Multi-criteria Decision-Making on Operational Risk in Banks

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Abstract. The frequency of application of different multi-criteria decision-making methods in business and financial problems is justified by the diversity and complexity of business decisions. The methods enable analysts and decision-makers to assess when making a decision. This research aims to present the contribution of multi-valued relationship methods in assessing operational risks in banks operating in Serbia. The article shows that the multi-criteria approach used in the initial phase of identifying operational risk increases the potential of bank management for further risk management, particularly in operational risk management (ORM). The research also included a comparative analysis of the results obtained by various MCDM methods, which were more concerned with business risk analysis. An example of a decision-making problem in operational risk management is presented, showing how the issue of decision-making in operational risk management is structured using the BWM method. The use of the BWM method proved to be highly acceptable for decision-makers in banks compared to other models. In all MCDM models, external factors and human resources rank first. The results unequivocally indicated the significant influence of external factors on banking operations – the consequences of the COVID-19 pandemic, part-time work, hacker attacks, economic policy, and adjustment of the economy to epidemiological restrictions. The approach is simple and provides an effective method that can be successful in solving other decision-making problems.

Keywords: Bank Risk Management · MCDM · BWM method

1 Introduction

Operational Risks Management (ORM) has become a key issue for every business organization in the last two decades, especially in banking risk management. This period of technological innovations and various crises is burdened with a large amount of important but irrelevant data that have led to the rapid development of analytical tools for operational risk management. The concept of operational risk related to the business performance of banks has not been recently conceived. However, it has recently reached its primacy among other banking risks and assumed its immense importance [15, 16]. Identifying current trends in ORM relate to different types of natural disasters, criminal

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acts, abuses, and all other negative impacts of man-made activities. Using data analysis tools and methods has greatly facilitated risk management in banks. Building on this, Araz et al. [8] highlighted integrating different analytical tools in the decision-making process.

In recent years, the use of multi-criteria tools crucial for decision-making has expanded. There are numerous examples of the use of these tools. Previously, they mostly referred to business management and decisions within the management structure of companies [39, 41, 61, 70, 71]. Their use has become significantly widespread; therefore, these tools are widely used nowadays when resolving complex problems in a decision-making process. Hybrid models are being developed, and new methods are emerging. These tools cover almost all areas of the business world, for example, the area of public investment [26], energy efficiency [17], diagnostics in medicine [36], the food industry [6], renewable energy production [4, 28], banking services [69], forecasting carbon price [2], location selection [43], distribution channels in the agricultural economy [56, 66], the choice of technology in urban wastewater treatment [54], assessing the quality scientific outputs [60], metaheuristic-based optimization algorithms [19], and, more importantly, in the field of risk management [32, 37, 38], especially in the area of operational risk [55].

Problem-solving with multi-criteria decision-making (MCDM) is realized through an arsenal of numerous methods which enable the calculation of criteria weights for problem assessment. The paper aims to enable a more accurate and symmetrical decision-making process, the BWM method (Best-Worse Method) will be used as a factor in improving decision-making in the field of banking. To make the final decision objectively, the results obtained by the BWM method [18, 21, 64, 69] will be compared with other MCDM methods, as follows: Analytical Hierarchy Process – the AHP method [9, 65], Fuzzy Analytical Hierarchy Process – the FAHP method [25], Technique for Order Performance by Similarity to Ideal Solution – Fuzzy TOPPSIS [40, 57], The Evaluation Based on Distance from Average Solution – EDAS [27], The Simple Additive Weighting – SAW (=WSM) [24], and Entropy weight method [35]. Although the BWM model has not been used so often in the analysis of financial problems, its wide application in various domains gives the author the idea to use this model to show that decision-making in preventing or mitigating operational risks in banking may be more accurate.

The contribution of the analysis of this paper is a critical review of multi-criteria problems in which the levels of a hierarchical structure contain different elements. A concrete example was used to prove that a hierarchical structure with a larger number of lower-level factors gives precise criteria weights that correspond to the decision-makers preferences.

The paper is structured in the following way. After the introductory part, Section II presents the operational risk and indicates the necessity of operational risk management. Section III contains a literature review. The methodology is presented thoroughly in Section IV, along with the modelling of decision-making problems. Section V displays the results of the research in which the solutions are presented as the final decisions of the bank management in the process of operational risk management by using the BWM method. The discussion is in Section VI. The last section gives the concluding considerations.

2 Operational Risk

Operational risk management requires the identification and assessment of operational risk. It is conducted itself from within. The bank management faces a set of fragmented activities with a wide range of risks. Since operational risk is not an integrated process, the potential sensitivity of banking activities to business risks is assessed. In the next step, the bank classifies the risks according to the impact on banking operations. This phase is crucial because it largely exposes the areas of weakness and can also help the management prioritize further activities. Risk indicators are the next stage. As for operational risk, defining indicators is hindered because it is difficult to define assessment criteria, and, as a rule, they are often re-examined. They can be, for example, the number of failed transactions, turnover rates per employee and the frequency of errors, and the severity of failures. It is difficult to measure these operational risks. Banks try to work out solutions by quantifying risk exposure with different approaches. For example, business data from previous years (e.g., data on loss or gain) may provide information to a bank to assess the bank's exposure to operational risk or be the basis for developing risk mitigation/control tools. Despite numerous procedures and tools that banks apply, operational risk is difficult to measure directly. Still, it probably gets higher with an increasing number of branches, employees, or loans to insiders.

As operational risk is a set of numerous difficult-to-measure indicators, it is necessary to implement a decision-making system to provide the best results. In this process, it is also important to involve competent and experienced bankers, both reliable and knowledgeable, who will, with the help of IT support, make key decisions to solve the problems caused by operational risk. The multiple-decision method is one of several available methods of assessing operational risk. First, it is adaptable to different impacts that can occur during banking operations. In that context, this method includes various effects, i.e., factors. By analysing them, evaluators can draw a better conclusion from several criteria and options.

