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Evaluation of Strategies for Eradicating Supply Chain Disruption in Steel and Rolling Industries in Bangladesh by MCDM Approaches

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Abstract

The coronavirus (COVID-19) pandemic has had wide-ranging industry-level impacts. As COVID-19 creates further economic uncertainty and loss, maximizing returns, and managing risk. The study starts by looking at underlying factors that lead to supply chain interruptions from COVID-19 to unforeseen uncertainty. The study also highlights the significance of continuous improvement and adaptation. In essence, the COVID-19 pandemic-related supply chain disruptions are being addressed by the global steel and rolling industries. We learn from this research which strategies essential for sustainability have the greatest positive effects. Aside from the strategies, the various impacts will be quantified. For studying the impacts based on various strategies and criteria, analytical Fuzzy TOPSIS and Best Worst Method (BWM) systems are utilized. Implementing a continuous learning culture and conducting post-disruption analysis facilitates the identification of lessons learned and the implementation of preventive measures. Agile and adaptable supply chain structures enable organizations to quickly respond to unforeseen disruptions and adjust their operations accordingly. Bangladeshi steel & rolling industries may successfully handle disruptions, improve supply chain resilience, and guarantee ongoing company operations in an increasingly unstable global environment by implementing these techniques and forming solid relationships.

Keywords
Supply chain risk management, Supply chain disruptions, Supply chain uncertainty and risk, Pricing, Enhancing sustainability.

1. Introduction

The COVID-19 epidemic, which has had a long-lasting effect on the worldwide supply chain, is expected to cause the international economy to sag for a while. The pandemic's effects are still being seen on a global scale. Workplaces, public policy, and industries all suffered greatly as a result of this catastrophe. The COVID-19 supply chain disruption is by far the largest and most widespread in recent memory. The rolling and steel industries are susceptible just like the other industrial sectors. It is not unexpected that scholars have given COVID-19 a lot of attention. Even though supply chain risk regulation has been broadly covered in the literature, it is anticipated that COVID-19 will spur new growth in this area, leading to significant changes in the industry. The purpose of this study is to analyze the literature on eradicating supply chain interruptions based on various tactics and criteria utilizing the Fuzzy TOPSIS and Best Worth Method (BWM).

The global market value of Bangladesh's steel sector is Tk 55,000 crore ($62 million), and the nation is one of the biggest users of ferrous scrap, with imports of ferrous scrap reaching 4,000,000 tones [Shaking covid lull Bangladesh steel industry eyes global foothold-50016, The Business Standard.]. But the production has been interrupted by the COVID-19 pandemic. The COVID-19 outbreak has hampered production owing to factory closures and the import of raw materials, which are primarily obtained from Russia, India, and the USA. As a result, the steel industry is expected to lose Tk 4000cr. [Bangladesh steel industry overview: New Vision Solutions Limited (newvision-bd.com)] As more than 90% of the raw materials are still imported, a lengthy lockdown in these nations might seriously harm the supply chain(Tomlin & Wang, 2011). Despite having local shipbreaking yards that also produce melted scrap, the majority of rolling mills will be forced to close due to a lack of raw materials.

Figure 1. Bangladesh steel melting capacity [Shaking COVID-19 lull Bangladesh steel industry eyes global foothold-50016, The Business Standard.]

1.1 Objectives

- Identify key causes of supply chain disruptions in Bangladesh's steel industry.
- Develop and apply an MCDM model to assess and prioritize mitigation strategies.
- Evaluate economic impacts and gather stakeholder input for practical strategy alignment.
- Recommend best practices to enhance resilience and support policy formulation

2. Literature Review

The COVID-19 epidemic is currently causing several disruptions and issues for the modern SC around the world. The SCs have previously had significant interruptions due to several natural or man-made disasters, such as earthquakes and SARS (Rejeb et al. 2023).In this research, we will assess MCDM-based approaches for preventing SC disruption in the steel and rolling sectors. According to K. Katsaliaki et al. the work was a comprehensive analysis and future research agenda on supply chain disruptions and resilience and the methodology was Resilience methods (Katsaliaki et al. 2022). Besides Tazim Ahmed et al. the work was determining and assessing important adaptable sustainable supply chain management strategies to combat the effects of COVID-19 and the methodology was a Delphi-based

Bayesian- BWM model (Karmaker et al. 2021). Yichen Lin et al. examining the factors that have influenced innovation in supply chain efficiency and channel integration used the partial least squares approach (PLS)(Lin et al. 2010). Nyoman Pujawan et al. supply chains affected by COVID-19 disruptions review of the literature and future research and used the systematic literature review (SLR) method (Taqi et al., 2020)(Sharif 2020). Dupont et al., Fan et al. & Maiyar and Thakka determine a logistics provider's flexibility capability (Pujawan & Bah 2022).

