessibility to business, education, healthcare, etc. Pamučar et al. [2] state that cities have become economic, social, and administrative centers providing numerous benefits for performing private and business activities. The more population in cities, the more complex organization, especially in transportation and traffic. The more cars, the more air and noise pollution, traffic congestion, and delays. Ghaderi et al. [3] declare that sustainable urban freight transport is the key element of the innovative city concept.

Along with the city population, the increasing number of vehicles on the streets is noticeable. One of the concerning issues in cities is related to the last-mile delivery (LMD)

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process. The LMD is the last step of the shipping process, where customers receive the ordered products at their addresses. According to Chen et al. [4], the LMD remains the supply chain's most expensive and emission-polluting part. Due to the rapid e-commerce development, more customers prefer buying products online and expect shipments at their addresses.

Moreover, the COVID-19 crisis accelerated online purchases due to restrictions in many countries related to the working time of shops or the movement of people. When purchasing online, in most cases customers can select the courier for the LMD. The selection of couriers is challenging for whomever the decision-maker is. Different couriers offer different services in terms of price, delivery, and flexibility. Multiple, often conflicting criteria may affect the decision. The courier evaluation and selection can be considered a multi-criteria decision-making problem.

Decision-making is one of the essential and inevitable factors in everyday life. However, in practice, many conflicting criteria affect the decision-making process. Zavadskas & Turskis [5] stated that real-world decision-making problems are usually too complex to be observed through a single criterion. If a decision is affected by a high number of criteria, it is challenging for the decision-maker to choose the most appropriate option [6]. Depending on the decision-maker, not all the criteria are equally important. Various authors primarily develop multi-criteria decision-making (MCDM) methods to address specific purposes such as evaluation, assessment, prioritization, ranking, and sorting [7]. However, a significant confusion among decision-makers in applying different MCDM methods is the difference in the obtained results when the methods are used for the same problem [5].

In recent years, many MCDM methods have been developed as supportive tools in decision-making. MCDM is a useful technique for choosing among alternatives when there are multiple criteria to consider [8]. Some methods rank the alternatives, while others evaluate the criteria' importance. Rezaei [9] developed the Best-Worst Method (BWM). Keršuliene et al. [10] proposed the Stepwise Weight Assessment Ratio Analysis (SWARA) method. Pamučar et al. [11] developed the Full Consistency Method (FUCOM). Stević & Brković [12] developed the measurement of alternatives and ranking according to the compromise solution (MARCOS) method and combined it with the FUCOM.

There are applications of those methods in various fields. For instance, Ortega et al. [13] used the BWM to find a sustainable park-and-ride location. Kant and Gupta [14] evaluated urban freight strategies using the BWM method. Regarding the AHP method, it is applied to various problems such as resolving the practical factors in the healthcare system management [15], risk assessment of metro systems [16], most popular search engine identification [17], etc. The SWARA method has applications to various problems such as supplier evaluation [18], road sections ranking [19], risk assessment in coal supply chain management [20], assessment of alternative railway systems for sustainable transportation [21]. When it comes to FUCOM method, it was applied to the manufacturing environment [22], human resources [12], landfill site selection [23], forklift efficiency analysis [24]. It can be concluded that the most often used subjective methods for criteria weight evaluation are the AHP, SWARA, BWM, and FUCOM.

Regarding the LMD issue, various MCDM methods have been applied. For example, Aljohani & Tompson [25] applied the TOPSIS method to the freight consolidation facilities in inner city areas. Švadlenka et al. [26] identified the best LMD mode from a sustainable perspective. Li et al. [27] proposed a Bayesian-based MCDM method to deliver staff competence assessment. Simić et al. [28] considered a selection of the LMD mode by picture fuzzy WASPAS method. Bošković et al. [29] addressed the electric vehicle selection problem for LMD. In addition, Bošković et al. [30] considered an investment decision on cargo bikes for LMD process.

The AHP method uses experts' opinions to create a pairwise comparison. The method combines the experts' opinions transformed into the numerical values (a one-to-nine-point scale) to find the importance of each criterion. On the other hand, the SWARA method eliminates the criteria with relatively low importance and prioritizes the most important criteria. The BWM is specifically used in cases where objective metrics are not available to assess the criteria. The main idea of the BWM is pairwise comparisons based on two opposite references (Best and Worst). This opposite strategy is useful to mitigate the anchoring bias. The FUCOM method uses n-1 pairwise comparison of criteria by applying comparison scales such as integer or decimal. The new FullEX method uses a Fuller's triangle pairwise comparison strategy, based on expert's opinions. In addition, the education degree, and years of experience of each expert are considered within the the FullEX method, while the other subjective methods do not consider it. Nevertheless, in the FullEX method, the consistency ratio is calculated in some new and original way, which is another important point over the existing subjective methods. The procedure implies a second round of interviewing the experts, where they do not know the results of the first round regarding the criteria assessed. The experts are requested to consider the criteria on a scale from 0 to 100 % and thus determine the percentage importance of each criterion. The experts should consider the condition that the evaluation for all "n" criteria must give the sum of 100 %. Table 1 shows the difference between the existing subjective methods and the newly proposed FullEX.

