An analytical approach for evaluating sustainable supply chain solutions during the COVID-19 pandemic: Benefits and better explanations

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Abstract

The influence of COVID-19 has been felt in many facets of personal and professional life. As a result of the international economic crisis and the pandemic's consequences, major supply chains (SCs) have been disrupted. Our study intends to examine the effect of COVID-19 on SCs and help organizations choose options depending on their relative relevance. Phase one and phase two of the investigation are the most important. As a first step in strengthening SCs' ability to withstand the pandemic, Phase 2 examines the difficulties, concerns, actions, and solutions that have been encountered so far. As part of this phase, a MARCOS method is proposed to select solutions that address the complex interrelationships that are involved in decision-making. Positive and negative solutions are considered and it is at the start of the creation of a preliminary matrix, utility degree is determined closer to both solutions, a new method of determining utility functions and their aggregates is proposed, and the method is stable enough to take into account a huge list of conditions and alternatives. Using this approach, decision-makers will be able to more properly weigh the relevance and influence of many options before making a final choice. The findings suggest that SCs should continue to rely on innovation to endure potential competition and disasters.

Keywords: COVID-19; MARCOS; Supply Chain; SC Solutions; MCDM; Decision-making

1. Introduction

Due to its global expansion and the severe impact it has had on continuing supply chains (SCs), COVID-19 has caused a scarcity of several essential items. COVID-19's characteristics have enhanced the vulnerability of SCs to disturbances. Both national and international SCs were impacted, although the pandemic had a higher effect on international SCs than on national ones. The worldwide supply chain has been severely disrupted as a result of supply and demand shifts and country steps to stop the virus from spreading (GSC). MENA SCs have been severely impacted, just as in some other parts of the world.

Decision-makers are beginning to see the effect of a pandemic on SCs, particularly in terms of market forces disruptions. An urgent necessity to develop acceptable solutions and show their influence on the SC's future performance and robustness has been recognized by enterprises. To guarantee that the SC is not overtaken by the epidemic and that commerce may continue unhindered and remain competitive into the future, it is necessary to provide a priority ranking to the many remedies that can be implemented simultaneously.

Following the review of relevant literature, a questionnaire was investigated based on the COVID-19 pandemic on SCs with the challenges, major concerns, and worries even during the pandemic; the walks needed to reach the new reality just after the pandemic; and the alternatives that could contribute to SC consistency and minimize the impact of disruptions. To find the best option for

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future SC resilience, a questionnaire was utilized to define each solution's importance and importance.

It is difficult to evaluate and pick SC alternatives because of the wide range of organization types, sizes, locations, and goals, as well as the inconsistent and varied backgrounds of decision-makers. The problems aren't any easier to solve by using any of the conventional measures. In addition, enterprises are unable to explore all options at the very same time because of the costs, the time involved, and the lack of available experts.

As of the end of January 2020, the World Health Organization (WHO) designated the outbreak of coronavirus illness a worldwide health emergency. All but one of the nations under lockdown in the first half of 2020 were infected by the virus [1]. In the event of a crisis, the supply chain is disrupted both at the source of the problem and at its destination[2], [3]. About 75% of companies reported disruptions in the supply chain (SC), and an additional 80% said they expected disruptions shortly; 62% noted delays in receiving goods; and 53% reported difficulties in obtaining information from China, according to the Institute of Supply Management (ISM)[4], [5]. The pandemic affects more than five million businesses that rely on Tier 2 supply (Dun and Bradstreet, 2020). Many of the 450 million people who work in GSCs have been affected by COVID-19 and have lost their jobs as a result (Kippenberg, 2020). Organizations throughout the world have started closing stores, canceling orders, and halting manufacturing. In several industries, such as textile, mining, jewelry, and autos, workers are among the most exposed to the pandemic (Kippenberg, 2020).

When it comes to dealing with the epidemic, researchers have traditionally concentrated on how to best allocate and distribute resources[5]. A study by Ivanov and Dolgui [6] looked at the literature to see how the pandemic would spread, concentrating on the structure and dynamics of the SCs, and drew management conclusions from it. To adapt to rapid changes, several academics have studied and advocated reconfigurable SC by combining components derived from robust, digitized, lean, nimble, and ecological SC[7], [8]. After long-term disasters like the COVID-19 pandemic, an organization's supply chain may be rebuilt with the use of a sustainable, agile, and resilient supply chain [9]. Some researchers have developed models to address particular issues in specific contexts [10]. Parts of the economy may benefit from research in management and operations [11]. While [11]offered a hybrid forecasting approach based on the closest supplier and regions to anticipate COVID-19 growth,[12] proposed an analytical model to explore if a technology-based supply chain can promote the continuation of enterprises. As the effects of the COVID-19 virus on SCs continue to worsen, concerns and possibilities arise in the field of modeling, technology, and organization [5].