The causes of operational risk are numerous - human factors, inadequate procedures, inadequate internal processes, inadequate management of information systems, inadequate business infrastructure of a bank, system errors, unpredictable external events, abuses and criminal actions, hacker attacks, etc. Further information on operational risk can be found in Table 1.

For the purposes of the analysis, experts in the field of banking were hired. They are long-term managers in key positions in their banks. One of them is an internal auditor in the bank who analyses the work of banks, the second one is a member of the bank's board, and the third is the CEO and regional manager. All information is obtained from the annual financial reports of banks, auditors' reports, and quarterly analyses, which are available on the official websites of the analysed banks (whose branches operate in Serbia).

Table 1. Elements of operational risk in banking operations

Internal processes	Human factors	System errors	External factors	International standards
Infrastructure	Education	Outdated procedures	Criminal acts	Regulation
Technology risks	Skills	Uncritical approach	Natural disasters	Recommendations
Unauthorized execution of a transaction	Culture (behavior)	Hardware failures	Crisis	Accounting standards
Data transferring errors	Ethics and moral	Software failures	Migration	Financial standards
Accounting errors	Labor law	IT security	Terrorism	ISO standards
Unauthorized access to customer accounts	Inadequate number of employees	Technical-technological problems	Pandemic	Financial technology
Misuse of confidential customer information	Safety at work and workplace safety	Telecommunication problems	Robbery, forgery	Innovation
Money laundering	Unfair termination of employment contracts	Power outages and similar situations	Cyber attacks	
Lack or wrong choice of bank products	Violation of health and safety regulations	Information system	Vandalism	
Abuse of position	Workforce management	Networks	Economy policy	
Internal control	Discrimination	Processes		
	Internal criminal activity	Capacities		
	Rewards and bonuses	Administration		
	Employee experience			
	Accountability system			

Source: the authors' analysis

It is important to mention that the experts, who defined the input elements of the matrix in the model, emphasized that since 2008 external factors have been identified as the main risks of banking operations (for efficient management of banking operations, see [49]); especially during the COVID-19 pandemic [13], which was not the case in previous decades. The Basel Committee on Banking Supervision [14] strongly advises banks to use their functions for operational risk management to constantly identify external and internal threats and potential losses resulting from inadequate processes caused by people and systems and immediately assess the vulnerabilities of critical operations and manage the resulting risks in line with their operational resilience expectations. That has greatly changed the outcome and ranking of the previous risk results in banking, not only from the aspect of operational risk, as one of the various risks in banking, but also within the operational risk factors.

According to the above, there is a real need to form an adequate model that will best assess the quality of each criterion and rank all the consequences of operational risk. The problem of ranking criteria, i.e., operational risk, in this case, is based on a large number of elements that reflect the quality of a bank, followed by creating a ranking list that allows cross-comparisons. The analysis is further complicated by the vast amount of business data of a bank which lead to a particular business result, and it is necessary to select only the most critical indicators. Additionally, the model should enable banks to identify the weaknesses of their operational risk management and accordingly make adequate adjustments to their business operation.

3 Applications of BWM: Literature Review

In everyday activities, decision-makers face complex decision-making problems. We often talk about (im)material and conflict (weight) criteria. So far, several multi-criteria decision-making (MCDM) methods have been developed. These methods measure the priority of conflict (weight) criteria used to select the best alternative for decision-making. At the same time, numerous MCDM methods sometimes confuse the users. Which method to choose? The point is to find out if there are logical, mathematical, social, or practical reasons why one method is better than the other. The basic problem in decision-making is the uncertainty associated with input parameters. Thus, there is uncertainty in setting the factors based on which the results are obtained and which should help the executor to make a decision. To put it another way, the uncertainty of inputs can lead to some unrealistic results, making it difficult to reach the best final decision.

The inevitable phase in solving multi-criteria problems is determining weight criteria. Various research studies on this topic, which have been used for decades, show no single division of the methods for determining weight criteria. It also shows us that the division of the methods was made according to the authors' understanding and the problems being solved. Mitigating previous subjective influences when choosing criteria weighs is done by applying objective models [67], which involve calculating the weight coefficients of the criteria based on the decision-making matrix.

The decision-making process refers to the ranking of alternatives which are based on several criteria. In MCDM problems, the number of alternatives is assessed according to a series of criteria to select the best alternatives and obtain the best solutions to the problem [6, 53]. One of the most widely used methods, with a long tradition of multi-criteria decision-making, which has been used as a decision-making tool since 1980, is the Analytical Hierarchical Process (AHP method). The major drawback of the

AHP method is the inconsistency of decision makers (in pairwise comparisons) due to a large number of pairwise comparisons of criteria. This drawback of the AHP method, a large number of pairwise comparisons of criteria, Rezaei [53] overcame by developing the BWM method. Applying the BWM method, optimal values of weight coefficients are obtained with only a small number of pairwise comparisons. By making only 2n-3 comparisons, the problem of inconsistency of pairwise comparison is overcome. This way, we get more reliable results, i.e., greater consistency of the obtained results. In the BWM method, unlike the AHP method, only the comparisons of the best and worst criteria are made with other criteria. This simple procedure eliminates redundant (secondary) comparisons [42]. According to Beemsterboer et al. [10], this inconsistency can be reduced by the Best-Worst method (BWM), which needs significantly fewer pairwise comparisons. In addition, BWM enables solving a nonlinear model to obtain weights from the comparison. Sadjadi and Karimi [58] state that BWM is formulated through linear programming and can be solved with even the simplest (commercial) software package. The proposed method has been applied in many cases in the literature, and preliminary results have proved that low perturbation can significantly affect the final ranking [28, 52, 54, 58].