Naimur Rahman Chowdhury et al. recognize important factors that can reduce the pharmaceutical industry supply chain disruptions during COVID-19 (Dupont et al. 2018). Belhadi et al. investigate the impact of COVID-19 on the supply chains for automobiles and airplanes (Fan et al. 2017). Ghadge et al.'s work was cyber-attack and data breach UO(Robust Optimization of Sustainable Food Grain Transportation with Uncertain Supply and Intentional Disruptions, n.d.). Bag, S.et al, Telukdarie, A. et al, Pretorius et al, J.H.C.et al and Gupta, Set al. recognizing industry 4.0 and supply chain sustainability framework and future research directions (N. R. Chowdhury et al. 2021)(Wang et al., n.d.)(Cai & Lo, 2020). Cai et al. Y.J. et al. and Lo et al., C.K.Y.et al. recognizing Omni-channel management in the New Retailing Era: a systematic review and Future Research Agenda. Chowdhury et al., M.T. et al., Sarkar, A. et al., Paul et al., S.K. et al. and Moktadir et al., M.A. A et al. case study on strategies to deal with the impacts of the COVID-19 pandemic in the food and beverage industry (M. T. Chowdhury et al. 2022).

Harjoto et al. M.A. et al and Rossi et al, F. et al market reaction to the COVID-19 pandemic evidence from emerging markets . Karmaker et al., C.L. et al., Ahmed et al., T. et al., Ahmed, S. et al., Ali et al., S.M. et al., Moktadir et al., M.A. et al. and Kabir, G. et al. improving supply chain sustainability in the context of COVID-19 pandemic in an emerging economy: exploring drivers using an integrated mode (Karmaker et al. 2021). Nandi et al., S. et al., Sarkis et al., J. et al., Hervani et al., A.A. et al. and Helms et al., M.M. et al. redesigning supply chains using blockchain-enabled circular economy and COVID-19 experiences (Belhadi et al., 2021)(Caporale et al., 2024). Taqi et al., H.M.M. et al., Ahmed et al., H.N. et al., Paul et al., S. et al., Garshasbi et al., M., Ali et al. S.M., Kabir et al., G. et al. and Paul et al., S.K. et al. strategies to manage the impacts of the COVID-19 pandemic in the supply chain: implications for improving economic and social sustainability (Taqi et al. 2020)(Ghadge et al. 2020).

3. Methods

3.1 Introduction

This chapter contains the methods and steps that will be followed while to eradicate the disruption of SCs. and finally, a detailed case study is presented. The research will assist emerging economies in making strategic decisions to address the effects of COVID-19. To eradicate the disruption of SCs the positive strategy and criteria will rank based on MCDM approaches which are Fuzzy TOPSIS & Best Worth Method (BWM).

3.2 Selection of potential COVID-19 Outbreak Impacts and preventative criteria, strategies on the Still and Rolling Industry

This section discusses solutions for resolving supply chain disruptions that were developed after reading the relevant literature and engaging in brainstorming sessions.

3.2.1 The strategies of this research

The possible strategies discussed below are in the steel and rolling industry supply chain. To identify the most important flexible SSC strategies, a thorough literature review was conducted using the key terms "Impacts of COVID-19 Pandemic," "Supply Chain Sustainability," "Flexible Strategies," "Strategies for Mitigating the Post-COVID-19 Impacts, etc. Eight crucial flexible SSC strategies were found after a review of the pertinent literature. The strategies are initiatives to reduce lead time across the supply chain, government incentives, the positioning of the inventory of the supply chain, logistics, and transportation, and arranging health monitoring & occupational safety. Potential strategies to address the effects of the COVID-19 outbreak in the supply chain for the steel and rolling industries are shown in Table 1.

