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[1]An Idea Evaluation Phase in Online Communities: A Case on the COVID-19 Innovation Platform

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Abstract: The COVID-19 pandemic has not only created public health issues but also sectoral problems and economic crises. As a response to this unexpected phenomenon, online communities have also started initiatives to tackle it. One of these initiatives was carried out in Turkey. Innovative project ideas were gathered from entrepreneurs and potential contributors regarding the problems brought about by the COVID-19 pandemic. The program occurred over three months (April 2020 to June 2020) through an open innovation platform in Turkey. The scope of this program is to collect business ideas from entrepreneurs and potential contributors, mature ideas with mentors and other entrepreneurs, and select the best ones by jury. In the process of evaluating the ideas, the weighted sum method (WSM) was used by the jury. The main purpose of this study is to reveal the effectiveness of the WSM via online communities in the idea evaluation phase. To demonstrate how this, we implemented different multi-criterion decision-making (MCDM) methods to the decision matrix dataset. We compare the results of WSM to those of the other two well-known (TOPSIS and VIKOR) MCDM methods. Besides, we conducted regression and sensitivity analysis to further clarify the differences between the results. Thereafter, we combine the rankings obtained from three MCDM methods by applying three aggregation methods as a compromise solution for the final decision. We find that the decision-makers can use WSM, TOPSIS, VIKOR, and aggregation methods separately according to the criterion weighting and the level of confidence in the scoring of the alternatives.

Keywords: *Multiple criteria analysis , COVID-19, decision-making, innovation platform, idea evaluation, open innovation*

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Introduction

The COVID-19 pandemic, which is one of the largest medical disasters since the Spanish flu pandemic of 1918, has brought about social and economic effects across the world, in addition to the irreparable losses of hundreds of thousands of deaths. Many efforts, funded by public, corporate, and non-governmental groups, were launched using innovation platforms (IPs) like contests, hackathons, and crowdsourcing techniques to mitigate the COVID-19 pandemic's consequences (Bolton et al., 2021; Braune et al., 2021; Desai et al., 2020; Freeman et al., 2020; Gama, 2020; Vermicelli et al.,2020). These open initiatives lead to not only successful innovations but also effective approaches in an economic downturn such as the current pandemic period (Ahn et al., 2018; Chesbrough and Garman, 2009; Chesbrough, 2020; Di Minin et al., 2010). This is achieved by implementing open innovation approaches to create a knowledge- and technology-sharing economy (Adamczyk, Bullinger, and Möslein, 2012; Boudreau, Lacetera, and Lakhani, 2011; Kim and Lee, 2019; Taeihagh, 2017; Terwiesch and Xu, 2008) and developing new products at the early stages of the innovation phase, known as the fuzzy front-end innovation process (Adamczyk, Bullinger and Möslein, 2012; Velamuri et al., 2017; Pisano et al., 2015).

Shortly after the pandemic started, several innovative initiatives were started in Turkey, as throughout the world, to cope with the social and economic effects of the COVID-19 pandemic. One of these initiatives is the COVID-19 Innovation Platform powered by an open innovation platform in Turkey. This program occurred over three months (April 2020 to June 2020) as the process of collecting business ideas from entrepreneurs, maturing these ideas with mentors and other entrepreneurs, and selecting the best project ideas by jury.

This study aims to reveal the effectiveness of the idea evaluation and selection phase in online communities since the idea evaluation phase has not been sufficiently examined and designed in online communities and IPs.

Some previous studies on IPs provide insight generally into certain aspects, such as how feedback from seekers (Jung et al., 2010; Vidal and Nossol, 2011), awards (Liu et al., 2014; Mazzola et al., 2020; Terwiesch and Xu, 2008; Toubia, 2006), the number of solvers (Boudreau et al., 2011; Che and Gale, 2003; Fullerton and McAfee, 1999), the solvers' submission behavior (Bockstedt et al., 2016), crowd voting (Chen et al., 2020), learning practices (Jung et al., 2020) and content briefs (Hu et al., 2020) affect solver success, contest performance, and participation. Studies on the idea evaluation phase in online communities and IPs are limited in number.

While most related studies generally focus on gathering ideas in depth, there are only a few studies considering the idea evaluation phase (Banken et al., 2019; Özaygen and Balagué, 2018; Zhu et al., 2021; Yang, M., Ooi, Y. M., & Han, C., 2022). This limited research has attempted to gain insight into the idea evaluation phase. For instance, Banken et al. (2019) suggest nine design principles and an approach for *Smart Idea Allocation* (SIA) as a design artifact, which gathers ideas into small subsets, uses cognitive biases, and fairly distributes the expected cognitive load among raters. Özaygen and Balagué (2018) analyze idea evaluation by participants in cooperative crowd innovation contests within a network perspective called social network analysis. By comparing three distinct rank-ordering strategies, Zhu et al. (2021) investigate the impact of a rank-ordering strategy on the performance of creative idea selection: choosing (i.e., rank-ordering ideas by stepwise selection of the most creative idea), elimination (i.e., rank-ordering ideas by stepwise removal of the least creative idea), and paired comparison (i.e., rank-ordering ideas by making a series of choices from pairs of ideas).

Other evaluation techniques are generally based on voting, ranking, or rating (scoring) of ideas. For instance, Klein and Garcia (2015) selected the best ideas with a ‘bag of lemons’ technique, which has been developed to filter out bad ideas accurately and quickly. Cui, Kumar, and Gonçalves (2019) addressed two idea evaluation methods, scoring vs. ranking, in the context of innovation management using an online experiment. Zhu et al. (2021) examined the rank-ordering method to select creative ideas, and the authors compared the three rank-ordering systems: choosing, elimination, and paired comparison.

To fill the gap in the literature, we apply Multi-Criteria Decision-Making (MCDM) methods to the idea evaluation phase of the COVID-19 Innovation Platform. During the three-month program, the jury used the WSM method as a supportive quantitative decision technique in the idea evaluation phase. The main aim of the study is to reveal the effectiveness of the WSM via online communities in the idea evaluation phase. To demonstrate this, we implement different MCDM methods in the decision matrix dataset. Therefore, our main research question is whether WSM is an accurate and reliable MCDM method in online communities. Later, we compare WSM with other MCDM techniques to show the effectiveness and reliability of each technique in the idea evaluation phase. Within this context, we select two more well-known MCDM methods in the literature, TOPSIS, and VIKOR, and then examine which of these methods would be more appropriate in the idea evaluation phase. For the situation when the decision-makers want to get a conclusion using all three methods (TOPSIS, VIKOR, and WSM), the results are also combined with some methodologies such as Grade Average, Borda, and Copeland, where the results of the methods are used together.