Based on the above-mentioned assessment of the subjective methods, the following research gaps were identified:

1) Experts' criteria assessment is an essential issue when subjective judgment is undertaken. The Experts' opinions must be considered when evaluating criteria. In addition, the experts' reputations such as YoE and ED are of utmost importance in a decision-making process. However, none of the above-mentioned subjective

TABLE 1. Subjective method's comparison.

Method	Pairwise Comparison Scale	Experts Included	Expert's Education Degree	Expert's Years of Experience	Consistency Ratio
AHP	1-9 (Saaty's Scale)	Yes	No	No	Yes
SWARA	1-9	Yes	No	No	Yes
BWM	1-9	Yes	No	No	Yes
FUCOM	Integer/Decimal	Yes	No	No	Yes
FullEX	Fuller's Triangle	Yes	Yes	Yes	Yes

methods consider the experts' reputations in the criteria assessment.

2) Most of the methods use a one-to-nine pairwise comparison scale, except the FUCOM method which uses either integer or decimal one. However, none of them applies the Fuller's triangle scale to make a comparison between criteria.

3) The challenging issue when dealing with subjective methods is the proof of the results of experts' assessments. All of the above-mentioned subjective methods propose some techniques to calculate the consistency ratio and contributes to this field. In our paper, we utilized different and unique approach that should be utilized to calculate the consistency ratio of the experts' assessments. This approach could be also applicable to check the consistency index for any other subjective weighting method, by simply following three easy-to-use-steps.

The new FullEX technique differs from other subjective methods proposed by various authors. This technique considers the expert's reputation in terms of years of experience and education degree. This is an essential pre-step in decision-making since those experts evaluate criteria and rank them by importance—the more years of experience of one expert, the more precise the decision. In addition, the education degree of one expert means having enough theoretical knowledge necessary for making the right decision. The higher the education degree, the more excellent theoretical knowledge. Compared to the above-mentioned subjective methods (BWM, SWARA, FUCOM, and AHP), none consider those two essential parameters in a decision-making process.

The introduced FullEX method combines Fuller's technique with an expert reputation and confirms that one expert's years of experience and education degree can significantly affect the final decision. In addition, the comparative analysis with the BWM reveals that the final ranking obtained by the FullEX method differs depending on various experts. On the contrary, the BWM gives the same results regardless of expert reputation. For this reason, the FullEX technique justifies its proposal while, on the other hand, opening new ideas and future research directions in subjective techniques.

This paper's new FullEX method is developed to assess the criteria' importance when selecting a sustainable LMD courier. The FullEX method is based on Fuller's triangle and the expert parameters such as years of experience and educational degree. Five criteria such as delivery service cost [31], [32], [33] on-time delivery [34], [35], air and noise pollution [36], [37], brand [38], [39], and safety [40] were assessed by the FullEX methodology. The following section will describe a step-by-step guide to the proposed method.

The significant contributions are as follows:

1. The new subjective FullEX methodology is developed for the criteria importance assessment.
2. The developed methodology is original and appears for the first time in the literature. The originality is reflected in the proposal of a specific manner for quantification of the experts' reputations and a specific calculation procedure for obtaining the final criteria rank.
3. The applicability of the newly proposed FullEX method is demonstrated in a case study, assessing the importance of sustainable LMD courier selection criteria.
4. The methodology is compared to the existing state-of-the-art BWM and presents a high level of robustness.
5. The proposed FullEX can be applied to any problem considering multiple criteria and including experts' opinions, where the experts' reputation is characterized by the years of experience and education degree.
6. A different approach to calculate the consistency index of the experts' assessments is also a part of the contribution. This approach could be applied to check the consistency ratio to any other subjective weighting method, by simply following three easy-to-use-steps.

The rest of the paper is organized as follows: Section II is the FullEX methodology. Section III applies FullEX to the case study of LMD courier selection in city logistics. Section IV discusses the results, while the last section provides significant conclusions and implications of the research.

II. METHODOLOGY

This section proposes the new FullEX methodology for the criteria importance assessment. It is based on Fuller's triangle and expert parameters such as years of experience and educational degrees. The methodology is described through the following steps:

Step 1. Formulate an input data matrix.

TABLE 2. Input-data matrix.