Table 1. Potential strategies to address the effects of the COVID-19 outbreak in the supply chain for the steel and rolling industries

Strategy code	Strategies	Description	Reference
S1	Initiative to reduce lead time across the supply chain.	Customers dislike waiting for raw materials because it hampers the assemblies. Take a proper step to reduce lead time.	de Sousa Jabbour *et al*., (2020) [15]
S2	Government incentives	When business is stranded, companies need government incentives.	Sharif (2020) [22]
S3	The positioning of the inventory of the supply chain.	The term "inventory positioning" refers to a company's strategic management of the location of its inventory, both physically and inside the supply chain.	Naimur Rahman Chowdhury *et al*. [12]
S4	Logistics and Transportation	Logistics is the control of the inbound and outbound movement of goods from the manufacturer to the final consumer.	Dupont *et al.* (2018) [9], Fan *et al.* (2017) [10] Maiyar and Thakkar (2019) [11]
S5	Arranging Health monitoring & Occupational safety	To encourage taking the vaccine. Social distance, wash the hand. Wear protective clothing. Avoid breathing in dust. Avoid getting hurt while doing heavy lifting.	Proposed
S6	Digitalization	Planned IT, Cyber-attack defender, Block chain implementation, IoT based monitoring, AI & big data based SCs transparency	Belhadi *et al.* (2021) [13] Ghadge *et al*. (2019) [14]
S7	Supply Management	Diversify supply, Risk sharing contract, Dual sourcing.	Tomlin and Wang (2011) [23]
S8	Using high end-predictive analytics and continuously adjusting parameters based on practical situation	Monitoring the need of requirements.	Proposed

3.2.2 Criteria of this research

This section discusses solutions for resolving supply chain disruptions that were developed after reading the relevant literature and engaging in brainstorming sessions. In order to identify the most important flexible SSC strategies, a thorough literature review was conducted using the key terms "Impacts of COVID-19 Pandemic," "Supply Chain Sustainability," "Flexible Strategies," "Strategies for Mitigating the Post-COVID-19 Impacts," "Emerging Economy," "Emerging Market," etc. Five crucial flexible SSC criteria were found after a review of the pertinent literature. The first criterion is the flexibility of delivery systems to meet the customer needs Companies are then able to maintain the level of customer experience that the process was initially designed to provide by deviating from it to meet consumer wants.

Table 2. Potential criteria to address the effects of the COVID-19 outbreak in the supply chain for the steel and rolling industries

Criteria code	Criteria	Description	Reference
C1	The flexibility of delivery systems to meet the customer needs	Companies are then able to maintain the level of customer experience that the process was initially designed to provide by deviating from it in order to meet consumer wants.	Yichen Lin[6]
C2	Shorter order cycle	A shorter order cycle make the system more efficient	Yichen Lin[6]
C3	Cost competitiveness	The following expenses make up the supply chain's overall cost: Actual costs including those incurred during manufacture and opportunity costs and other indirect costs while deciding on a different option	Yichen Lin[6]
C4	Flexible customer response	One of the most important aspects in assessing SC performance is how well the company responds to customer demands and changes in needs. This shows a high level of customer responsiveness.	Yichen Lin[6]
C5	Strengthen the supplier partnership	Being a regular and effective communicator with supplier the SCs is more efficient.	Yichen Lin[6]

A shorter order cycle makes the system more efficient. Cost competitiveness the following expenses make up the supply chain's overall cost: Actual costs including those incurred during manufacture and opportunity costs and other indirect costs while deciding on a different option while keeping it as low as possible.

Flexible customer response One of the most important aspects in assessing SC performance is how well the company responds to customer demands and changes in needs. This shows a high level of customer responsiveness. Strengthening the supplier partnership expresses being a regular and effective communicator with the supplier the SCs are more efficient. Potential criteria to address the effects of the COVID-19 outbreak on the supply chain for the steel and rolling industries are shown in Table 2.

3.3 Best Worst Method

BWM is an MCDM technique that can be applied in various stages of resolving an MCDM issue. Specifically, it can be used to assess the alternatives in light of the requirements. BWM is an MCDM technique that can be applied in various stages of resolving an MCDM issue. Specifically, it can be used to assess the alternatives in light of the requirements (specially in the cases where objective metrics are not available to evaluate the alternatives). The weight (importance) of the criteria that are utilized to create a solution that will satisfy the primary goal(s) of the challenge can also be determined. Many MCDM issues in the fields of business and engineering, education, and agriculture have been resolved using BWM.
Figure 2 shows the flow chart of BWM.