Pamučar et al. [42] state that the BWM method has been used to solve some real problems in various fields in the last five years. In supply chains, the BWM method has broad applications [10, 63]. Ghaffari et al. [21] use the BWM method to analyse success factors in the area of technological innovation in the field of the aviation industry, while Salimi and Rezai [59] and Salimi [60] used it in the field of research and development, as well as education. In the energy field, the BWM method is applied in decision-making on energy efficiency in urban areas [22]. In another study, the BWM method was applied in the field of communications [68]. It is also used in tourism [1]. Yadollahi et al. [69] apply this method in the field of banking services. It is also successfully used in research that uses the BWM method in combination with other methods (multiple integrations). Some studies use fuzzy versions of the BWM method. Thus, Raj and Srivastava [50] used the Fuzzy BWM method (FBWM) to analyse the sustainability performance of an aircraft manufacturing company, while Khanmohammadi et al. [29] used it to create strategies and innovations to reach sustainable performance and company growth. Pamučar et al. [42] have developed an advanced BWM method (BWM-I) in renewable energy performance analysis. A step further were the researchers that combined the BWM method with other robust techniques, aiming to achieve better results [7, 19, 20, 22, 23, 33, 34, 44, 51, 62, 64]. The combined methods gave better results in the decision-making process in the assessment of performance in production, vague triangular sets in performance assessment, supply chain management, energy sector, transport and investment sector, supplier selection, web service selection, or green performance of airports, as well as for comparative analyses at wind farms.

What is common for all these studies from different areas is that all of them apply the traditional BWM algorithm, meaning that one best criterion and one worst criterion are defined by consensus. The studies have shown that using the BWM method can lead to consistent assessments that will provide decision-makers with an adequate solution to decision-making problems. Applying the BWM method was not so common in banking, because previous research conducted through the analyses of marketing and management activities in companies was also used in banks. This paper is an opportunity to analyse banks' operational risk management through multi-criteria decision-making.

4 The Best-Worst Method (BWM) – Methodology

The application of the BWM method is widespread in the analysis of multi-criteria decision-making because it is easy to apply and can be solved with the help of software packages. The advantage of the BWM method is reflected in the ability to obtain optimal values of weight coefficients with only a small number of pairwise criteria comparisons. Only by comparing $2n-3$ pairs of criteria is the problem of inconsistency, which occurs during the comparison of input criteria, overcomes. This simple procedure eliminates unnecessary comparisons, making the results more reliable (there is a greater consistency of the obtained results). The most significant advantage of the BWM method is that it is formed through linear programming, which can be solved with the simplest (commercial) software package. The main disadvantage of the BWM method is reflected in the fact that, while solving problems, several criteria appear that exert the same influence on decision-making. They are rather noticeable if there is a large set of criteria with similar characteristics, i.e. which have a similar impact on the problem being solved. Then it is recommended to use the hybrid/fuzzy BWM method or to combine the BWM method with other multi-criteria decision-making tools.

The implementation of the analysis of multi-criteria decision-making by the BWM method is realized in several steps. In the first step of the analysis, it is necessary to determine a set of decision criteria. The size of the set depends on the problem that is set as the goal of the analysis that needs to be solved. The advantage of the BWM method is that it allows the analysis of a wide set of criteria based on the opinion of a decision-maker. Hence, its application is widespread in the decision-making process. In the second step, defining the best and worst criteria from the already defined set of decision criteria is essential. Since the best and worst criteria have been already defined, it is necessary to express the preference of the decision maker by setting, first, *the best criterion over all other criteria, and then the preference for all other criteria over the worst one*:

$$A_B = (a_{B!}, a_{B2}, \ldots, a_{Bn}), \tag{1}$$

where a_{Bj} indicates the advantage of the best criterion B over criterion j. Therefore, it is obvious that $a_{BB} = 1$.

$$A_W = (a_{!W}, a_{2W}, \ldots, a_{nW})^T, \tag{2}$$

where a_{jW} indicates the advantage of criterion j over the worst criterion W. Therefore, it is obvious that $a_{WW} = 1$.

Table 2. Decision maker preference scale

The meaning of the numbers 1–9:
1: **Equal** importance
2: Somewhat between Equal and Moderate
3: **Moderately** more important than
4: Somewhat between Moderate and Strong
5: **Strongly** more important than
6: Somewhat between Strong and Very strong
7: **Very strongly** important than
8: Somewhat between Very strong and Absolute
9: **Absolute** important

The preference of a decision maker is measured by choosing a number on a scale from 1 to 9, defined in Table 2.

After defining the criteria, conducting a pairwise comparison of each of these two criteria (best and worst) and other criteria, and setting the preferences of a decision maker following the value scale of the best and worst criteria compared to all other criteria, we move on to the last fifth step. It is necessary to calculate the values of optimal weights. The optimal weight for each criterion is the one where for each pair $\left({}^{w_B}/_{w_j}\right)$ and $\left({}^{w_j}/_{w_W}\right)$ is $\left({}^{w_B}/_{w_j} = a_{Bj}\right)$ and $\left({}^{w_j}/_{w_{jW}} = a_{jW}\right)$. To fulfill these conditions for all j, the solution should be determined where the maximum absolute distances $\left|{}^{w_B}/_{w_j} - a_{Bj}\right|$ and $\left|{}^{w_j}/_{w_{jW}} - a_{jW}\right|$ for all j are minimized. Thus, the level of consistency is assessed

$$Min\, \xi_L, \tag{3}$$

to determine the rank of the best criterion above all the others and all others above the worst criterion:

$$\left|w_b - a_{Bj} * w_j\right| \le \xi_L, zasvakoj \tag{4}$$

$$\left|w_b - a_{Bj}{*}w_j\right| \le \xi_L,\ \ za\ svako\ j \tag{5}$$

where:

$$\sum w_j = 1 \tag{6}$$

proving that

$$\sum w_j \ge 0, zasvakoj \tag{7}$$

The closer the amount of consistency, i.e., the final number, is to zero, the more reliable the result is, and a better decision can be made.