Experts/ Criteria	C_1	C_2	.	C_j	.	C_p
E_1	x_{11}	x_{12}	.	x_{1j}	.	x_{1p}
E_2	x_{21}	x_{22}	.	x_{2j}	.	x_{2p}
…	.	.	.	.	.	.
E_i	x_{i1}	x_{i2}	.	x_{ij}	.	x_{ip}
…	.	.	.	.	.	.
E_q	x_{q1}	x_{q2}	.	x_{qj}	.	x_{qp}

where $E_1, E_2, \ldots, E_q$ are experts and q is the number of experts, $C_1, C_2, \ldots, C_p$ are criteria and p is the number of criteria, and x_{ij} are the experts' criteria importance assessments based on Fuller's triangle.

Fuller's method is a well-known method used to compare the criteria to obtain their importance [41]. Paired comparison always means comparing only two assessed criteria with each other and determining a more important in the pair being compared. When fulfilling the data by Fuller's method, an expert determines the preference of one criterion over another.

Step 2. Calculate the experts' reputations.

The triangular shape is achieved by gradual criteria comparison and by omitting the criterion compared in the line above.

For an explanation of the method, six available criteria are used. Due to the triangular shape of the form filled by the experts, the method is often referred to as Fuller's triangle, as Fig. 1 depicts.

To calculate the experts' reputations, first it is necessary to calculate the level of competence of each expert (L_i). For this purpose, in this paper, we propose two parameters to be considered, i.e., years of experience in the considered field and educational degrees:

$$L_i = \frac{YE_i + ED_i}{2}, \quad i = 1, 2, \ldots, q, \tag{1}$$

where YE_i denotes the number of years of experience of the *i-th* expert, while ED_i is the educational degree of *i-th* expert.

C_1	C_1	C_1	C_1	C_1
C_2	C_3	C_4	C_5	C_6
C_2	C_2	C_2	C_2	
C_3	C_4	C_5	C_6	
C_3	C_3	C_3		
C_4	C_5	C_6		
C_4	C_4			
C_5	C_6			
C_5				
C_6				

FIGURE 1. An example of Fuller's criteria comparison.

Regarding the educational degrees, the authors agreed to give a one-to-three-point scale, where one means a bachelor's degree, two means a master's degree, and three means a Ph.D. degree. After calculating the level of competence of each expert, the reputation of the i-*th* expert is calculated by applying the following equation:

$$W^{Ei} = \frac{L_i}{\sum_{i=1}^{q} E_i}, \quad i = 1, 2, \ldots, q. \tag{2}$$

Step 3. Normalize the input-data matrix.

After the input data matrix is formulated, the data normalization is performed. In this method, the normalization technique is applied by Eq. (3) and presented in Table 3:

$$v_{ij} = \frac{x_{ij}}{\sum_{i=1}^{q} x_{ij}}, \quad i = 1, 2, \ldots, q, \; j = 1, 2, \ldots, p. \tag{3}$$

TABLE 3. Normalized input-data matrix.

Experts/Criteria	C_1	C_2	…	C_j	…	C_p
E_1	v_{11}	v_{12}	…	v_{1j}	…	v_{1p}
E_2	v_{21}	v_{22}	…	v_{2j}	…	v_{2p}
…	…	…	…	…	…	…
E_i	v_{i1}	v_{i2}	…	v_{ij}	…	v_{ip}
…	…	…	…	…	…	…
E_q	v_{q1}	v_{q2}	…	v_{qj}	…	v_{qp}

Step 4. Obtain the expert-weighted normalized input-data matrix.

In this step, the normalized input data are multiplied by the experts' importance calculated in Step 2. It is calculated by Eq. (4) and presented in Table 4.

$$r_{ij} = v_{ij} \cdot W^{Ei}, \quad i = 1, 2, \ldots, q, \; j = 1, 2, \ldots, p. \tag{4}$$

TABLE 4. Expert-weighted normalized input-data matrix.

Experts/Criteria	C_1	C_2	…	C_j	…	C_p
E_1	r_{11}	r_{12}	…	r_{1j}	…	r_{1p}
E_2	r_{21}	r_{22}	…	r_{2j}	…	r_{2p}
…	…	…	…	…	…	…
E_i	r_{i1}	r_{i2}	…	r_{ij}	…	r_{ip}
…	…	…	…	…	…	…
E_q	r_{q1}	r_{q2}	…	r_{qj}	…	r_{qp}

Step 5. Identify an optimal value for each criterion.

This primary purpose of this step is to identify each criterion's optimal value ($V_{j\,max}$) by columns. It is calculated by Eq. (5) and presented in Table 5.

$$V_{j\,max} = \max_{i=1,2,\ldots,q} r_{ij}, \quad j = 1, 2, \ldots, p. \tag{5}$$

TABLE 5. The optimal value of each criterion in the expert-weighted normalized input-data matrix (V_{jmax}).