3.3.1 Flow chart of BWM

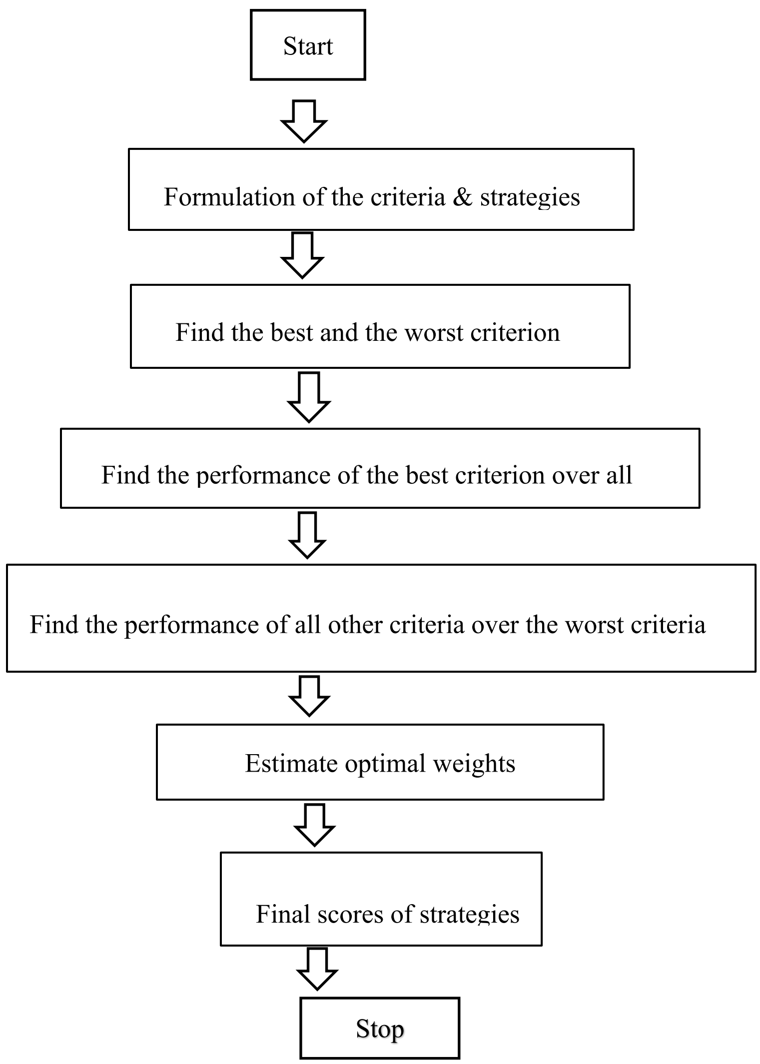

Figure 2. Flowchart of the BWM 4. Data Collection

Data collection from expert 1:
Table 3, Table 4, Table 5, and Table 6 show the different steps including the development of the problem, identifying the best and worst criteria, determining which criterion is preferred over all others determining the desirable criteria. and determining which criteria are preferred over the least desirable ones.

Step 1:

Table 3. Development of the problem.

Criteria Number = 5	**Criterion1**	**Criterion2**	**Criterion 3**	**Criterion4**	**Criterion 5**
Names of Criteria	flexibility of delivery systems to meet the customer needs	Shorter order cycle	Cost competitiveness	Prompt response toward variable customer needs	Strengthen the supplier partnership

Step 2: Table 4. Identify the best and worst criteria

.

Select the Best	Strengthen the supplier partnership
Select the Worst	Prompt response toward variable customer needs

Step 3: Table 5. Determine which criterion is preferred over all others

Best to Others	Flexibility of delivery systems to meet customer needs	Shorter order cycle	Cost competitiveness	Prompt response toward variable customer needs	Strengthen the supplier partnership
Strengthen the supplier partnership	7	6	8	7	1

Step 4: Table 6. Determine which criteria are preferred over the least desirable ones.

Others to the Worst	**Prompt response toward variable customer needs**
Flexibility of delivery systems to meet customer needs	6
Shorter order cycle	7
Cost competitiveness	8
Prompt response toward variable customer needs	1
Strengthen the supplier partnership	8

Step 5: Calculate the optimal weights.