5 Results

The results of all ranks of operational risk criteria according to different MCDM models are presented in Table 3. They unequivocally show that external influences and employees are key elements of operational risk. In contrast, internal processes and procedures are less important elements by rank.

Different operational risk factor weights are obtained by solving the BWM model through all the above phases. The values in Fig. 1 show the main factor weights based on the assessment of experts in the field of banking and finance. Based on the obtained weights, it can be seen that the experts estimated that external effects dominate in operational risk. Human factors and international standards follow while internal processes and system errors are the final ones. In addition to the displayed values of the weight criteria, the software also calculates the value $\xi x = 0.089$. The values of ξx are very close to zero, indicating a high degree of consistency in the comparison and high reliability of the obtained results.

The obtained weights show that external factors' influence is the major cause of operational risk in banks. The situation with the COVID-19 pandemic significantly influenced the assessment of the experts in banking. System errors had a minimal impact.

Table 3. Ranks of criteria according to different MCDM methods

MCDM	**1**	**2**	**3**	**4**	**5**
AHP	External Factors	Human Resources	Inadequate Infrastructure	System Events	/
Fuzzy AHP	External Factors	Human Resources	Inadequate Infrastructure	System Events	/
Fuzzy TOPPSIS	Human Factors	External Effects	Inadequate Infrastructure	System Events	/
EDAS	External Factors	Human Resources	Inadequate Infrastructure	System Events	/
SAW (=WSM)	Human Factors	External Effects	Internal Processes	International Standards	System Errors
Entropy	External Effects	Human Factors	International Standards	Internal Processes	System Errors
BWM	External Effects	Human Factors	International Standards	Internal Processes	System Errors

Source: the authors' calculation

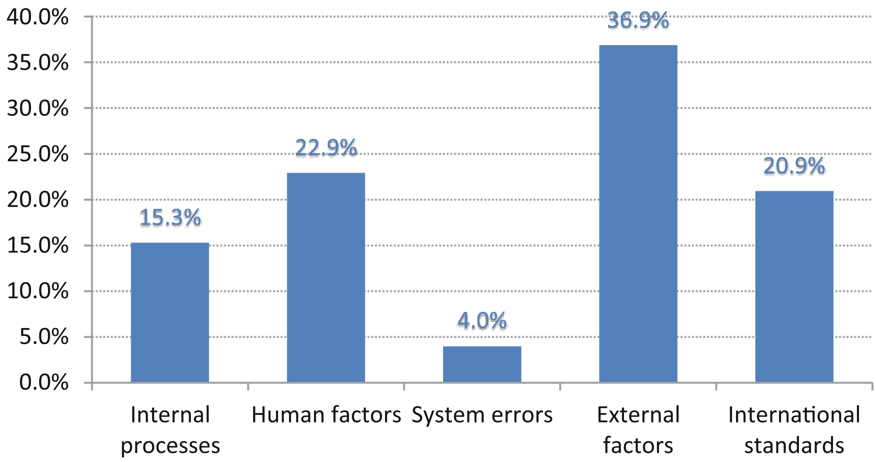

Fig. 1. Main Factor Weights

6 Discussion

The upper part of the paper shows that operational risk is the dominant operational risk in the banking sector. Furthermore, numerous methods of multi-criteria decision-making are listed, and the methods we will use later in the analysis are explained. Recognizing the importance of operational risk management and the advantages of the BWM method, it is important to note that the paper's analysis will be realized through a simple software package.

This study aimed to identify and determine the priority elements of operational risk formed using different methods. The experts analysed all operational risk factors - a total of five factors (criteria) and 57 sub-factors (operational risk elements) from Table 1. Using the BWM method, they determined the significance and preference of the components and sub-factors from the point of view of the bank management.

In the decision-making process, the experts in banking analysed all operational risk factors to see where the highest level of risk threatens bank operations and used this knowledge to improve operational risk management. They generated the first level of input criteria - Human Factors, Internal Processes, System Errors, External Factors and International Standards (See Table 1). Afterward, they analysed the elements through which operational risk is manifested for each of the mentioned criteria. The idea was to specify the source of the problem to reach a more precise solution. As for human resources, they singled out the elements related to the personality of workers - education, skills, culture (behaviour), ethics and morals, labour law; then the elements related to regulations, that is, occupational safety, job security, unfair termination of employment contracts, violations of health and safety regulations, lawsuits related to discrimination, inadequate number of employees, the system of responsibility in an organisation; labour resource management, internal criminal activity, rewards and bonuses, employee experience. Internal processes are complex processes that ensure the realization of daily activities in a bank. These are the processes that arise from the basic activity of a bank and are related first to the infrastructure that a bank has at its disposal, technologies, and equipment of the bank; then, the elements related to the business process were singled out, namely data transmission errors, lack or wrong choice of bank products, accounting errors, unauthorized transactions, unauthorized access to customer accounts, money laundering within a bank and the internal control (audit) proved to be the most important; finally, the elements related to human factors criteria, which are an abuse of position, misuse of confidential information of clients. A system error is an important link in banking operations and transactions with clients since it relates to technical equipment, namely technical-technological problems and processes, hardware and software failures, telecommunications problems, power outages, and similar situations, outdated procedures, uncritical approach, IT security, capacity, information systems and networks, slow-moving and cumbersome administration. External factors have become dominant. There is a growing influence of factors on banking operations beyond the bank's scope. In addition to natural disasters (floods, earthquakes), external factors are manifested through criminal acts (robberies, counterfeiting, vandalism, terrorism), modern technologies and stock exchanges (hacker attacks, speculation in the stock market due to crises), as well as through economic policy of a state (tax policy, monetary policy, exchange rate policy). International standards unequivocally determine the credibility of a bank, and if internationally valid regulations, standards (accounting, financial, ISO), and recommendations are not timely incorporated into national regulations; it could adversely and fatally affect the entire banking system. The impact of innovation and financial technologies in financial services has increased dramatically in recent years, especially due to the COVID-19 pandemic.