In this regard, our research questions are as follows:

- Is there any difference in the rankings of acquired ideas based on MDCM methods?
- Whether WSM is an accurate and reliable MCDM method in online communities.
- Could different MDCM method ranking lists be combined into a single list without choosing a method? If so, what would the result be?

We expect that this study will contribute to the existing literature both in the importance of MCDM in the idea evaluation phase and in benchmarking the selected MCDM techniques among themselves. Therefore, we contribute to the literature in two ways. First, we want to state the importance of MCDM, because most idea evaluation phases in online communities and IPs are based on a simple rating or ranking system. Second, we want to contribute to the existing literature on the benchmarking of selected MCDM methods to analyze which methods give better results. By analyzing this situation, we want to guide both innovation professionals and decision-makers.

MCDM in Open Innovation Context

The idea evaluation and selection phase is a challenging task complicated by several factors, including the expert level of decision-makers and the complexity of the cognitive processes (Banken et al., 2019). While decision-makers can have a large dataset during the idea collection phase, it is unclear which approach is effective for evaluating and selecting these ideas. As the number of ideas increases, evaluating them occurs more challenging, and generating more ideas does not always lead to a better idea quality level (Zhu et al., 2021). On the other hand, only a small percentage of business ideas ever achieve success in the new product development process

(Cui et al., 2019). The importance and difficulty of the evaluation and selection phase are thus evident (Bhimani et al., 2021; Cui et al., 2019). Therefore, selection process of ideas is needed to be conducted in a systematic manner (Li et al., 2021).

The evaluation of ideas in online communities has generally two approaches: top-down and bottom-up (Eisenreich et al., 2021). Bottom-up approaches based on a community-based evaluation that uses the wisdom of crowds may be essential for pre-assessment of ideas. Ordinary approaches such as commenting, voting, ranking, or rating can be used during the bottom-up. Top-down approaches are used for more high decision quality. In this approaches, experts or a cross-functional group of senior managers get involve to decision process. In this context, MCDM constitute one of the important decision tools to guide experts and managers in evaluating of ideas (Li et al., 2021).

MCDM techniques are among the most popular methods used in previous research on corporate sustainability for innovation, and they are effective techniques for investigating, evaluating, and ranking projects (Chowdhury and Paul, 2020). Furthermore, web 2.0 technologies offer a technological platform for open knowledge management, facilitating the exchange of substantial volumes of discrete knowledge within an open innovation ecosystem. An efficient technique for evaluating knowledge might be established via MCDM in open innovation settings (Wang et al., 2017). In environments where uncertainties such as innovation prevail, making decisions by evaluating and analyzing under different criteria rather than simple evaluations also increases accuracy. In this respect, MCDM should be kept ahead of simple evaluation techniques in innovation-based projects that might have high investment and risks.

Although several studies combine MCDM with open innovation concept (Diouf and Kwak, 2018; Wang et al., 2017), multi-criteria rating scales with innovation contests (Blohm et al., 2011; Riedl et al., 2013) and new product development (Li et al., 2021), we could not find a common or systematic approach that uses MCDM in online communities and IPs. However, some studies revealing the evaluation of R&D and innovation projects according to MCDM methods are presented below.

Khaw et al. (2023) established a particular set of criteria and sub-criteria for sustainability and circular economy behaviors under eco-innovation for energy firms in Iraq. Then, the order of significance of these criteria was established using the MCDM method. For instance, like this study, studies commonly contain cause-and-effect correlations from the perspective of MCDM techniques and combinations.

Karaveg et al. (2015) analysed a combined technique using SEM and TOPSIS for the commercialization capability of R&D project evaluation. In their study, criteria are obtained by 272 successful entrepreneurs and researchers. Then, structural equation modelling is used to analyse and weighted the obtained criteria. Six criteria are evaluated: marketing, technology, finance, non-financial impact, intellectual property, and human resources. An experimental evaluation is provided in their study to validate the method. TOPSIS method is used to rank alternatives provided in the experimental evaluation.

Liu et al. (2021) proposed the R-number-based BWM method for R&D project selection for a medical device company. R numbers analyse the effects of uncertainty and risk. Can et al. (2021) weighted the six sigma projects with AHP, and then prioritization is performed by CODAS.

Similarly, Oliveira et al. (2021) used the AHP-TOPSIS method to prioritize business projects. Samanlioglu and Ayağ (2020) used a fuzzy AHP-VIKOR method implemented the selection of innovation projects. Popiolek and Thais (2016) recomnended the ELECTRE method to public administrators to choose the best innovation strategy to reduce greenhouse gas emissions.

Although MCDM has been implemented in different innovation projects, there has not been much study specific to online communities. Therefore, our study is valuable both in terms of being specific to this field and comparing the selected MCDM methods. The main reasons for the selection of these three methods (WSM, TOPSIS, and VIKOR) are their frequent use in the literature (Behzadian et al., 2012; Dong et al., 2010; Opricovic and Tzeng, 2004; San, 2011; Zanakis et al., 1998; Zavadskas et al., 2016), and their accurate and reliable results in many cases (Opricovic and Tzeng, 2007; Shih, Shyur and Lee, 2007; Zanakis et al., 1998). The findings of this analysis reveal the relative superiority and weaknesses.