Table **7**. Optimal weights

Weights	flexibility of delivery systems to meet the customer needs	Shorter order cycle	Cost competitiveness	Prompt response towards variable customer needs	Strengthen the supplier partnership
	0.121158911	0.141352063	0.10601404	0.046093064	0.58538191
Ksi*	0.262730465				

These weights are typically determined by the experts' opinions engaged with that sector shown in Table 7.

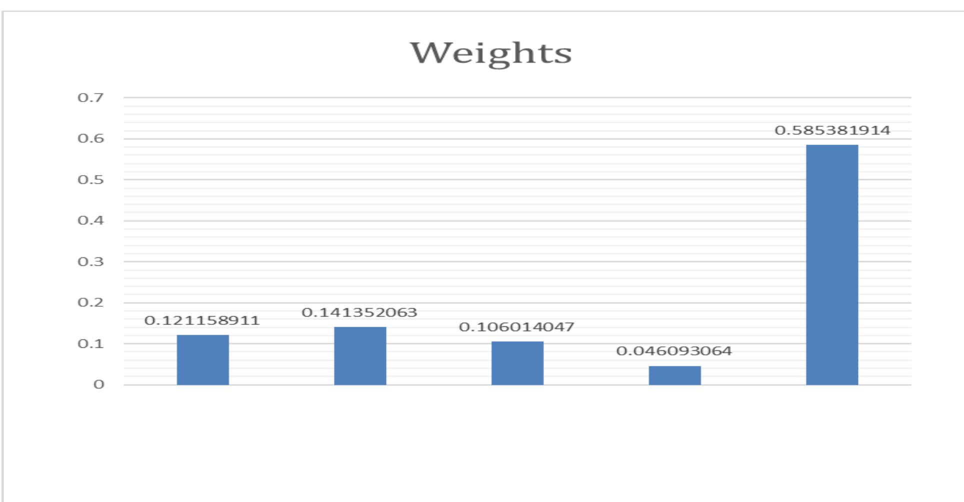

Figure 3. Output of the criteria weight

Figure 3 shows the output of the criteria weight. The process is again applied for another expert response.

Data collection from Expert 2:
Table 8, Table 9, Table 10, and Table 11 show the different steps including the development of the problem, identifying the best and worst criteria, determining which criterion is preferred over all others determining the desirable criteria. and determining which criteria are preferred over the least desirable ones.

Step 1

Table 8**.** Development of the problem.

Criteria Number = 5	Criterion1	Criterion2	Criterion 3	Criterion4	Criterion 5
Names of Criteria	flexibility of delivery systems to meet the customer needs	Shorter order cycle	Cost competitiveness	Prompt response towards variable customer needs	Strengthen the supplier partnership

Step 2:

Table 9**.** Identify the best and worst criteria

.

Select the Best	Strengthen the supplier partnership
Select the Worst	Prompt response toward variable customer needs

Step 3:

Table 10. Determine which criterion is preferred over all others

Best to Others	flexibility of delivery systems to meet the customer needs	Shorter order cycle	Cost competitiveness	Prompt response toward variable customer needs	Strengthen the supplier partnership
Strengthen the supplier partnership	8	4	1	8	6

Step 4:

Table 11. Determine which criteria are preferred over the least desirable ones.

Others to the Worst	**Prompt response toward variable customer needs**
flexibility of delivery systems to meet the customer needs	7
Shorter order cycle	6
Cost competitiveness	5
Prompt response toward variable customer needs	1
Strengthen the supplier partnership	6

Step 5: Calculate the optimal weights.

Table 12. Optimal weights

	flexibility of delivery systems to meet the customer needs	Shorter order cycle	Cost competitiveness	Prompt response towards variable customer needs	Strengthen the supplier partnership
Weights	0.0982758	0.196551724	0.522413793	0.051724138	0.13103448
Ksi*	0.263793103				

These weights are typically determined by the experts' opinions engaged with that sector shown in Table 12.