As outlined in this work, seven basic stages have been used to establish a novel approach called Assessment of Alternates and Ranking according to COmpromise Solution (MARCOS). It is based on the evaluation of alternatives and the subsequent rating of those options in light of an acceptable compromise. Per the distances between positive and negative solutions, the compromise solution determines utility functions. Through the invention of a novel strategy for tackling complex issues, this study has made a significant addition to the area of decision-making.

For the most part, the paper is divided into several parts. An overview of the prior research supply chain is provided in the second part. The MARCOS method's technique is laid forth by the third party. Four sections of the article describe a case study using the MCDM model in detail. The report concludes with a set of recommendations for further research in the final parts.

2. Related Work

Findings from COVID-19 reveal several operational and managerial issues for SCs[13]. As a result of the pandemic's disruptions, the GSC has seen extraordinary occurrences, with significant degrees of uncertainty, prolonged disruptions, as well as wide-reaching repercussions. Following COVID-19, the need for social distance has affected global industry and SCs [14]. The manufacturing and availability of vital medical and health supplies are severely depleted [15]. SCs have encountered supply interruptions, demand unpredictability, lack of readiness, and weaknesses in current response plans throughout crises, but there have also been possibilities to improve SC resilience during these times of crisis[16].
SC decision-makers must create SCs that are more intelligent, more robust, and more adaptable in the future. When it comes to dealing with the epidemic, there has been a stronger link between geopolitical factors and the SC decision-making mechanism, as well as a shift toward a more direct

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role for SCs and higher government involvement. Designing SC networks that can resist interruptions and remain sustainable is the major problem. Adaptation, digitization, preparedness, execution of a recovery plan, reduction of the consequences of a disaster, and SC viability have all been part of COVID-19's SC operations and administration[5].

Sustainable supply chain management (SC) demands intelligent workflow, the use of smart SC technologies like AI and virtual reality, supply network optimizations, and preparation for the new baseline [17]. In the early stages of a pandemic, sharing essential resources, controlling risks, and ramping up production may all help enhance productivity[10]. 3D printers can speed up the manufacture of unique essential items required to fill SC shortages, like as urgently needed healthcare supplies[18]. Risk mitigation measures must be evaluated qualitatively and quantitatively to reach solutions and practices [19].

It is possible to regulate the performance of an SC using an ANP approach, which is a quick multi-attribute decision-making tool. Useful for analyzing both theoretical and practical elements since it explores the interdependencies among hierarchies[20]. Prioritizing SC endeavors based on the causal linkages among different choice factors is accomplished using the ANP approach [21]. Similar to MCDM, the ANP approach may be utilized to provide an SC process performance evaluation model[22].

TOPSIS is an MCDM approach that uses similarity to select and prioritize the optimal answer from a group of alternatives. An assessment technique is used to rate options in several domains of decision-making[23]. It takes into account the interdependency of criteria and is often used to rank order lean techniques[24], [25]. A decision-making process called TOPSIS takes into account the ambiguity of decision-making and uses a restricted collection of choice solutions to choose the optimal option. It's popular since it's simple to apply and makes sense.

For assessing facility layout selection[26], identifying the best suppliers, assessing and choosing suppliers [27], as well as choosing the best location for a service apartment, a hybrid model based on integrated ANP-TOPSIS and the fuzzy Delphi technique has been proposed[28]. Selecting a knowledge transfer policy and a product launch approach for new goods may be made easier using ANP-TOPSIS and the multi-choice goal programming technique, both of which are based on the ANP-TOPSIS framework [29]. [30]With this technique, each criterion's weight is determined, a mechanism for ranking all options is developed, and the best alternative is selected while taking into account experts' subjective judgments and the difficulty in making decisions in a complicated selection process.

3. MCDM MARCOS Method

An in-depth look at the MARCOS framework is provided in the following paragraphs. There are two phases in this framework to rate the answers. The following is a summary of the methodology utilized to better understand its applications and efficacy.