Experts/Criteria	C_1	C_2	…	C_j	…	C_p
E_1	r_{11}	r_{12}	…	r_{1j}	…	r_{1p}
E_2	r_{21}	r_{22}	…	r_{2j}	…	r_{2p}
…	…	…	…	…	…	…
E_i	r_{i1}	r_{i2}	…	r_{ij}	…	r_{ip}
…	…	…	…	…	…	…
E_q	r_{q1}	r_{q2}	…	r_{qj}	…	r_{qp}
$V_{j\,max}$	$V_{1\,max}$	$V_{2\,max}$	…	$V_{j\,max}$	…	$V_{p\,max}$

Step 6. Obtain the optimal decision-making matrix.

In this step, each element of the expert-weighted normalized matrix is divided by the optimal value (V_{jmax}). It is obtained by applying Eq. (6) and presented in Table 6.

$$y_{ij} = \frac{r_{ij}}{V_{j\,max}}, \quad i = 1, 2, \ldots, q, \; j = 1, 2, \ldots, p. \tag{6}$$

Step 7. Summarize all the values by columns in the optimal decision-making matrix.

$$K_j = \sum_{i=1}^{q} y_{ij}, \quad i = 1, 2, \ldots q, \; j = 1, 2, \ldots, p. \tag{7}$$

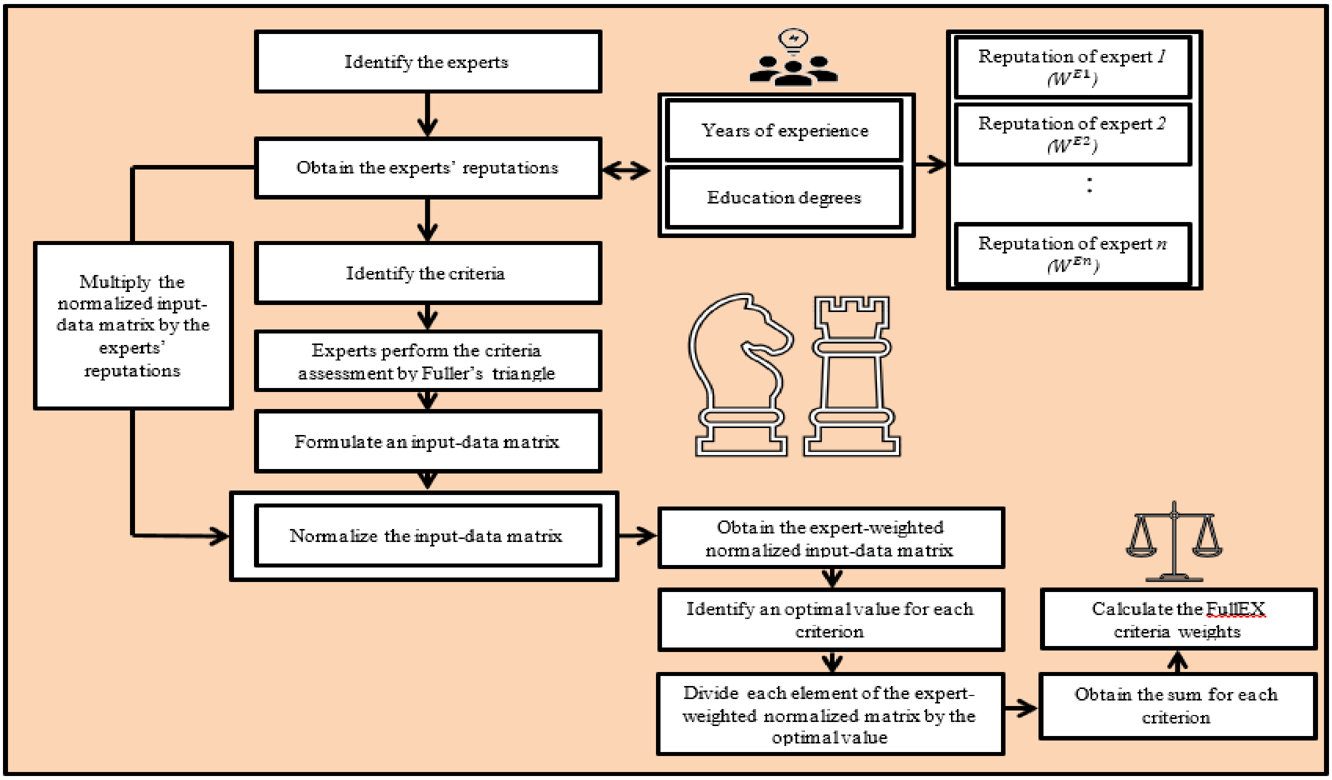

FIGURE 2. A flowchart of the FullEX approach.

TABLE 6. Optimal decision-making matrix.

Experts/Criteria	C_1	C_2	…	C_j		…	C_p
E_1	y_{11}	y_{12}	…	y_{1j}		…	y_{1p}
E_2	y_{21}	y_{22}	…	y_{2j}		…	y_{2p}
…	…	…	…		…	…	…
E_i	y_{i1}	y_{i2}	…	y_{ij}		…	y_{ip}
…	…	…	…		…	…	…
E_q	y_{q1}	y_{q2}	…	y_{qj}		…	y_{qp}

Step 8. Apply the final ranking.