Methodology

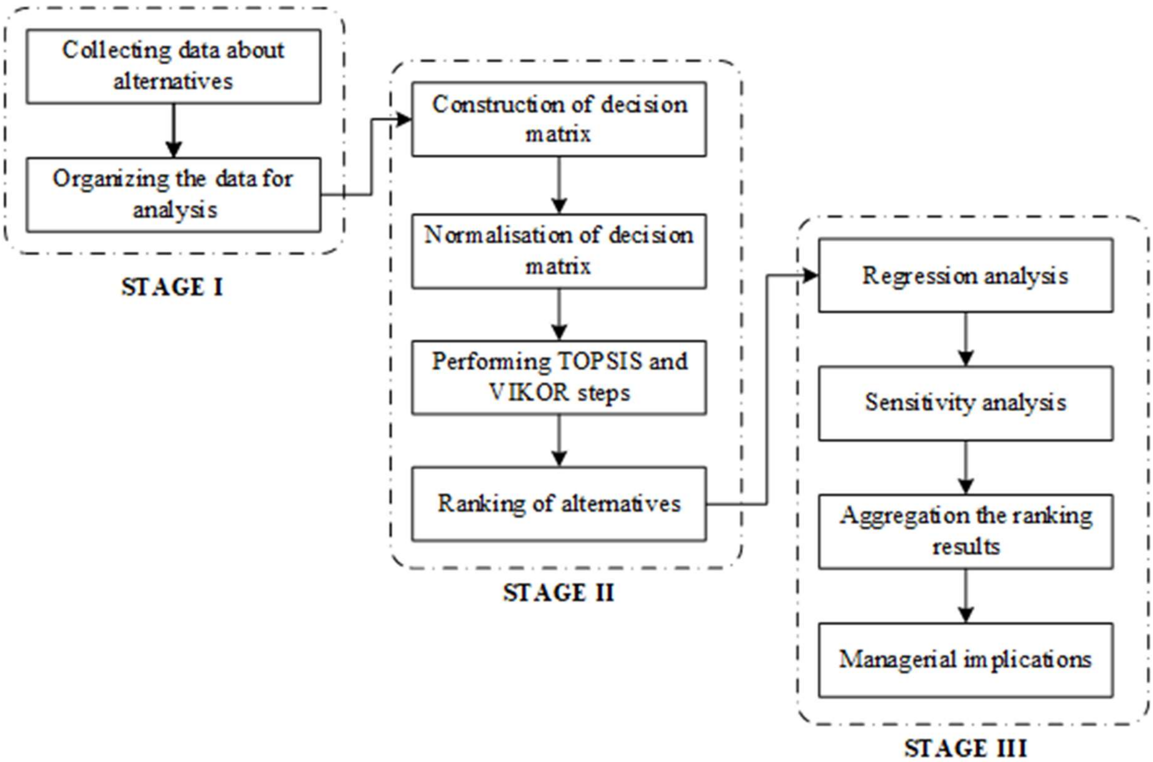
MCDM is a part of operations research that supports the decision-maker in solving problems when multiple conflicting criteria are involved and need to be evaluated (Sitorus et al., 2019; Kumar et al., 2017). Since many decisions are made on various criteria in this method, different criteria can be decided by weights, and all weights are taken by experts in environments with uncertainty and complexity, MCDM may be a useful method (Aruldoss and Veenkatesan, 2013). To find the best solution to a problem and provide the best decision to decision-makers, it is concerned with making decisions based on several factors (Triantaphyllou et al., 1998; Yang and Sing, 1994; Zavadskas and Turskih, 2011).

Innovation represents an environment of uncertainty. Given the uncertainty of the future, it is reasonable to expect uncertainty to be inherent in any innovation process (Jalonen, 2012; Storey and Sykes, 1996). One of the most appropriate methods to make the best decisions under this uncertainty is the MCDM method, which evaluates every criterion under uncertainty (Bonissone et al., 2009) In the COVID-19 Innovation Platform, the evaluation of the project ideas was made by a jury under the WSM, which is a simple MCDM method. Our main research question is whether WSM is an accurate and reliable MCDM method. Therefore, we add two more frequently used MCDM methods in the literature, TOPSIS and VIKOR, and then examine which of these methods would be more appropriate in the idea evaluation phase.

Among these MCDM methods, one of the oldest and most widely used methods in the literature, especially in one-dimensional problems, is the WSM (Triantaphyllou, 2000). Therefore, the WSM was preferred within the scope of the program. Other methods are VIKOR (Kriterijumska Optimizacija I Kompromisno Resenje) and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), which are later applied to the idea evaluation phase to demonstrate the effectiveness of the WSM. In addition to being well accepted in the literature and providing a compromise respond to, TOPSIS and VIKOR are helpful techniques when the decision-maker is unable to voice his views (Opricovic and Tzeng, 2007; Jahan et al., 2011; Zhang and Wei, 2013, Lourenzutti and Krohling, 2016; Shyur, 2006; Athawale and Chakraborty, 2010, Mannan and Hallem, 2017).

Figure 1 exhibits the research framework of the study. The first stage was carried out during the 3-month program. The second stage includes the processes of making the data obtained from the first stage with the WSM methodology ready for benchmarking with other methods. We compare the results of WSM to TOPSIS and VIKOR. In the last stage, we first perform a regression analysis to indicate how much the methods' results can mathematically explain the initial decision matrix. Moreover, we conduct sensitivity analysis to further clarify the differences between results since all methods in regression analysis are sufficiently explanatory. Thereafter, we combine the rankings obtained from three MCDM methods by applying three aggregation methods as a compromise solution for the final decision.

Figure 1. The research framework of the study



WSM

In this method, the decision maker places weight on each criterion (Tzeng and Huang, 2011). The reason why the WSM is used by decision-makers in the current applications is that it is a well-known method that is simpler and easier to calculate compared to other methods (Wang et al., 2016; Stanujkic and Zavadskas, 2015). The fundamental concept of WSM is to combine all the available evaluations against a set of criteria into a single result to determine the relative importance of the alternatives. The WSM is used to determine the degree of importance of each alternative considering the criteria. In the calculation of the WSM, the mx1 dimensional importance R matrix, which is formed by the sum of the product of the weights of the criteria and the values given to the alternatives by the decision-makers, will be obtained. The best alternative is the one that has the highest value in this matrix (Helff, Gruenwald et al. 2016).

$$R_{m\times 1} = \begin{pmatrix} w_{11} & \cdots & w_{1k} \\ \vdots & \ddots & \vdots \\ w_{m1} & \cdots & w_{mk} \end{pmatrix} \times \begin{pmatrix} c_1 \\ \dots \\ c_k \end{pmatrix}$$

where c_k is the weight of the k^{th} criterion.