Here, the MARCOS method's algorithm is described. The MARCOS technique is centered on establishing a connection between potential solutions and established benchmarks for success (ideal and anti-ideal alternatives). A compromise ranking is constructed regarding positive and cost solutions based on the connections outlined in this paper. Utility functions serve as a foundation for defining decision preferences. A utility function is a comparison between a positive and a less-than-perfect solution. That which is most like the ideal while also being furthest from the anti-ideal is the greatest option. Listed below are the stages of the MARCOS technique. Figure 1 the framework of the study.

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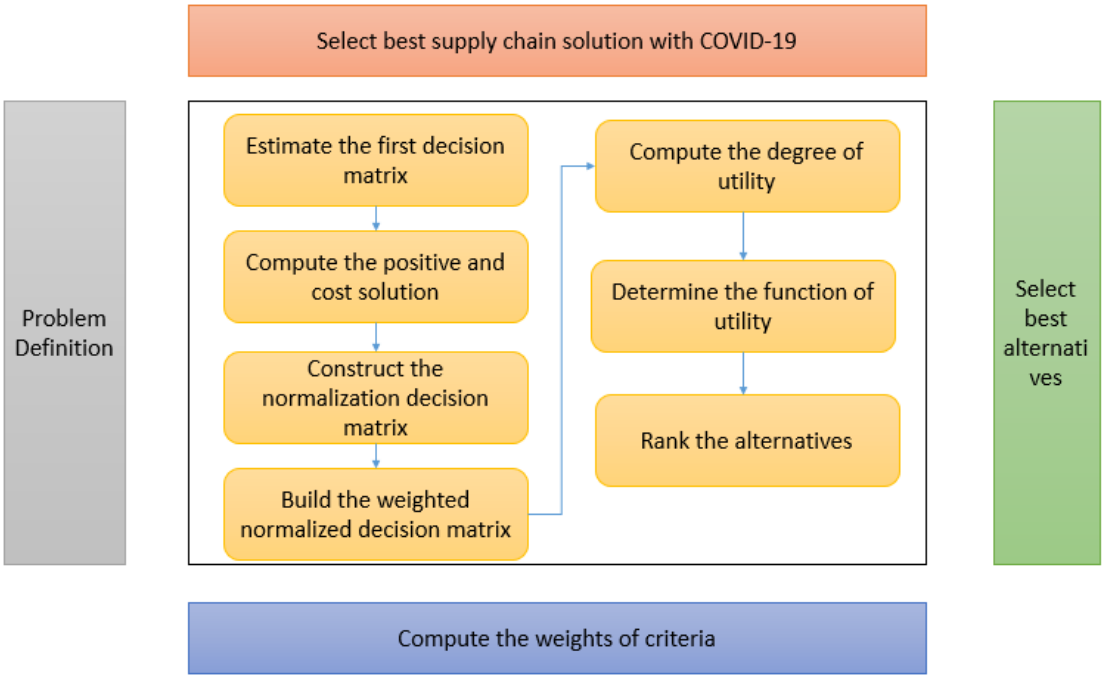

Figure 1: The framework of the study.

Step 1: Estimate the first decision matrix

The creation of a preliminary decision matrix. The formulation of a collection of n factors and m options is part of a multi-criteria model. When reaching a choice as a group, a team of qualified specialists should be assembled to weigh the pros and cons of various options in light of the stated criteria. Specialist assessment matrices are combined into an original group decision-making matrix in the event of a collective decision.

The decision matrix between criteria n and alternatives m as

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$$

Where x_{ij} refers to the value of criteria and alternatives by decision-makers

$$i = 1,2,3 \ldots . m; j = 1,2,3 \ldots . n$$

Step 2: Compute the positive and cost solution by the max and min values then build the decision matrix based on the positive and cost solution

$$\begin{cases} Neg = \min\limits_{i} x_{ij}, if\ j\ is\ positive\ criteria \\ Pos = \max\limits_{i} x_{ij}, if\ j\ is\ positive\ criteria \end{cases}$$

$$\begin{cases} Neg = \max\limits_{i} x_{ij}, if\ j\ is\ cost\ criteria \\ Pos = \min\limits_{i} x_{ij}, if\ j\ is\ cost\ criteria \end{cases}$$

$$X = \begin{matrix} \\ SSA_1 \\ SSA_2 \\ \vdots \\ SSA_m \\ Neg \\ Pos \end{matrix} \begin{matrix} \begin{matrix} SSC_1 & \cdots & SSC_2 \end{matrix} \\ \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ x_{21} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots \\ x_{m1} & \cdots & x_{mn} \\ x_{Neg1} & \cdots & x_{Negn} \\ x_{Pos1} & \cdots & x_{Posn} \end{pmatrix} \end{matrix}$$