In this step, the criteria importance (F_j) is computed as follows:

$$F_j = \frac{K_j}{\sum_{j=1}^{p} K_j}, \quad i = 1, 2, \ldots q, \; j = 1, 2, \ldots, p. \tag{8}$$

These eight easy-to-use steps are essential for the newly proposed FullEX method (Fig. 2).

III. CASE STUDY AND RESULTS

The newly developed FullEX decision-making method is applied to evaluate the criteria for LMD courier selection in city logistics. Five criteria were identified from the literature for testing the methodology and discussed with the experts (Table 7).

TABLE 7. Description of criteria.

Criteria	Reference
Delivery service cost (C_1)	[31-33]
On-time delivery (C_2)	[34, 35]
Air and noise pollution (C_3)	[36-37]
Brand (C_4)	[38, 39]
Safety (C_5)	[40]

Delivery service cost is a cost that a customer pays for a delivery service. On-time delivery means that the supplier respects the promised time frame to deliver the items. Air and noise pollution levels show the pollution level emitted by the exact courier. Brand means the reputation of the actual courier, while safety represents the level of safety that the courier has in terms of lost items, security during transportation, etc.

In addition, five experts from the logistics and postal traffic fields also participated in the criteria evaluation. The names of the experts are not mentioned according to the agreement with them. The experts are named from 1 to 5. However, the available expert information for this study is presented in Table 8.

The schematic structure of the criteria importance assessment is depicted in Fig. 3. As can be noticed, there are five criteria and five experts who evaluate them.

TABLE 8. Expert information.

Experts	YE	ED	Expert reputation (W^{Ei})
E_1	5	3	0.1951
E_2	6	1	0.1707
E_3	7	1	0.1951
E_4	10	2	0.2927
E_5	3	3	0.1463

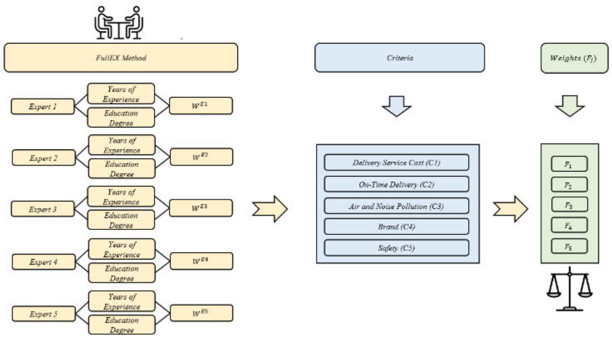

FIGURE 3. The illustration of the problem.

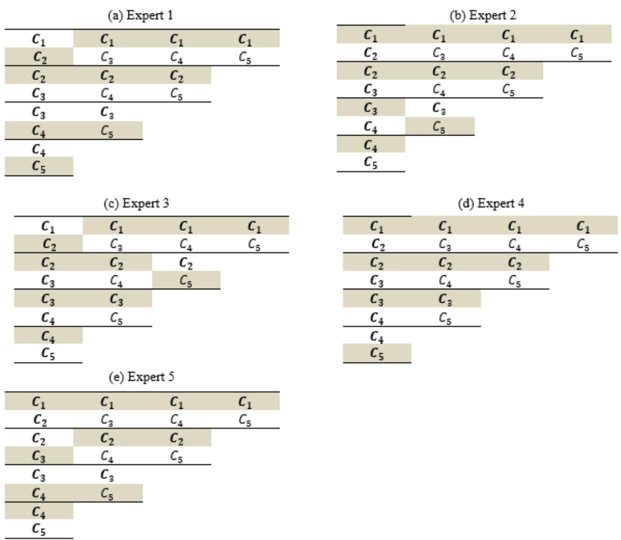

FIGURE 4. Experts' criteria assessment.

By applying Fuller's triangle principle, experts compare two criteria and mark a better one based on their opinion. In this way, the input data matrix is formulated, which is the first necessary condition for further calculation of the criteria importance. Fig. 4 presents the experts' assessments.

After the experts' assessment, the input data matrix is formulated and presented in Table 9.

The normalization of the input data with the expert-weighted matrix is calculated using Eq. (3) and Eq. (4) and presented in Tables 10 and 11, respectively.

Each element from the expert-weighted normalized input-data matrix is divided by the optimal one (V_{jmax}) to obtain the optimal decision-making matrix (Table 12).

TABLE 9. Input-data matrix.

Experts/Criteria	C_1	C_2	C_3	C_4	C_5
E_1	3	4	0	1	2
E_2	4	3	1	1	1
E_3	3	3	2	1	1
E_4	4	3	2	0	1
E_5	4	2	1	2	1
Σ	18	15	6	5	6

TABLE 10. Normalized input-data matrix.