The analysis proved that the most important operational risk factor is an external factor, while the least important factor is a systemic error. The results obtained based on global weights showed that the influence of a human factor is the second highest, followed by international standards and internal processes. Although there are not many studies on the assessment of operational risk factors in banking operations through multi-criteria decision-making methods, similar findings of the previous studies throw light on the findings of this study. Knežević [31] analysed the sources of operational risk in the example of banks in Serbia and discovered the existence of a high impact of external factors on bank operations. According to her findings from 2013, most of the realized and potential losses came from external factors - 81% in total, while 43% are related to the existence of risk! Out of that, frauds dominate within external factors, with as much as 70%. In the January issue of the bulletin of the Bank for International Settlements [12], it was stated that the COVID-19 pandemic further increased the cyber risk to which banks had already been exposed. Through the analysis of a number of banks in different regions, Aldasoro et al. [3] showed that cyber losses have a small share in total operating losses, but they can have a large share in operational value-at-risk.

The obtained results based on the weight criteria of each factor, which are very close to each other, indicate that all the factors and their elements are immensely important for improving the general concept of operational risk management, although the results prefer external operational risk factors. Therefore, managers should not neglect the factors with less weight because the mutual influences are so profound that they can bring risk management out of banks' control.

One of the positive points of this analysis is that the identified operational risk factors (input criteria in the matrix) were general criteria for defining the final solution (weight criteria) for decision-making. To put it differently, valuable answers for the bank's management have crystallized here: which effects of operational risk are the most significant and how to manage operational risk in banking operations. Since the subjective impact is rather powerful, it is necessary to study it from the point of view of a bank manager employed in the risk sector. Hence, the choice of management is vital for risk management since, according to Borge [11], the power of risk management lies in the ability of managers to make good decisions. Studies show that personal characteristics of management, like gender and age, could significantly influence the decision-making process regarding achieved performances and ethics. However, some pioneer studies in Serbia show that the gender and age of the decision-makers do not influence performance [30, 46] or the ethical aspect [45, 47, 48]. In this paper, the BMW method has successfully quantified expert estimates and numerical results that managers can use effectively.

7 Conclusion

This analysis enabled bank managers to identify operational risk factors, improve operational risk management, and finally make valid decisions based on multi-criteria decision-making methods. All this will enable the bank management to reduce the pressure of negative effects on banks' financial results and meet the expectations of banks' shareholders. The study helped them better understand the meaning of factors, identify priority elements of operational risk in a newly created situation, and properly allocate their resources to mitigate or eliminate operational risk.

The use of the BWM method proved to be highly acceptable for decision-makers in banks compared to other models. In all models, external factors and human resources rank first. The results unequivocally indicated the significant influence of external factors on banking operations. These are the consequences of the COVID-19 pandemic, part-time work, hacker attacks, economic policy, and adjustment of the economy to epidemiological restrictions.

The implementation of assessments through matrices faces one specific limitation. The limitation refers to the existence of subjective interpretation when reaching final results, which occurs in both phases; the phase of the input elements of the matrix and the final stage of ranking and evaluation of the obtained results of the matrix. In this analysis, this limitation could be presented through, e.g., categorization of the frequency of risk occurrence (phase of input elements in the matrix) and risk assessment (results or outcomes). The limitation exists due to the subjective interpretation of experts, where different users may receive opposite assessments from the same contingent of quantitative risks. Hence, this limitation should not be seen as abandoning the use of matrix in decision-making analysis, but it suggests that the use of risk matrix should be handled with caution and only with careful explanation of the elements and results of the matrix.

The study primarily focused on the elements of operational risk that simultaneously represented the input criteria for the matrix. Although external effects exerted a dominant influence during the COVID-19 pandemic and other factors had a minor impact, additional efforts are needed and more research done on the same factors in stable economic and social conditions. The results need to be confirmed for the entire Balkan region. Moreover, test results can also be confirmed in different service sectors. Furthermore, future efforts should also be made to identify additional operational risk factors. Finally, the impact of operational risk on business operations should be researched in the future to gain a deep insight into the overall operations of companies, not just banks.