TOPSIS

Another method applied is TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). This method is preferred because its content is simple and understandable, simple to use, and powerful in the calculation (Lourenzutti and Krohling, 2016; Shyur, 2006; Athawale and Chakraborty, 2010). The calculation steps of TOPSIS can be summed up as follows: normalizing the decision matrix by applying vector normalization; computing the weighted normalized decision matrix; identifying the positive ideal solution and negative ideal solution (NIS); calculating the separation or distance of each alternative from an ideal solution and negative ideal solution; calculating the ranking index; and finally ranking the preference order.

The TOPSIS method attempts to select alternatives that have the shortest distance to the positive ideal solution and the furthest distance to the negative ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. To apply this technique, the attribute values must be numerical, increasing or decreasing monotonously and have measurable units (Behzadian et al., 2012; Yon and Hwang, 1995; Chen and Hwang, 1992). The purpose of this method is to find the alternative closest to the positive ideal solution and the furthest from the negative ideal solution. The alternative closest to the positive ideal solution and furthest from the negative ideal solution will be the best (Hwang and Yoon 1981).

The TOPSIS method consists of the following basic steps (Lai, Liu, et al. 1994, Bhutia and Phipon 2012, Ginting, Fadlina et al. 2017):

Step 1: Normalized decision matrix:

$$n_{ij} = w_{ij} \,/\, \sqrt{\sum_{i=1}^{m} w_{ij}^2}$$

$$n_{ij} = \begin{pmatrix} w_{11} \,/\, \sqrt{\sum_{i=1}^{m} w_{i1}^2} & \cdots & w_{1k} \,/\, \sqrt{\sum_{i=1}^{m} w_{ik}^2} \\ \vdots & w_{ij} \,/\, \sqrt{\sum_{i=1}^{m} w_{ij}^2} & \vdots \\ w_{m1} \,/\, \sqrt{\sum_{i=1}^{m} w_{i1}^2} & \cdots & w_{mk} \,/\, \sqrt{\sum_{i=1}^{m} w_{ik}^2} \end{pmatrix}$$

w_{ij}= i^{th} alternative importance according to j^{th} criteria

Step 2: The weighted normalized value is:

$$v_{ij} = n_{ij} \times c_j$$

where c_j is the criterion weight.

Step 3: Determination of positive and negative ideal solutions:

Among the alternatives for each criterion, the solution with the highest score in the utility criterion (J) and the lowest scale in the loss criterion (J') is called the positive ideal solution (D*), and the solution with the highest scale in J' the loss criterion and the lowest in the J utility criterion is called the negative ideal solution (D^-).

$$D_k{}^* = \left\{ \left(Max\ v_{ij} \mid j \in J \right), \left(Min\ v_{ij} \mid j \in J' \right) \right\}$$

$$D_k^- = \left\{ \left(Min\ v_{ij} \mid j \in J \right), \left(Max\ v_{ij} \mid j \in J' \right) \right\}$$

Step 4: Distance of alternatives to positive and negative ideal solutions:

The distances of the alternatives from the positive and negative ideal solutions are calculated using the Euclidean distance:

$$S_i{}^* = \sqrt{\sum_{i=1}^{m} \left(v_{ij} - D_k^* \right)^2}$$

$$S_i^- = \sqrt{\sum_{i=1}^{m} \left(v_{ij} - D_k^- \right)^2}$$

Step 5: Obtaining the relative closeness to the positive ideal solution:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i{}^*}, \quad 0 \le C_i^* \le 1$$

A Ci* value that is approximately 1 indicates that the pertinent alternative is far from the positive ideal solution and somewhat close to the negative ideal solution. The best option is the one that offers the highest value of Ci*.

VIKOR

The decision-maker chooses the alternative closest to the ideal, and solutions are evaluated according to the criteria considered. The VIKOR method was first introduced by Opricovic (1998) (Salabun et al., 2020). The VIKOR technique provides effective decision making in areas where the selection of the best alternative is highly complex. (Mardini et al., 2016). It focuses on sorting and choosing among alternatives with contradictory and different unit criteria. In the VIKOR approach, ranking is accomplished by comparing the measure of proximity with the ideal alternative, and the optimum point means an agreement created by mutual compromise (Opricovic and Tzeng, 2004). The calculation steps of VIKOR method can be summarized as follows: determining the best and the worst values; calculating the positive and negative ideal solutions; computing the S, R, and Q values and finally ranking the alternatives.

Assuming that all alternatives are evaluated for each criterion, VIKOR allows for reaching a common solution depending on the criterion weights. By comparing the measure of closeness between the best values of the criteria and the alternative values, a consensus is obtained, that is, a ranking consisting of the most suitable solution to the ideal (Opricovic 2007; San Cristobal, 2011)

The VIKOR method consists of the following basic steps (Opricovic, 2007; Jahan et al., 2011)

Step 1: For each evaluation criterion, the best (fi*) and the worst (fi -) values are determined.

$$f_i^* = \max w_{ij}$$

$$f_i^- = \min w_{ij}$$

Step 2: Sj and Rj values are obtained.

Sj : The mean group score for the jth alternative.

Rj : The worst group score for the jth alternative.

$$S_j = \sum_{i=1}^{k} c_k (f_i^* - w_{ij}) / (f_i^* - f_i^-)$$

$$R_j = \max\left[c_k (f_i^* - w_{ij}) / (f_i^* - f_i^-)\right]$$

Step3: Qj values are determined for all of the alternatives:

$$Q_j = h(S_j - S^*) / (S^- - S^*) + (1-h)(R_j - R^*) / (R^- - R^*)$$

h; maximum group benefit,

‘1-h’ refers to the weight of the minimum regret of the dissidents.

Consensus, Majority, ‘h > 0.5’ Consensus, ‘h=0.5’ Veto ‘h < 0.5’ can be achieved.

Step 4: The Sj , Rj, and Qj values are ordered from smallest to largest to determine the order among alternatives.

Step 5: The alternative with minimum Q value can be considered optimal if the following two conditions are met.

Condition-1 (Acceptable advantage):

$$Q(A'') - Q(A') \geq DQ$$

where,

A’: is the first alternative according to the value Q

A^n: is the second alternative according to the value Q

DQ=1/(m-1)

Condition-2 (Acceptable stability):

Alternative A' must also have a minimum value of at least one of the S and/or R values.