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Step 3: Construct the normalization decision matrix for cost and positive criteria as:

$$r_{ij} = \frac{x_{Posi}}{x_{ij}}, j \text{ is cost criteria}$$

$$r_{ij} = \frac{x_{ij}}{x_{Posi}}, j \text{ is positive criteria}$$

Step 4: Build the weighted normalized decision matrix by multiplying the weights of criteria by the normalization matrix as:

$$wr_{ij} = r_{ij}\, w_j$$

Step 5: Compute the degree of utility for every alternative

$$K_i^- = \frac{S_i}{S_{Negi}}$$

$$K_i^+ = \frac{S_i}{S_{Posti}}$$

$$S_i = \sum_{i=1}^{n} wr_{ij}$$

Step 6: Determine the function of the utility of the previous step as:

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}}$$

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-}$$

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-}$$

Step 7: Rank the alternative ascending order of utility function

4. MCDM Application

In this research, a system based on the novel MCDM MARCOS approach is used to pick evaluate supply chain solutions in the context of COVID-19.MARCOS may be employed in a model to evaluate supply chain solutions in the context of COVID-19. This work included three decision-makers and experts.

The first step was to identify the experts who would be responsible for the evaluation. As a second step, five alternatives were picked from the total number of potential alternatives. Alternatives are included in figure 2. They also gathered information about these alternatives from interviews and questionnaires. The criteria for evaluating alternatives were also established, which was the fourth step. Five, three specialists examined the alternatives. Figure 2. Shows the criteria of this work. We used five alternatives included: Empowered team SSA1, Diversifications of supply SSA2, Technological solution SSA3, Government intervention SSA4, and. Network agility SSA5

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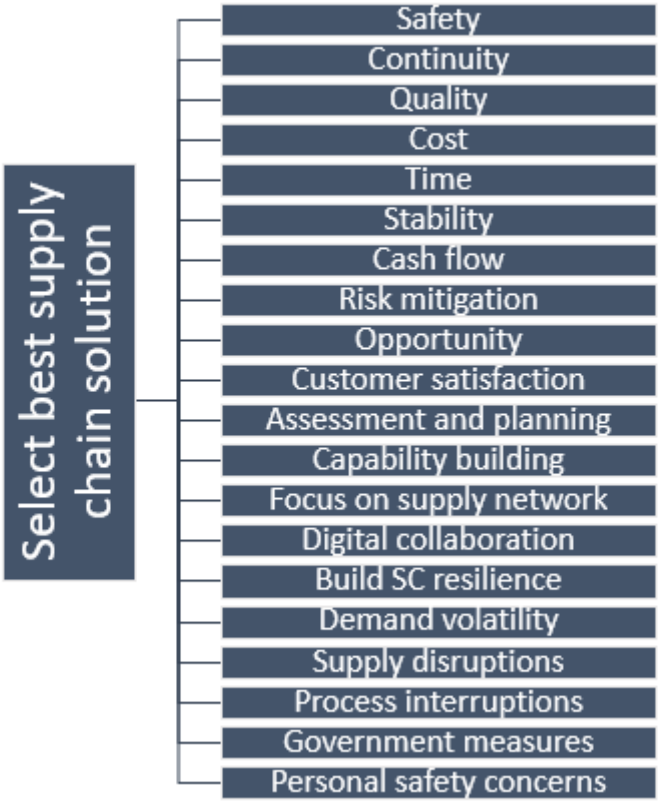

Figure 2: The criteria of this work.

The decision-makers evaluated the criteria. Then normalize their opinions to compute the weights of the criteria. The highest weights of criteria are key steps followed by concerns and the worst alternative challenges. Figure 3. Shows the weights of the main criteria. Then compute the global weights of criteria in figure 4.