References

1. Abadi, F. A., Sahebi, G. I., Arab, A., Alavi, A. (2018): Application of Best-Worst Method in Evaluation of Medical Tourism Development Strategy. Decision Science Letters 7(1), 77-86 (2018). doi: https://doi.org/10.5267/j.dsl.2017.4.002
2. Abdi, A., Taghipour, S.: Forecasting Carbon Price in the Western Climate Initiative Market Using Bayesian Networks. Carbon Management 10(3), 255-268 (2019). doi: https://doi.org/10.1080/17583004.2019.1589842
3. Aldasoro, I., Gambacorta, L., Giudici, P., Leach, T.: Operational and Cyber Risks in the Financial Sector. BIS Working Papers no 840, February (2020).
4. Ali, T., Ma, H., Nahian, A. J.: Justification of Solar Home System in Rural Bangladesh Based on Risk Indicators: An Integrated Multi-Criteria Decision Making Approach. International Journal of Renewable Energy Research 9(4), 1948-1956 (2019).
5. Alimohammadlou, M., Bonyani, A.: Fuzzy BWANP Multi-Criteria Decision-Making Method. Decision Science Letters 8 (1) 85-94 (2019). doi: https://doi.org/10.5267/j.dsl.2018.4.002
6. Alimohammadlou, M., Bonyani, A.: A Novel Hybrid MCDM Model for Financial Performance Evaluation in Iran's Food Industry. Accounting and Financial Control 1(2), 38-45 (2017). doi:https://doi.org/10.21511/afc.01(2).2017.05
7. Amoozad Mahdiraji, H., Arzaghi, S., Stauskis, G., Zavadskas, E.: A Hybrid Fuzzy BWM-COPRAS Method for Analyzing Key Factors of Sustainable Architecture. Sustainability 10(5), pp. 1626 (2018). doi: https://doi.org/10.3390/su10051626
8. Araz, O.M., Choi, T.M., Olson, L D., Salman F.S.: Role of Analytics for Operational Risk Management in the Era of Big Data. Decision Sciences 51(6), 1320-1346, (2020). https://doi.org/10.1111/deci.12451
9. Badi, I., Abdulshahed, A.: Ranking the Libyan Airlines by Using Full Consistency Method (FUCOM) and Analytical Hierarchy Process (AHP). Operational Research in Engineering Sciences: Theory and Applications 2(1), 1-14. (2019). doi: https://doi.org/10.31181/oresta1901001b
10. Beemsterboer, D. J. C., Hendrix, E. M. T., Claassen, G. D. H.: On Solving the Best-Worst Method in Multi-Criteria Decision-Making. IFAC-PapersOnLine 51(11), 1660-1665 (2018). doi: https://doi.org/10.1016/j.ifacol.2018.08.218
11. Borge, D.: The Book of Risk. 1st Ed. John Wiley & Sons Inc., New York (2001).
12. BIS: Covid-19 and cyber risk in the financial sector. BIS Bulletins no 37 (2021).
13. BIS: Revisions to the Principles for the Sound Management of Operational Risk. Consultative Document, Basel Committee on Banking Supervision, August 2020.
14. BIS: Principles for Operational Resilience. Consultative Document, Basel Committee on Banking Supervision, August 2020.
15. BIS: International Convergence of Capital Measurement and Capital Standards. Comprehensive Version, Basel Committee on Banking Supervision, June 2006.
16. BIS: High-Level Principles for Business Continuity. The Joint Forum, Basel Committee on Banking Supervision, August 2006.

17. Carli, R., Dotoli, M., Pellegrino, R.: A Decision-Making Tool for Energy Efficiency Optimization of Street Lighting. Computers and Operations Research 96, 223–235 (2018). doi: https://doi.org/10.1016/j.cor.2017.11.016
18. Chahal, H., Dutta, K.: Measurement and Impact of Customer Experience in Banking Sector. Decision 42(1), 57-70 (2015). doi:https://doi.org/10.1007/s40622-014-0069-6
19. Diyaley, S., Chakraborty, S.: Optimization of Multi-Pass Face Milling Parameters Using Metaheuristic Algorithms. Facta Universitatis: Series Mechanical Engineering 17(3), 365-383 (2019). doi: https://doi.org/10.22190/FUME190605043D
20. Garg, C.P., Sharma, A.: Sustainable Outsourcing Partner Selection and Evaluation Using an Integrated BWM–VIKOR Framework. Environment, Development and Sustainability: A Multidisciplinary Approach to the Theory and Practice of Sustainable Development, Springer 22(2), 1529–1557 (2020). doi: https://doi.org/10.1007/s10668-018-0261-5
21. Ghaffari, S., Arab, A., Nafari, J., Manteghi, M.: Investigation and Evaluation of Key Success Factors in Technological Innovation Development Based on BWM. Decision Science Letters 6(3), 295–306 (2017). doi: https://doi.org/10.5267/j.dsl.2016.12.001
22. Gupta, H., Barua, M.K.: A Framework to Overcome Barriers to Green Innovation in SMEs Using BWM and Fuzzy TOPSIS. Science of the Total Environment 633, 122-139 (2018). doi: https://doi.org/10.1016/j.scitotenv.2018.03.173
23. Hashemkhani Zolfani, S., Ecer, F., Pamučar, D., Raslanas, S.: Neighborhood Selection for a Newcomer via a Novel BWM-Based Revised MAIRCA Integrated Model: A Case from the Coquimbo-La Serena Conurbation Chile. International Journal of Strategic Property Management 24(2), 102-118 (2020). doi: https://doi.org/10.3846/ijspm.2020.11543
24. Ibrahim, A. Surya R. A.: The Implementation of Simple Additive Weighting (SAW) Method in Decision Support System for the Best School Selection in Jambi. Journal of Physics: Conference Series, 1338, pp. 012054 (2019). doi:https://doi.org/10.1088/1742-6596/1338/1/012054
25. Ishizaka, A. Hoang, N. N.: Calibrated Fuzzy AHP for Current Bank Account Selection. Expert Systems with Applications 40(9), 3775-3783 (2013). doi: https://doi.org/10.1016/j.eswa.2012.12.089
26. Juričić, D., Vašiček, D., Drezgić, S.: Multiple Criteria Decision Analysis of Public Investment Options: Application to Streetlighting Renewal Projects. Economic Research – Ekonomska Istraživanja 33(1), 3288-3306 (2020). https://doi.org/10.1080/1331677X.2020.1763820
27. Keshavarz-Ghorabaee, M., Zavadskas, E., Maghsoud, A., Zenonas, T.: Extended EDAS Method for Fuzzy Multi-Criteria Decision-Making: An Application to Supplier Selection. International Journal of Computers Communications & Control 11(3), 358-371 (2016). doi: https://doi.org/10.15837/ijccc.2016.3.2557
28. Kheybari, S., Kazemi, M., Rezaei, J.: Bioethanol Facility Location Selection Using Best-Worst Method. Applied Energy, Elsevier 242(C), 612-623 (2019). doi: https://doi.org/10.1016/j.apenergy.2019.03.054
29. Khanmohammadi, E., Zandieh, M., Tayebi, T.: Drawing a Strategy Canvas Using the Fuzzy Best–Worst Method. Global Journal of Flexible Systems Management 20, 57-75 (2019). doi: https://doi.org/10.1007/s40171-018-0202-z
30. Knežević, G., Pavlović, V., Bojičić, R.: Does the board gender diversity impact financial performance in agriculture? - Case of Serbian agriculture companies listed at Stock Exchange. Custos e Agronegócio on line 13(3), 2-20 (2017).
31. Knežević, M.: Operational Risk – Challenges for Banking Industry. Economic Analysis 46(1-2), 40-52 (2013).
32. Kou, G., Wu, W.: An Analytic Hierarchy Model for Classification Algorithms Selection in Credit Risk Analysis. Mathematical Problems in Engineering 2014, Article ID 297563, p. 7 (2014). doi: https://doi.org/10.1155/2014/297563