If a condition is not met, a range of compromise solutions is proposed, consisting of

a) If the acceptable stability condition is not met, both alternatives A’ in the first order and A^n in the second order are determined as the best compromised joint solution.

b) If the admissible advantage condition is not met, $Q(A^M) - Q(A') < DQ$ is determined for the alternatives A’, A’’,….,A^M, and the maximum value of *M*.

Among the alternatives ranked according to the Q value, the alternative with the smallest value is the best.

Combining the ranking results

Each MCDM method has its advantages and disadvantages. Therefore, different results may arise in the solution of the problems. Three different aggregation methods are used to increase the reliability of the obtained results and to reach a single ranking result. We examine the aggregation methods in this section. The goal is to reconcile the findings or rankings obtained using MDCM methods to arrive at a new and compromised result. The grade average, Borda, and Copeland methods are all explained in the sub-titles in this context.

The Grade Average Method

The grade-average method is an easy-to-use and the common aggregation technique. It provides a solution based on the arithmetic average of alternatives according to used different methods.

The Borda Method

While the Borda method, developed by Jean-Charles de Borda (1784), is generally used in social election or voting problems, it can be used for aggregation in MCDM problems. In the Borda method, first, a pairwise comparison matrix is created. In comparing the rankings of alternatives obtained from different methods, if the rank of one alternative is dominant over the others, then it is written as 1 otherwise the value of 0 is assigned to the corresponding matrix element. After the pairwise comparison matrix is created, the sum of each row is calculated, and the alternatives are ranked according to this value.

The Copeland Method

The Copeland method is a modified version of the Borda method considering the number of victories, draws, and defeats of the alternatives compared to the other alternatives (Copeland, 1951). First, the row and column sums are determined using the pairwise comparison matrix created by the Borda method. Then, the Copeland number is obtained from the difference between the row sum and the column sum for each alternative. Finally, the alternatives are ranked by this number.

COVID-19 Innovation Platform

An accelerated program was established in Turkey to contribute to the development of innovative solutions to Covid-19. The purpose of this platform is to facilitate the rapid development of ideas and the expeditious implementation of projects by bringing together entrepreneurs, mentors, and pertinent institutions and organizations.

Through this platform, business owners who publish their project ideas may receive online coaching and guidance. Furthermore, assistance was given, leading to collaboration, to enable pertinent institutions and organizations to put their ideas into practice. Conversely, business owners would be able to view one another's ideas and support one another's arguments by ranking and commenting. After registering on the portal, entrepreneurs who offered project ideas were paired with a mentor in the relevant industry. Training exercises and input from mentors and other business owners helped them refine their concepts. After completing the mentoring phase, entrepreneurs showcased their projects to the jury. Following the assessment, the sponsors gave them cash or in-kind prizes as compensation.

Instead of being a competition, this program made sure that creative solutions utilizing public wisdom were quickly implemented for this major global issue. Business ideas were gathered from entrepreneurs as part of this process, developed by mentors and other entrepreneurs, and ultimately chosen by a panel of experts as the best ideas among the developed ideas. During the program, the WSM was presented to the jury to evaluate the project ideas. The research question is how the results are affected if this evaluation is made with another MCDM method instead of the WSM. Therefore, the research question of this study is whether the WSM, which is an MCDM method in the idea evaluation phase of the COVID-19 Innovation Platform, is an accurate and reliable method. Within the scope of the research, the scores given by the jury were analyzed by applying other MCDM (TOPSIS, VIKOR) methods, and whether there is a difference in the best project ideas selected was examined.

Thanks to this platform, the following main topics which offer solutions to short- and long-term problems related to the COVID-19 pandemic were collected and the evaluation process was passed:

1. Solutions to reduce the spread of the pandemic.
2. Solutions to improve health services and facilitate their access.
3. Solutions to reduce the economic effects of the pandemic.
4. Education during the pandemic.
5. Food and agriculture during the pandemic.
6. Sports, entertainment, culture, and tourism during the pandemic.

During the program, 176 project ideas were gathered, 102 of them passed to the mentor stage, and 38 ideas were submitted to the expert jury team. 172 experts volunteered as mentors and a jury team of 34 people consisting of senior managers of the program's stakeholder institutions. The jury rated the ideas from 1 to 5 under every criterion. The criteria for the idea evaluation for COVID-19 projects made by the jury are presented in Table 1. The decision-makers evaluated the alternatives based on each criterion, yielding a 38*6-dimension decision matrix. Due to the confidentiality of the alternative project ideas, they are coded as A#.

Table 1. The criteria and their weights

	The Criteria	**Criteria Weights (%)**
(1)	The effect, benefit, and urgency of the idea	25
(2)	Feasibility of the idea	20
(3)	Time to implement the idea	20
(4)	The commercial potential of the idea and scalability	20
(5)	Teams' competence level	10
(6)	The innovation level of the idea	5

Findings

The WSM was used to evaluate the project ideas on the COVID-19 Innovation Platform by the jury. Since we want to show the WSM's sensitivity and accuracy, in this study, we aim to examine whether the WSM is an ideal MCDM method for evaluating new project ideas. In Table 2, we compare the results of the WSM to the results of the other two MCDM methods: TOPSIS and VIKOR.

The first two projects in each of the three techniques were ranked the same. In general, there is no significant difference in the order of the three procedures when compared. Despite the closeness of the rankings, the solution approaches assigned distinct thoughts to different ranks. Because the solution processes and representations of the three strategies differ, a comparison can be done as shown in Table 2 below if they are to be expressed together.

The score values generated in the WSM and TOPSIS procedures are ordered from greatest to smallest to produce a priority-ranking table of alternatives/ideas. There is a compromise solution in VIKOR; the priority idea table can be obtained by sorting the scores from least to largest. As a result, the proposal with the lowest VIKOR score is the best idea project.