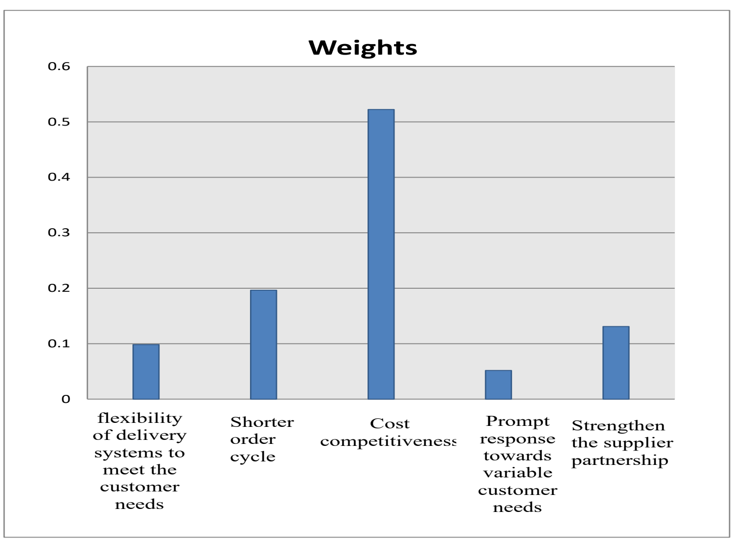

Figure 4. Output of the criteria weight

Figure 4 shows the output of the criteria weight. The process is continued for the next 8 responses.

Step 6: Final outcomes of criteria
The final outcomes of the following criteria are listed in Table 13.

Table 13. Final outcomes of criteria

Names of Criteria	flexibility of delivery systems to meet the customer needs	Shorter order cycle	Cost competitiveness	Prompt response towards variable customer needs	Strengthen the supplier partnership
1	0.121158911	0.141352063	0.10601404	0.046093064	0.585381914
2	0.098275862	0.196551724	0.52241379	0.051724138	0.131034483
3	0.54887218	0.067669173	0.12781954	0.127819549	0.127819549
4	0.047619048	0.352380952	0.171428571	0.171428571	0.257142857
5	0.23655914	0.157706093	0.415770609	0.11827957	0.071684588
6	0.518575851	0.069659443	0.108359133	0.151702786	0.151702786
7	0.054216867	0.120481928	0.120481928	0.584337349	0.120481928
8	0.122905028	0.05027933	0.581005587	0.122905028	0.122905028
9	0.357142857	0.267857143	0.178571429	0.089285714	0.107142857
10	0.140186916	0.140186916	0.140186916	0.514018692	0.065420561
Mean	0.224551266	0.156412476	0.247205156	0.197759446	0.174071655
%Mean	22.45512661	15.64124765	24.72051562	19.77594462	17.4071655

Fuzzy TOPSIS:
TOPSIS refers to a Technique for order performance similar to the ideal solution which is the technique for Multiple-Criteria Decision Making (MCDM).

Table 14. Description Value [24]

Term	**Fuzzy Number**
Very low	1,1,3
Low	1,3,5
Average	3,5,7
High	5,7,9
Very High	7,9,9

One of the most well-liked MCDM techniques at the moment is called Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and it has successfully been used in several applications. Hwang and Yoon invented this technique first. One of the greatest ways to find the optimal answer among comparable possibilities is to use fuzzy TOPSIS (NĂdĂban et al. 2016). Additionally, it can be utilized to automate the procedure and get rid of confusion and ambiguity in the selection process.