33. Kumar, A., Aswin, A., Gupta, H.: Evaluating Green Performance of the Airports Using Hybrid BWM and VIKOR Methodology. Tourism Management, 76, pp. 103941 (2020). doi: https://doi.org/10.1016/j.tourman.2019.06.016
34. Li, J., Wang, J.Q., Hu, J.H.: Multi-Criteria Decision-Making Method Based on Dominance Degree and BWM with Probabilistic Hesitant Fuzzy Information. International Journal of Machine Learning and Cybernetics 10(7), 1671-1685 (2019). doi: https://doi.org/10.1007/S13042-018-0845-2
35. Li, P. Zhang, Z.: Study on the Fragility of the Banking System – Application of Entropy Method. 2nd International Conference on Materials Science, Machinery and Energy Engineering (MSMEE 2017). Advances in Engineering Research 123, 1460-1468 (2017).
36. Luo, M., Zhao, R.: A Distance Measure Between Intuitionistic Fuzzy Sets and Its Application in Medical Diagnosis. Artificial Intelligence in Medicine 89, 34-39 (2018). doi: https://doi.org/10.1016/j.artmed.2018.05.002
37. Md. Sum, Rabihah: Risk Management Decision Making. Proceedings of the International Symposium on the Analytic Hierarchy Process. Sydney (2013). doi: https://doi.org/10.13033/isahp.y2013.073.
38. Michnik, J. MCDM Approach to Financial Risk Management. Proceedings of The 35th International Conference on Computers and Industrial Engineering (CIE), pp. 1385-1390. Istanbul Technical University, Istambul (2005).
39. Mikušová, M.: To Be or Not to Be a Business Responsible for Sustainable Development? Survey from small Czech businesses. Economic Research - Ekonomska Istraživanja 30(1), 1318-1338 (2018). doi: https://doi.org/10.1080/1331677X.2017.1355257
40. Nădăban, S., Dzitac, S. Dzitac, I.: Fuzzy TOPSIS: A General View. Procedia Computer Science 91, 823-831 (2016). doi: https://doi.org/10.1016/j.procs.2016.07.088
41. Pakhchanyan, S.: Operational Risk Management in Financial Institutions: A Literature Review. International Journal of Finance Studies 4(20), 2-21 (2016), doi:https://doi.org/10.3390/ijfs4040020
42. Pamučar, D., Ecer, F., Ćirović, G., Arlasheedi, M. A.: Application of Improved Best Worst Method (BWM) in Real-World Problems. Mathematics 8(8), 1342 (2020). doi: https://doi.org/10.3390/math8081342
43. Pamučar, D., Pejčić Tarle, S., Parezanović, S.: New Hybrid Multi-Criteria Decision-Making DEMATEL-MAIRCA Model: Sustainable Selection of a Location for the Development of Multimodal Logistics Centre. Economic Research-Ekonomska Istraživanja 31(1), 1641-1665 (2018). doi: https://doi.org/10.1080/1331677X.2018.1506706
44. Pamučar, D., Gigović, L., Bajić, Z., Janošević, M.: Location Selection for Wind Farms Using GIS Multi-Criteria Hybrid Model: An Approach Based on Fuzzy and Rough Numbers. Sustainability 9(8), 1315 (2017). https://doi.org/10.3390/su9081315
45. Pavlović V, Knežević G, Bojičić R.: Board gender diversity and earnings management in agricultural sector - Does it have any influence? Custos e Agronegócio on line 14(2), 340-363 (2018).
46. Pavlović, V., Knežević, G., Bojičić, R.: Does board of director's age diversity affect financial performance in agricultural sector? - Evidence from an emerging country. Custos e Agronegócio on line 15(3), 313-340 (2019).
47. Pavlović V, Knežević G, Bojičić R.: Does board of director's age impact earnings management in agriculture? - Case study Serbian agricultural sector. Custos e Agronegócio on line 15(1), 254-272 (2019).
48. Pavlović V, Knežević G, Bojičić R.: The impact of gender and age on earnings management practices of public enterprises: A case study of Belgrade. Economic Studies (Ikonomicheski Izsledvania) 31(3), 130-148 (2022).
49. Prokopenko, Y., Bondarenko, D.: Operational Risk Management: Best Practice Overview and Implementation. IFC World Bank Group, Tirana, Albania, September 10–11 (2012).