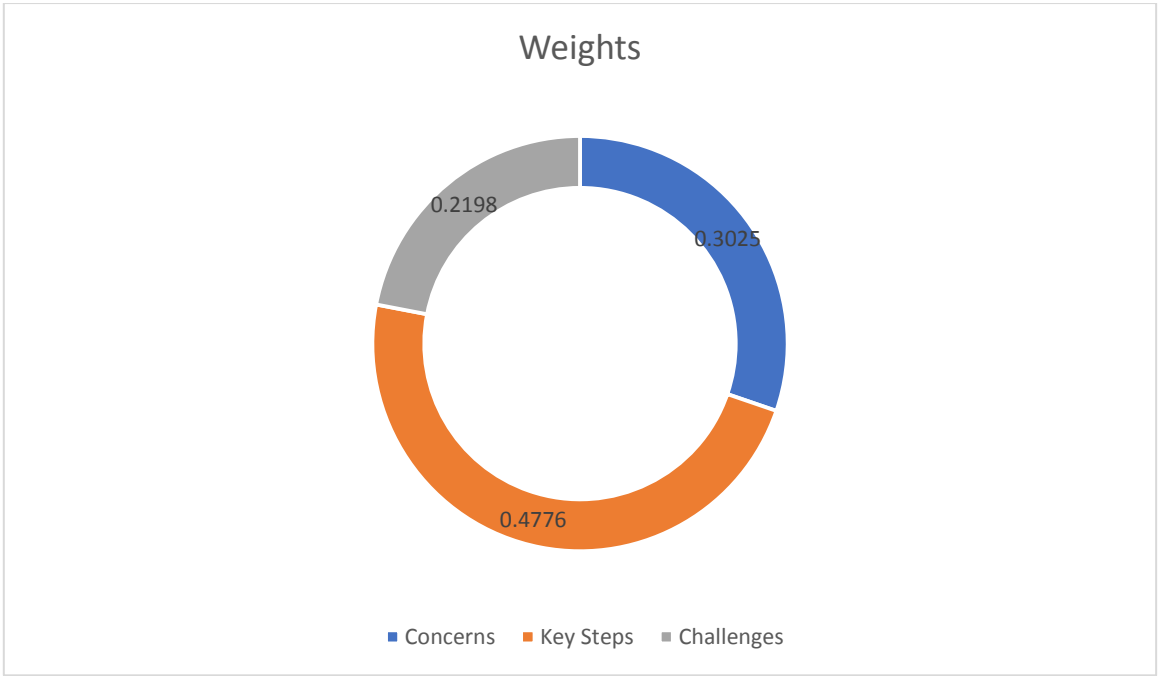

Figure 3:The weights of main criteria.

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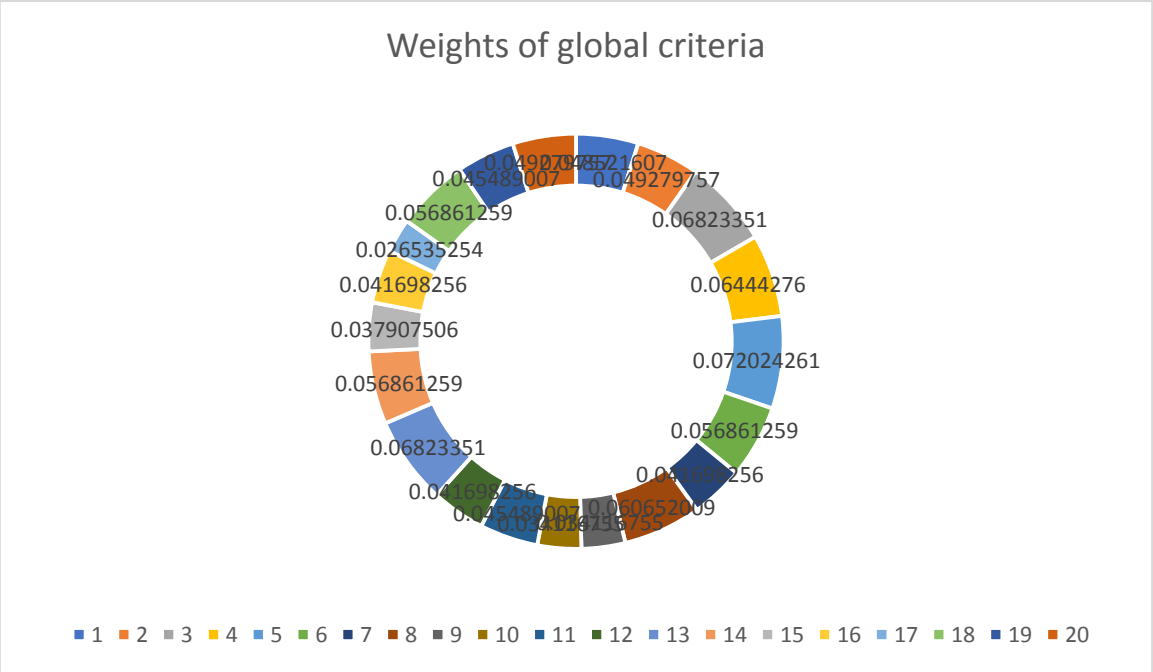

Figure 4: The weights of global criteria.