Experts/Criteria	C_1	C_2	C_3	C_4	C_5
E_1	0.1667	0.2667	0.0	0.20	0.3333
E_2	0.2222	0.20	0.1667	0.20	0.1667
E_3	0.1667	0.20	0.3333	0.20	0.1667
E_4	0.2222	0.20	0.3333	0.0	0.1667
E_5	0.2222	0.1333	0.1667	0.40	0.1667

TABLE 11. Expert-weighted normalized input-data matrix.

Experts/Criteria	C_1	C_2	C_3	C_4	C_5
E_1	0.0325	0.0520	0.0	0.0390	0.0650
E_2	0.0379	0.0341	0.0285	0.0341	0.0285
E_3	0.0325	0.0390	0.0650	0.0390	0.0325
E_4	0.0650	0.0585	0.0976	0.0	0.0488
E_5	0.0325	0.0195	0.0244	0.0585	0.0244
$V_{j\,max}$	0.0650	0.0585	0.0976	0.0585	0.0650

TABLE 12. Optimal decision-making matrix.

Experts/Criteria	C_1	C_2	C_3	C_4	C_5
E_1	0.50	0.8889	0.0	0.6667	1.0
E_2	0.5833	0.5833	0.2917	0.5833	0.4375
E_3	0.50	0.6667	0.6667	0.6667	0.50
E_4	1.0	1.0	1.0	0.0	0.750
E_5	0.50	0.3333	0.250	1.0	0.3750
F_j	0.2091	0.2355	0.1498	0.1978	0.2077

The final criteria weights (F_j) are calculated by applying Eq. (7) and depicted in Fig. 5.

According to the proposed FullEX approach, the best-ranked criterion is on-time delivery (C_2), followed by delivery service cost (C_1), safety (C_5), brand (C_4), and air and noise pollution (C_3). According to the discussion with experts, it is concluded that when selecting a courier for LMD, the essential conditions, except the brand and air and noise pollution, are on-time delivery, delivery service cost, and safety. The obtained results are in line with other literature sources. It is supposed that the potential courier needs to respect the promised delivery timeframes [42]. However, it is often not the case in practice. Consequently, it may decrease the number of customers, increase delays, and generate additional costs for the organization with a contract [43], [44]. Regarding safety, this criterion is among the three top-ranked criteria when selecting the LMD courier [45], [46].

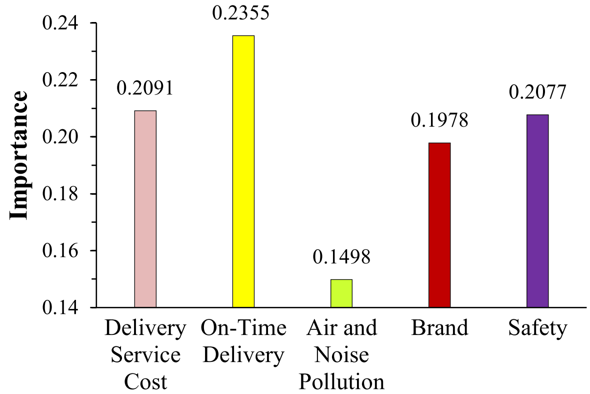

FIGURE 5. FullEX criteria importance.

A. CONSISTENCY INDEX CALCULATION

When it comes to subjective methods, which in this case is the FullEX method, an important issue is measuring the reliability of the collected answers by the experts. In the AHP method, the authors proposed a well-known approach to measure the inconsistency rate. In that case, the inconsistency rate should be less than 0.1 to consider the results reliable. In case of FullEX, this approach cannot be utilized, therefore the authors applied another approach [41] for measuring the consistency index (CI). The procedure implies a second round of interviewing the experts, where they do not know the results of the first round regarding the criteria assessed. In the second round, the experts are asked to consider the criteria on a scale from 0 to 100 % and thus determine the percentage importance of each criterion. The experts should be careful that the evaluation for all "n" criteria must give the sum of 100 %. Finally, the results from both rounds are compared and it gives a decision-maker to the conclusion regarding the reliability of the results. If we denote the answers from the second round of the interview by P_j and previously obtained FullEX weights by F_j, then the consistency index (CI) can be calculated as follows Eq. 9 (Table 13).

$$CI = \frac{\sum_{j=1}^{n} \left| F_j * 100 - P_j \right|}{100} \quad (9)$$

If the CI is less than 0.1, the results should be considered reliable. Contrary, the experts should repeat the criteria assessment procedure. It can be concluded that the Consistency Index is satisfactory.

IV. DISCUSSIONS

A. COMPARATIVE ANALYSIS

Comparative analysis is performed to check the reliability of the introduced FullEX method. The highlighted criteria importance assessment problem is solved by the BWM developed by Rezaei [9]. The results of the obtained criteria weights from both methods are presented in Table 14.