50. Raj, A., Srivastava, S.K.: Sustainability Performance Assessment of an Aircraft Manufacturing Firm. Benchmarking: An International Journal 25(5), 1500-1527 (2018). doi: https://doi.org/10.1108/bij-01-2017-0001
51. Rezaei, J., Kothadiya, O., Tavasszy, L., Kroesen, M.: Quality Assessment of Airline Baggage Handling Systems Using SERVQUAL and BWM. Tourism Management 66, 85-93 (2018). doi: https://doi.org/10.1016/j.tourman.2017.11.009
52. Rezaei, J.: Best-Worst Multi-Criteria Decision-Making Method: Some Properties and a Linear Model. Omega vol. 64, 126-130 (2016). doi: https://doi.org/10.1016/j.omega.2015.12.001
53. Rezaei, J.: Best-Worst Multi-Criteria Decision-Making Method. Omega, Vol. 53, 49-57 (2015). doi: https://doi.org/10.1016/j.omega.2014.11.009
54. Ren, J., Liang, H., Chan, Felix T.S.: Urban Sewage Sludge, Sustainability, and Transition for Eco-City: Multi-Criteria Sustainability Assessment of Technologies Based on Best-Worst Method. Technological Forecasting and Social Change, Elsevier, 116(C) 29-39 (2017). doi: https://doi.org/10.1016/j.techfore.2016.10.070
55. Ristanović V., Primorac D., Kozina G.: Operational risk management using multi-criteria assessment (AHP model). Technical Gazette 28 (2), 678–683 (2021). doi: https://doi.org/10.17559/TV-20200907112351
56. Ristanović V., Tošović-Stevanović A., Maican S., Muntean A. Economic overview of the distribution channels used by Eastern European small farms for their agricultural products, Agricultural Economics – Czech 68 (8), 299–306 (2022). doi: https://doi.org/10.17221/168/2022-AGRICECON
57. Rostamzadeh, R., Ghorabaee, M.K.; Govindan, K., Esmaeili, A., Nobar, H.B.K.: Evaluation of Sustainable Supply Chain Risk Management Using an Integrated Fuzzy TOPSIS-CRITIC Approach. Journal of Cleaner Production 175, 651-669 (2018). doi: https://doi.org/10.1016/j.jclepro.2017.12.071
58. Sadjadi, S., Karimi, M.: Best-Worst Multi-Criteria Decision-Making Method: A Robust Approach. Decision Science Letters 7(4), 323-340 (2018). doi: https://doi.org/10.5267/j.dsl.2018.3.003
59. Salimi, N., Rezaei, J.: Evaluating Firms' R&D Performance Using Best Worst Method. Evaluation Program Planning 66, 147-155 (2018). doi: https://doi.org/10.1016/j.evalprogplan.2017.10.002
60. Salimi, N.: Quality Assessment of Scientific Outputs Using the BWM. Scientometrics 112(1), 195-213 (2017). doi: https://doi.org/10.1007/s11192-017-2284-3
61. Sandberg, J., Tsoukas, H.: Making Sense of the Sensemaking Perspective: Its Constituents, Limitations, and Opportunities for Further Development. Journal of Organizational Behavior 36(S1), S6–S32 (2014). doi: https://doi.org/10.1002/job.1937
62. Serrai, W., Abdelli, A., Mokdad, L., Hammal, Y.: Towards an Efficient and a More Accurate Web Service Selection Using MCDM Methods. Journal of Computational Science 22, 253-267 (2017). doi: https://doi.org/10.1016/j.jocs.2017.05.024
63. Setyono, R.P., Sarno, R.: Vendor Track Record Selection Using Best Worst Method. Proceeding books, International Seminar on Application for Technology of Information and Communication, pp. 41-48, IEEE, Semarang, Indonesia, 7 October (2018).
64. Stević, Ž., Pamučar, D., Kazimieras Zavadskas, E., Ćirović, G., Prentkovskis, O.: The Selection of Wagons for the Internal Transport of a Logistics Company: A Novel Approach Based on Rough BWM and Rough SAW Methods. Symmetry 9(11), 264 (2017). doi: https://doi.org/10.3390/sym9110264
65. Tošović-Stevanović A., Ristanović V., Lalić G., Žuža M., Stepien S, Borychowski M.: Determinants for the viability of small-scale family farms in Serbia: an example of the use of a multi-criteria assessment tool, Studies in Agricultural Economics 123(1), 23-32 (2021). doi: https://doi.org/10.7896/j.2101

66. Tošović-Stevanović A., Ristanović V., Ćalović D., Lalić G., Žuža M., Cvijanović G.: Small farm business analysis using the AHP model for efficient assessment of distribution channels. Sustainability 12(24), pp. 10479 (2020). doi: https://doi.org/10.3390/su122410479
67. Tzeng, G.-H., Chen, T.-Y., Wang, J.C.: A Weight-Assessing Method with Habitual Domains. European Journal of Operational Research 110(2), 342-367 (1998).
68. Van de Kaa, G., Fens, T., Rezaei, J., Kaynak, D., Hatun, Z., Tsilimeni-Archangelidi, A.: Realizing Smart Meter Connectivity: Analyzing the Competing Technologies Power Line Communication, Mobile Telephony, and Radio Frequency Using the Best Worst Method. Renew, Renewable and Sustainable Energy Reviews 103, 320-327. (2019). doi: https://doi.org/10.1016/j.rser.2018.12.035
69. Yadollahi, S., Kazemi, A., Ranjbarian, B.: Identifying and Prioritizing the Factors of Service Experience in Banks: A Best-Worst Method. Decision Science Letters 7(4), 455-464 (2018). doi: https://doi.org/10.5267/j.dsl.2018.1.002
70. Zavadskas, E. K., Antucheviciene, J., Vilutiene, T., Adeli, H.: Sustainable Decision-Making in Civil Engineering, Construction and Building Technology. Sustainability 10(1), 14 (2017). doi: https://doi.org/10.3390/su10010014
71. Zavadskas, E. K., Turskis, Z.: Multiple Criteria Decision Making (MCDM) Methods in Economics: An Overview. Technological and Economic Development of Economy 17(2), 397–427 (2011). doi: https://doi.org/10.3846/20294913.2011.593291