Table 2. The results of the MCDM Methods (Ideas are coded as Alternative 1 to 38: A1, A2,…, A38)

	WSM		*TOPSIS*		*VIKOR*	
Rank	***Alternative***	***Score***	***Alternative***	***Score***	***Alternative***	***Score***
1	A33	4,000	A33	0,942	A33	0,000
2	A38	3,843	A38	0,884	A38	0,095
3	A32	3,756	A15	0,879	A32	0,107
4	A15	3,672	A32	0,872	A15	0,111
5	A25	3,641	A25	0,864	A25	0,115
6	A30	3,627	A30	0,851	A30	0,141
7	A37	3,592	A29	0,848	A29	0,175
8	A9	3,563	A9	0,838	A37	0,410
9	A29	3,553	A37	0,832	A9	0,219
10	A14	3,475	A26	0,823	A26	0,245
11	A26	3,470	A14	0,813	A14	0,295
12	A1	3,375	A1	0,782	A22	0,302
13	A22	3,281	A16	0,767	A16	0,305
14	A16	3,278	A22	0,765	A1	0,313
15	A35	3,200	A12	0,764	A35	0,335
16	A31	3,193	A35	0,758	A12	0,371
17	A5	3,163	A5	0,749	A3	0,377
18	A3	3,154	A3	0,741	A31	0,393
19	A7	3,146	A31	0,741	A7	0,405
20	A19	3,039	A7	0,741	A19	0,405
21	A11	3,017	A19	0,710	A37	0,410
22	A18	3,000	A11	0,703	A18	0,421
23	A17	2,994	A18	0,693	A28	0,427

24	A36	2,923	A21	0,691	A17	0,428
25	A21	2,919	A17	0,689	A27	0,432
26	A2	2,898	A27	0,685	A21	0,433
27	A28	2,872	A28	0,678	A5	0,434
28	A27	2,859	A36	0,675	A36	0,444
29	A34	2,850	A34	0,670	A34	0,460
30	A4	2,682	A2	0,667	A20	0,529
31	A20	2,670	A10	0,664	A4	0,569
32	A8	2,519	A20	0,630	A8	0,597
33	A10	2,517	A4	0,623	A2	0,617
34	A12	2,517	A8	0,588	A23	0,631
35	A23	2,469	A23	0,588	A24	0,669
36	A24	2,400	A24	0,574	A10	0,701
37	A6	2,069	A6	0,489	A6	0,778
38	A13	1,500	A13	0,360	A13	1,000

The jury used the WSM to make their decision. Within the scope of the research, the scores given by the jury were analyzed by applying other MCDM (TOPSIS, VIKOR) methods and whether there is any significant difference in the best project ideas selected was examined. The regression values were initially examined for this. Regression analysis was conducted for each method as shown in Table 3, and R^2 coefficients for each method were produced. The reason why each method is evaluated by regression analysis is that regression analysis is a statistical technique that enables the determination of the causal relationship between the final of the alternative score and the MCDM methods (Chatterjee and Hadi, 2015; Allen, 2004). Because of the regression analysis, to show an explanation of each method in the idea evaluation process, in Table 3, the R^2 coefficients are shown in descending order from the highest to the lowest.

Table 3. Regression Analysis of MCDM Methods

Method	R	R Square	Adjusted R Square	Std. The error of the Estimate
WSM	1,000[a]	1,000	1,000	,1295987
TOPSIS	,998[a]	,997	,996	,00713111
VIKOR	,921[a]	,848	,818	4,74075

a. Predictors: (Constant), K6, K5, K3, K4, K2, K1

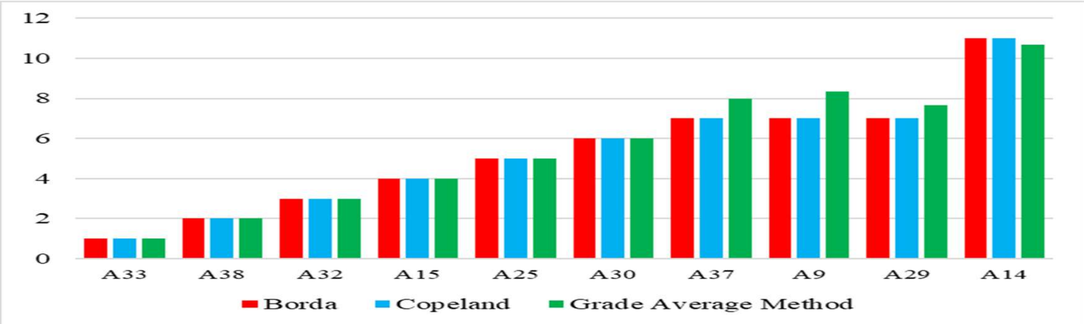
The R^2 value, which is close to 1, indicates that the method can strongly explain the decision matrix. In other words, the causal relationship between the final scores of alternatives and the decision matrix is explained mathematically. Therefore, the value of R2 should be close to 1 (Tjur, 2009). The determination coefficient R^2 of WSM was calculated as the highest. However, the R^2 of all methods is satisfactory in general. As a result, a comparison cannot be made based only on R^2. Because all methods are quite explanatory.

Results of combining the ranking results

As can be seen in Table 2, the solutions obtained using different MCDM techniques can differ from each other. After applying more than one MCDM technique to the same decision problem, aggregation techniques can be used for a compromise result. To combine the ranking results of the alternatives, the aggregation techniques described in Section 3.5 are applied and the results are presented in Figure 2.

Aggregation techniques are used to determine the consistency of the rankings obtained according to different methods. When the results in Figure 2 are examined, it is seen that the aggregation techniques rank the alternatives similarly. The x-axis represents the alternatives, while the y-axis performs the ranking of the alternatives. While there is no change in the first six rankings of aggregation techniques, the order of the alternatives may change after the seventh ranking.

Figure 2. Comparison of the aggregation techniques



Sensitivity Analysis

In this section, the effect of the change in the weight coefficient of the criteria on the ranking results is analyzed. Criterion weights can influence ranking results. Sensitivity analysis is used to show that MCDM method emphasizes the criterion weight the most. To analyze the effect of changes in weight values on the ranking results, 10 scenarios are created as given in Table 4. The weight of the criterion is changed to create these scenarios. The real weight of the criteria used in this study is represented by S2.