The proposed FullEX method generates the following ranking order $C_2 > C_1 > C_5 > C_4 > C_3$. On the

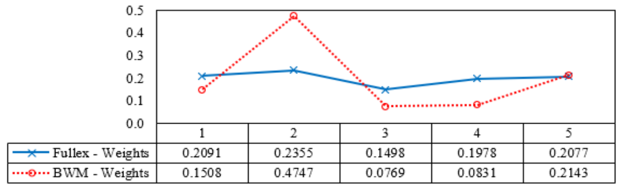

FIGURE 6. Comparative analysis of FullEX and BWM.

other hand, BWM generates the order $C_2 > C_5 > C_1 > C_4 > C_3$. The developed FullEX method, compared to the BWM, has a definitive agreement since they generate similar ranking order of the criteria. Therefore, the comparative analysis confirmed the high reliability of the newly formulated FullEX approach. The results of the comparative analysis are also depicted in Fig. 6.

B. SENSITIVITY ANALYSES

The sensitivity analyses are performed to check the stability of FullEX.

1) CRITERIA RANKING WHILE CHANGING THE EXPERTS' REPUTATION

In this sensitivity analysis, the model is tested regarding the variations in the experts' reputations. First, the expert's reputation based on years of experience (YE) is used in the model. Second, the educational degree (ED) is only used to calculate the reputation and is further applied within the FullEX method. The results are depicted in Fig. 7.

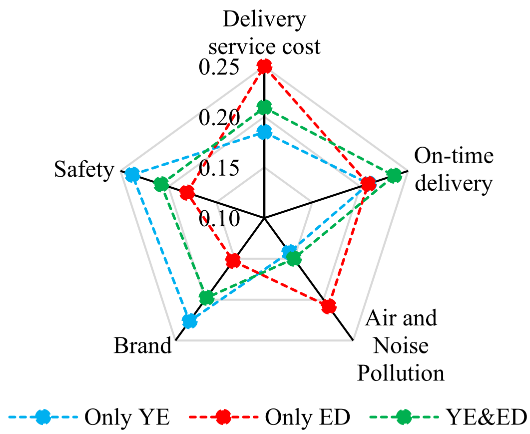

FIGURE 7. The results of the first sensitivity analysis.

It may be noticed from Fig. 7 that when both variables are included for the calculation of experts' reputations in a decision-making process, the model presents higher stability (see the green line). On the other hand, if only one variable is considered, it may significantly affect the final criteria ranking. This leads to the conclusion that differentiating the experts by the years of experience or education degree impacts the final solution, which justifies a proposal of a new criteria weighting technique, such as FullEX.

TABLE 13. Consistency index.

	F_j	E_1 (%)	E_2 (%)	E_3 (%)	E_4 (%)	E_5 (%)	Average P_j	$\lvert F_j * 100 - P_j \rvert$	CI_j
C_1	**0.2091**	25	30	15	15	15	20	0.91	0.0091
C_2	**0.2355**	30	25	20	20	35	26	2.45	0.0245
C_3	**0.1498**	25	5	15	30	5	16	1.02	0.0102
C_4	**0.1978**	15	15	35	25	10	20	0.22	0.0022
C_5	**0.2077**	5	25	15	10	35	18	2.77	0.0277
									0.0737

TABLE 14. Criteria weights.

Experts/Criteria	C_1	C_2	C_3	C_4	C_5
E_1	0.1930	0.4868	0.0789	0.0965	0.1447
E_2	0.1447	0.4868	0.0789	0.0965	0.1930
E_3	0.1483	0.4989	0.0809	0.0742	0.1978
E_4	0.1320	0.4440	0.0720	0.0880	0.2640
E_5	0.1361	0.4571	0.0739	0.0605	0.2723
Weights (BWM)	0.1508	0.4747	0.0769	0.0831	0.2143
Weights (FullEX)	0.2091	0.2355	0.1498	0.1978	0.2077

2) EXCLUDING THE MOST EXPERIENCED EXPERT FROM THE DECISION-MAKING PROCESS

In the second sensitivity analysis, we tested the stability of the proposed FullEX method by excluding the most experienced expert (i.e., expert 4) from the decision-making process. In addition, we excluded one more randomly selected expert (e.g., expert 5) to make a comparison. Fig. 8 depicts the results of the testing procedure.

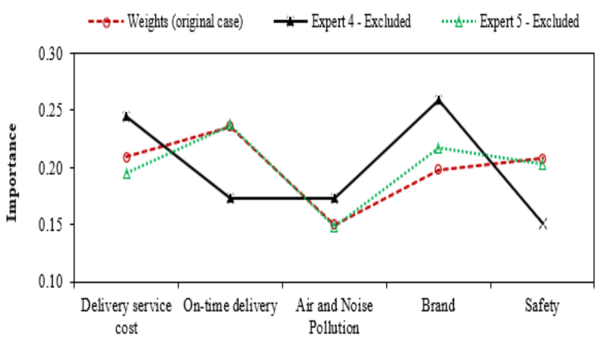

FIGURE 8. Excluding the most experienced and randomly selected experts from FullEX.