Let three experts evaluate criteria and alternatives to build the decision matrix. Then aggregated their opinions. Then compute the normalization matrix based on the positive and cost solution. The cost and time criteria are cost criteria but all criteria are benefit criteria. Table 1. Show the normalization matrix by the positive and cost criteria. Then multiply the weights of criteria by the normalization values to compute the weighted normalized decision matrix as in table 2. Then compute the degree of utility of each alternative as in table 3. Then compute the function of utility as in table 3. Then rank the alternatives based on the highest value of the utility function. SSA3 is the best alternative and the SSA1 is the worst alternative.

Table 1: The normalization decision matrix

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8	SSC9	SSC10
SSA1	0.944	0.222	0.765	0.680	0.684	0.696	0.667	0.778	0.522	0.700
SSA2	1.000	0.704	1.000	1.000	0.867	0.565	0.630	1.000	0.913	1.000
SSA3	0.500	0.704	0.765	1.000	0.619	0.478	1.000	0.778	0.913	0.400
SSA4	0.722	1.000	0.882	0.810	0.684	0.652	0.481	0.926	1.000	0.650
SSA5	0.833	0.630	0.882	0.680	1.000	1.000	0.667	0.407	0.913	0.950
	SSC11	SSC12	SSC13	SSC14	SSC15	SSC16	SSC17	SSC18	SSC19	SSC20
SSA1	0.280	0.852	1.095	0.957	0.926	0.368	0.222	1.000	1.095	0.913
SSA2	1.000	1.000	1.000	0.696	1.000	0.737	0.741	0.833	0.524	0.913
SSA3	0.840	0.407	0.286	0.739	0.704	0.684	0.704	0.833	0.476	0.739
SSA4	0.320	0.444	1.000	1.000	0.630	0.789	1.000	1.000	1.000	0.652
SSA5	1.000	0.481	1.000	0.522	0.259	1.000	0.815	0.389	0.571	1.000

Table 2: The weighted normalized decision matrix.

	SSC1	SSC2	SSC3	SSC4	SSC5	SSC6	SSC7	SSC8	SSC9	SSC10
SSA1	0.046	0.011	0.052	0.044	0.049	0.040	0.028	0.047	0.018	0.024
SSA2	0.049	0.035	0.068	0.064	0.062	0.032	0.026	0.061	0.031	0.034
SSA3	0.024	0.035	0.052	0.064	0.045	0.027	0.042	0.047	0.031	0.014
SSA4	0.035	0.049	0.060	0.052	0.049	0.037	0.020	0.056	0.034	0.022
SSA5	0.040	0.031	0.060	0.044	0.072	0.057	0.028	0.025	0.031	0.032
	SSC11	SSC12	SSC13	SSC14	SSC15	SSC16	SSC17	SSC18	SSC19	SSC20
SSA1	0.013	0.036	0.075	0.054	0.035	0.015	0.006	0.057	0.050	0.045
SSA2	0.045	0.042	0.068	0.040	0.038	0.031	0.020	0.047	0.024	0.045

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SSA3	0.038	0.017	0.019	0.042	0.027	0.029	0.019	0.047	0.022	0.036
SSA4	0.015	0.019	0.068	0.057	0.024	0.033	0.027	0.057	0.045	0.032
SSA5	0.045	0.020	0.068	0.030	0.010	0.042	0.022	0.022	0.026	0.049

Table 3: The degree of utility and utility function values.