Table 4. The results of the sensitivity analysis

Scenario/Criteria	C1	C2	C3	C4	C5	C6
S1	0,16	0,16	0,16	0,16	0,16	0,16
S2	0,25	0,2	0,2	0,2	0,1	0,05
S3	0,05	0,175	0,175	0,175	0,175	0,25
S4	0,15	0,25	0,15	0,15	0,15	0,15
S5	0,15	0,15	0,25	0,15	0,15	0,15
S6	0,15	0,15	0,15	0,25	0,15	0,15
S7	0,15	0,15	0,15	0,15	0,25	0,15
S8	0,15	0,15	0,15	0,15	0,15	0,25
S9	0,23	0,2	0,2	0,2	0,1	0,06
S10	0,3	0,14	0,14	0,14	0,14	0,14

After the application of new weighting coefficient vectors in the WSM, TOPSIS, and VIKOR methods, new rankings and new values are obtained through scenarios. The top three rankings of alternatives, which are the same in all VIKOR, TOPSIS, and WSM methods, do not change in any of the ten scenarios, as shown in Figures 3, 4, and 5. On the other hand, the method with the most change under different scenarios is VIKOR, followed by TOPSIS and WSM.

Figure 3. The results of the sensitivity analysis in the WSM method

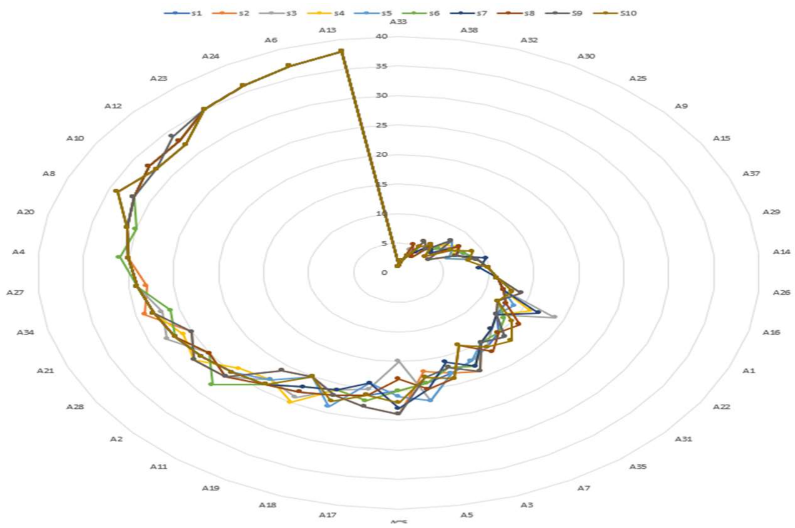


Figure 4. The results of the sensitivity analysis in the TOPSIS method

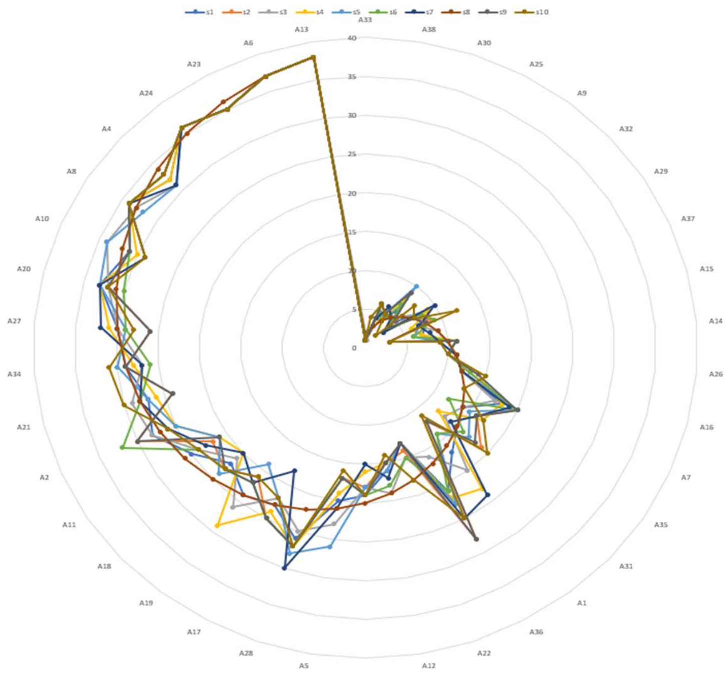
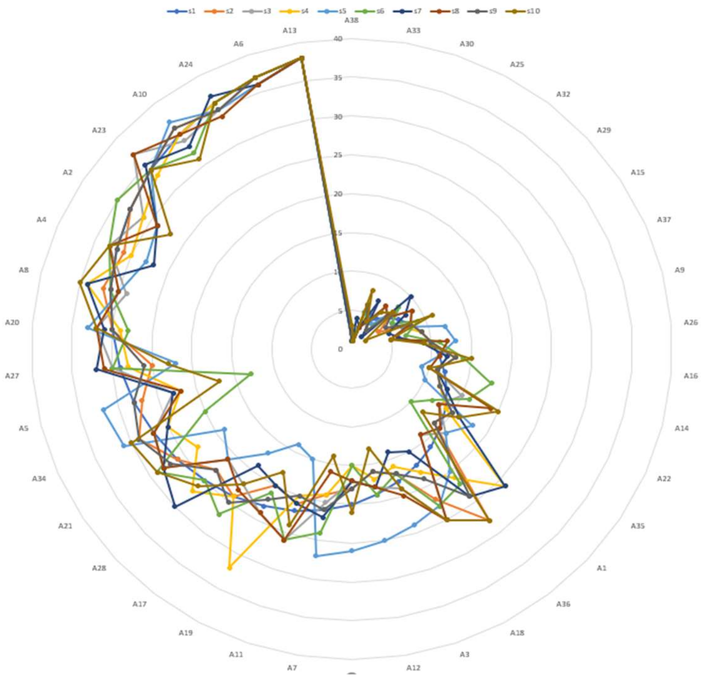


Figure 5. The results of the sensitivity analysis in the VIKOR method



The explanation for this difference in sensitivity analysis may be traced back to standard deviations of ranking values of methodologies. As a result, when the standard deviation increases, the methods' sensitivity rises, and the rankings change. In this research, the highest standard deviation belongs to the VIKOR method as given in Table 5. Therefore, we can say that the VIKOR method is more sensitive than the WSM and TOPSIS methods for both criterion weights and decision-maker scores.