It can be noticed from Fig. 8 that when the most experienced expert (i.e., expert 4) was excluded from decision-making, the criteria rank changed. However, the criteria rank remained the same after excluding the randomly selected expert (e.g., expert 5), whose importance was not close to the highest. The obtained results show that an expert's reputation significantly influences the decision-making process.

Apart from this, the same procedure was followed with the BWM method. After excluding the decisions from expert four and expert five, the results presented in Fig. 9 were reached.

In the BWM, the sensitivity analysis results reveal that when the most experienced and randomly chosen experts

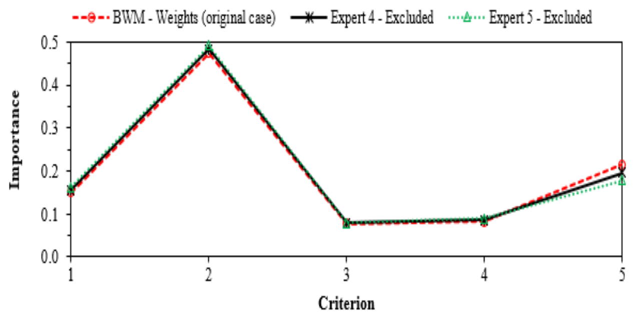

FIGURE 9. Excluding the most experienced and randomly selected expert from BWM.

were excluded from the decision-making, the ranking order of the criteria was not changed (Fig. 9). However, in BWM, we considered the average weights of all experts to obtain the final ranking order. In the case of FullEX, the experts' reputations affected the decision-making by changing the ranking order. It may be concluded that including the experts' reputations does make sense in the decision-making and justifies the proposed FullEX approach.

V. CONCLUSION AND IMPLICATIONS

The criteria importance assessment is one of the crucial segments in decision-making. Different assessments of criteria importance may significantly affect the final ranking of alternatives. Proper evaluation of the criteria according to their importance is vital. For this reason, the paper develops the FullEX methodology to support the decision-making in terms of the criteria assessment. The methodology is based on Fuller's triangle and the expert's support. Also, it considers the years of experience and the education degree of experts in a decision-making process.

The new FullEX method is compared with BWM to test the results. Both methods ranked the criteria in a similar ranking order, which may prove that the FullEX methodology is a highly reliable supporting tool in decision-making. The sensitivity analyses of the FullEX methodology are performed to test its stability. The results indicated that the model is stable until the most experienced expert participates in the decision-making process. A general conclusion of the stability analysis is that the criteria ranking is dependent on the experts' reputations, which confirms a justification for proposing FullEX as a new criterion weighting technique.

The considered case study can significantly influence the market of postal and courier services. This type of research promotes the competition between LMD couriers and suggests which parameters of service should be particularly monitored in the production process. Further, this leads to higher customer satisfaction, regardless of legal entities, individuals, or state and city authorities. All the previously mentioned are expected to bring higher profits to the delivery sector. Also, this study supports policymakers in setting regulations concerning LMD and city logistics. The results of this paper can support urban planners and decision-makers to better understand the influence of various factors on the organization of LMD. However, the proposed FullEX is general and can be applied in various contexts to evaluate the importance of specific criteria and to contribute to the development of many business sectors.

The Limitations of the FullEX method are as follows: 1) The results of this method may be different which depends on the experts' reputations in different areas. The decision maker must identify the experts with the highest reputation to obtain more confident results. 2) The FullEX method is limited only to the crisp values. However, future research aims to include the uncertain environment and extend the proposed FullEX approach.

Since the proposed FullEX is not limited only to the applied problem, a recommendation for future research could be to apply it to some other problem considering multiple criteria where their assessment is needed. In addition, the possible future research directions could be to extend the methodology on fuzzy sets, to couple the FullEX method with some of the existing MCDM methods to obtain criteria weights, or to integrate the FullEX method with some of the MCDM methods for ranking the alternatives which would complete the process of selecting a sustainable LMD courier.

CRediT Authorship Contribution Statement

Sara Bošković: Conceptualization, Investigation, Writing - Original Draft, Review & Editing. **Libor Švadlenka:** Resources, Project administration, Writing - Original Draft, Review & Editing. **Stefan Jovčić:** Methodology, Software, Validation, Formal analysis, Visualization, Data Curation, Writing - Original Draft, Review & Editing. **Momčilo Dobrodolac**: Investigation, Data Curation, Writing - Original Draft, Review & Editing. **Vladimir Simic**: Methodology, Visualization, Writing - Original Draft, Review & Editing. **Nebojsa Bacanin:** Methodology, Visualization, Writing - Original Draft, Review & Editing.

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