	K+	K-	F(K+)	F(K-)	F(K)
SSA1	1.143	7.988	0.052	0.044	0.123
SSA2	1.173	6.795	0.068	0.064	0.144
SSA3	1.192	6.210	0.052	0.064	0.156
SSA4	1.147	7.803	0.060	0.052	0.126
SSA5	1.181	6.513	0.060	0.044	0.149

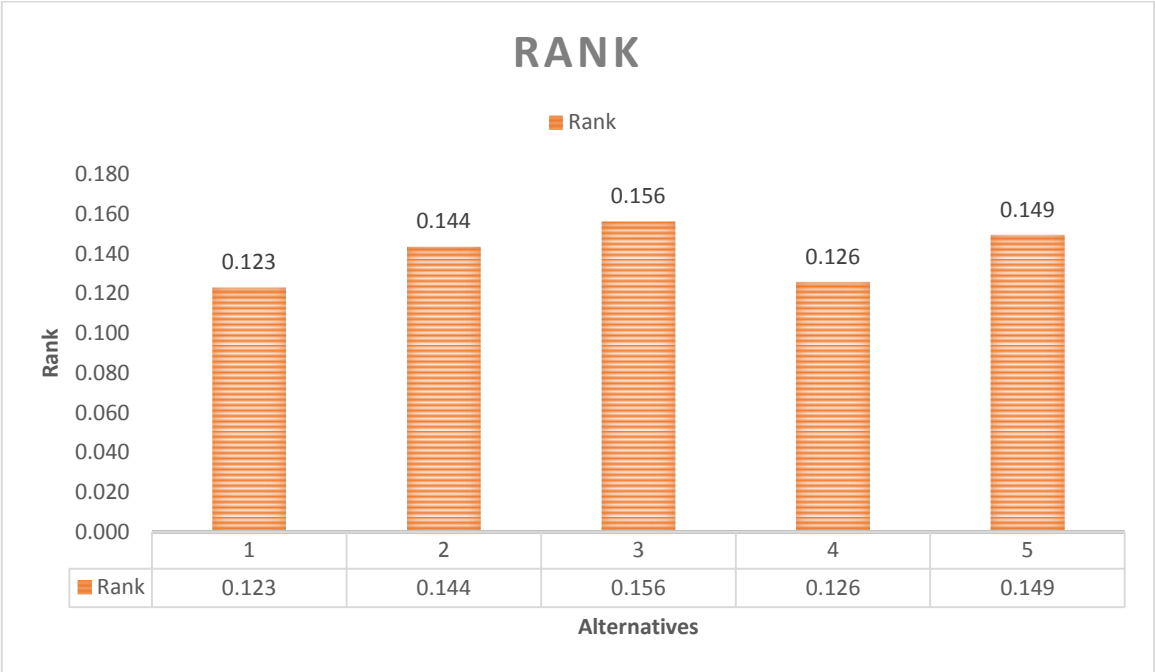

Figure 5: The rank of alternatives.

5. Conclusion

COVID-19 has had a worldwide influence on many parts of society, including the economy and the environment. There has been a wide range of outcomes based on factors including the number of bacteria, government efforts, and safety regulations.
The global economy and business, on the other hand, have been impacted across the board in almost every country and industry. Those most at risk are the SCs, and particularly the GSCs, which are the lifeblood of the population. Supply, distribution, and process interruptions have had a profound effect on the SC. Many SC activities are negatively impacted by disruptions, including the availability of commodities to customers at the right quantity and pricing.

Short-term (such as diversifying resources to fulfill demand) and medium-term (such as controlling costs, quality, and customer happiness), and long-term (such as ensuring SC competition and stability to prevent future crises) remedies are urgently needed, the organizations realized. Because organizations can't adopt all solutions at once, the need to prioritize them based on their relative relevance and efficacy has arisen.

This research was conducted in two stages utilizing actual data from key organizations and corporations and the views of a panel of professionals to examine the link between the SC and the pandemic. As part of the first phase, a survey was designed and distributed to a range of companies in the Middle East and North Africa (MENA) to investigate the link between COVID-19 and SC in terms of challenges faced by COVID-19, the preferences and source materials of consideration and concerns that decision-makers see as influencing COVID-19's business during a pandemic, and the appropriate steps toward the stabilization of the SC.

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Finding, analyzing, and prioritizing solutions is a difficult task for decision-makers in SCs since the scope, nature, and goals of various organizations, as well as their judgment' and administrators' differing viewpoints and experiences, all play a role in the decision-making process. Due to non-traditional criteria, it is difficult to identify the best SC solution now. Additionally, firms must choose solutions owing to the interrelation of influencing variables, the magnitude and complexity of the issue, and the difficulty of executing them simultaneously. In addition, the cost, time, and resources needed to deploy a solution are all factors that firms must consider.

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