Table 5. The deviation of MCDM Methods

MCDM Methods	Std. Deviation
TOPSIS	0,119089
VIKOR	0,209422
WSM	0,004354

Discussion of the Findings

The applicability of the proposed methodology is demonstrated through the case study COVID-19 Innovation Platform, where an accelerated program was conducted to collect innovative business ideas to tackle the COVID-19 case.

To analyze the robustness of the algorithm, we consider the effect of changes in the criteria weights on the ranking. Therefore, sensitivity analysis was performed by changing the criterion weights. While the first three rankings of the three methods did not change in any of the 10 different criteria weighting scenarios, it is observed that the highest change is seen in VIKOR, TOPSIS, and WSM, respectively, under different scenarios. This analysis can be observed in the same way in the standard deviation of the ranking values of the methodologies. Determining the criteria weights diversely allows much more different ranking results to emerge if the VIKOR method is used as the first choice.

As a result, if the decision-maker has doubts about the criterion weights and score values that will be assigned to a significant portion of the alternatives, the WSM method, which has a lower standard deviation and criterion weight sensitivity than the other two methods, may be preferred. If the decision-maker is sure that he/she has formed the criteria weights accurately and has given the scores to the decision alternatives unbiased, then he/she may prefer VIKOR and TOPSIS methods, respectively, for the result ranking. If the uncertainty on criterion weights and score values is at a moderate level, time aggregation methods can be employed as a reasonable compromise for the final decision.

As a brief result of the study, the ranking results in Table 2 and the regression results in Table 3 for the three methods reveal that there are no significant ranking differences between the three methods. However, it should be noted that entrepreneurial and innovative business ideas require serious investments and contain risks and uncertainties. Therefore, the decision-making phase must be carried out very carefully because different decision outcomes that may arise because of small ranking differences can have big effects.

Conclusion

During the pandemic, people's lives have changed over a long period. As it is integrated with different processes during this change period, newer business ideas and different ways of conducting business have emerged. Therefore, in this process, a startup acceleration program is needed to realize these ideas as a project, and ideas from entrepreneurs are gathered through the COVID-19 IPs. One of the important issues is the process of evaluating the gathered ideas. Most idea evaluation phases in IPs are based on a simple rating or ranking system. It is necessary to design effective decision mechanisms in environments where uncertainty is high.

Although mechanisms such as rating, ranking, and the wisdom of the crowd provide foresight, final decision-making requires expert judgment, and an effective decision analysis is needed. Since uncertainty is the central characteristic of innovation, decision-making in these environments depends on subjective and biased expert evaluations. At this point, MCDM methods can be used. In this study, WSM, which is a simple MDCM method based on quantitative methods, was used instead of a simple ordering by the jury. The question that forms the base of this study is how the results would be affected if another MCDM method is used instead of WSM.

The WSM, which is applied to real-life data, and other MDCM methods are compared and how results are given by each method is analyzed. Within the scope of the research, the scores given by the jury are analyzed by applying other well-known MCDM (TOPSIS and VIKOR) methods and whether there is any difference in the ranking of project ideas is examined. In addition, the aggregation methods are compared with the methods themselves to determine the consistency of the rankings. Among the aggregation methods, the Grade Average, Borda, and Copeland methods are used. After that sensitivity analysis is conducted to analyze the differences and superiority of the methods compared to each other.

In this study, there is a practice based on real data. Therefore, it is necessary to explain the contributions of the study under two headings: theoretical and practical contributions.

Theoretical Contributions:

This study makes significant contributions to the literature on both decision-making and innovation contexts. After the research question that led to the emergence of the study (whether the WSM is an accurate and reliable MCDM method), the literature was researched, and only a limited number of studies were found that combine the MCDM method with open innovation and the idea evaluation process. Therefore, this study fills this gap, and we use the MCDM in the open innovation-based idea evaluation process. While there are many mechanisms for the idea evaluation phase in online communities, most of them use a simple ranking or ranking system. However, the methodology proposed in this study is important because MCDM evaluates different aspects of an idea simultaneously. Consequently, in this study, using MDCM, a more systematic and holistic approach is presented instead of ranking and rating, which are simple evaluation techniques, at the idea evaluation stage in innovation platforms. In addition, since different rankings can be obtained using different MCDM methods, some question marks can be raised for researchers about the reliability of the ranking results. To overcome these questions, aggregation methods are used and sensitivity analysis is conducted.

Practical Contributions:

The reason for using MCDM in this field increases the accuracy of decision making under the evaluation criteria of experts in uncertain and complex environments, such as innovative project selections. In addition, since it was applied to COVID-19 projects, it collected important projects in such a critical area and accelerated the transition to implementation.

One of the contributions is the use of real-world data. Both researchers and experts should evaluate real data in terms of both methods used and the establishment of a COVID-19 IP. This is because the use of non-hypothetical real data indicates accuracy in practice as it is a dataset produced from real life. In this way, future users and employees are guided based on reality, both in comparing MDCM methods and in evaluating new business ideas.

With this study, innovation professionals and decision-makers can see the usability of the robustness of MCDM methods in the idea evaluation phase. As a result, if they have doubts about the criterion weights and score values that will be assigned to a significant portion of the alternatives, the WSM method, which has a lower standard deviation and criterion weight sensitivity than the other two methods, may be preferred. If they are sure that they form the criteria weights accurately and give the scores to the decision alternatives unbiased, then they might prefer VIKOR and TOPSIS methods, respectively, for the result ranking. If the uncertainty on criterion weights and score values is at a moderate level, aggregation methods can be employed as a reasonable compromise for the final decision.

Limitations and Future Studies:

More methods could not be chosen due to mathematical analysis and comparison difficulties. For future studies, the results may be compared using different MDCM methods (for example, Additive Ratio Assessment-ARAS, Elimination and Choice Expressing Reality-ELECTRE, Analytic Network Process-ANP, Weighted Product Model-WTM). The results can also be compared under different evaluation criteria and weights.

In decision-making environments, especially in an innovation context, imprecision and uncertainty are common; therefore, they might not be precisely described only by crisp or deterministic models. Fuzzy sets have been widely used in various applications to address these issues. It could be addressed in future studies.

Evaluating and selecting innovative business ideas presents a challenging task, complicated by several factors, including the qualification level of decision-makers and the complexity of the cognitive processes. Quantitative evaluation methods are important, but all potential factors affecting the decision process should be considered, and studies on this need to increase.

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