Flow chart of the Fuzzy TOPSIS

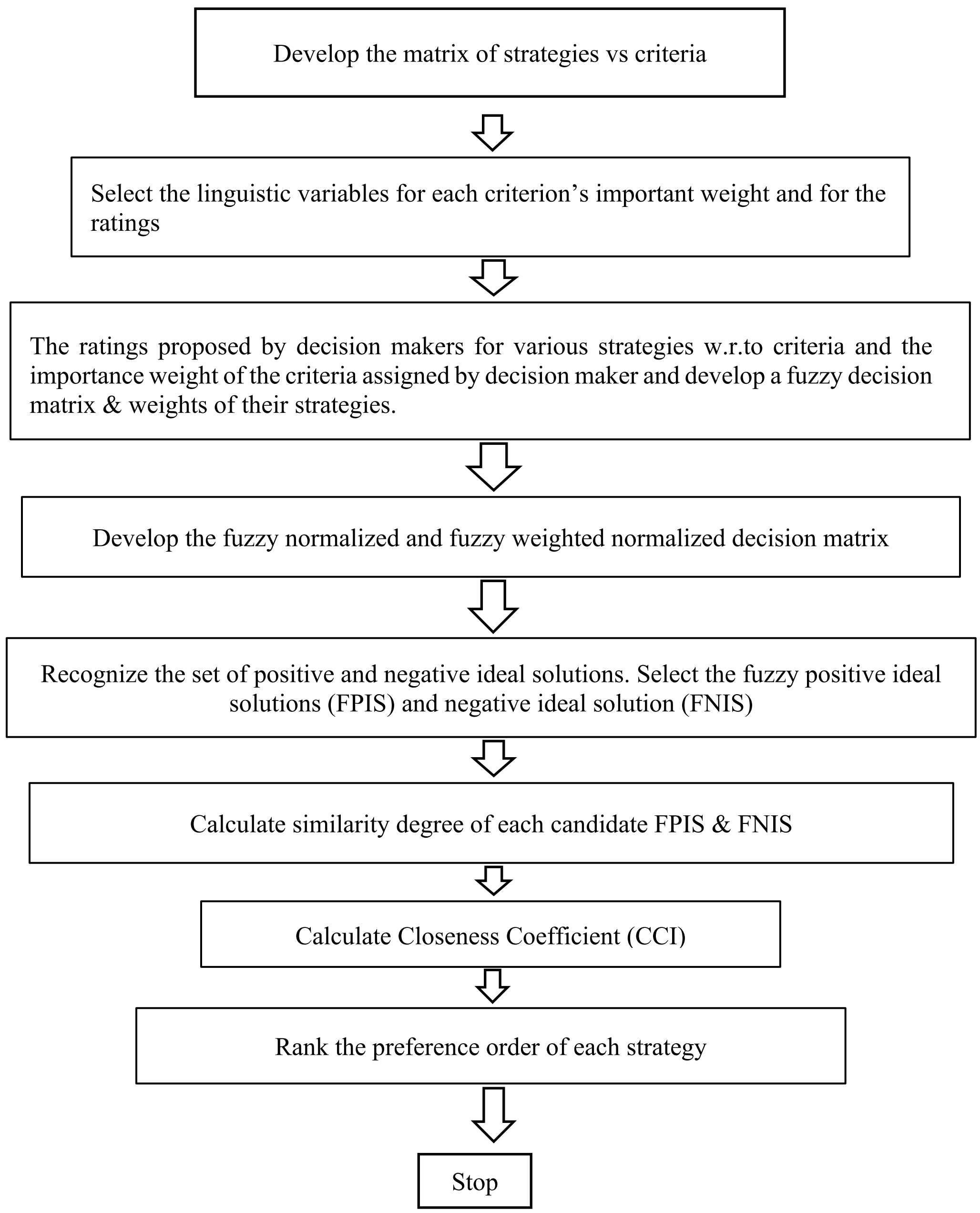

Figure 5. Flow chart of the Fuzzy TOPSIS

The group DM problem can be solved using this approach quite effectively in a fuzzy environment. The ratings of qualitative criteria and the priority weights assigned to distinct criteria are regarded in this method as linguistic variables. Table 14 represents the description value.

If x=(a1,b1,c1), y=(a2,b2,c2) are two triangular FNs .

We presume that the decision-making body has N members. I have shown two expert responses among ten responses. The Nth decision maker's fu. assessment of the alternative Ai w.r.t Cj is denoted x^N and the weight of criterion Cj is denoted Wj =(Wj1, Wj2, Wj3). Figure 5 shows the flow chart of Fuzzy TOPSIS

Step 1: Give each of the criteria and the alternatives a rating.

Table 15. the criteria and the strategies for a rating

	flexibility of delivery systems to meet the customer needs	**Shorter order cycle**	**Cost competitiveness**	**Prompt response toward variable customer needs**	**Strengthen the supplier partnership**
Initiative to reduce lead time across the supply chain	very high	high	high	average	high
Government incentives	average	average	high	average	high
The positioning of the inventory of the supply chain	high	high	high	high	Average
Logistics and Transportation	Very High	High	High	High	Average
Arranging Health monitoring & Occupational safety	Average	Average	Low	Average	Average
Digitalization	Very High	High	High	High	High
Supply Management	Very High	High	High	High	High
Using high-end-predictive analytics and continuously adjusting parameters based on practical situation	Very High	High	Very High	High	Very High

Table 16. the criteria and the strategies for a rating (numerical analysis)

5	7	9	7	9	9	5	7	9	3	5	7	7	9	9
5	7	9	5	7	9	3	5	7	5	7	9	5	7	9
3	5	7	5	7	9	3	5	7	3	5	7	5	7	9
3	5	7	3	5	7	5	7	9	5	7	9	3	5	7
3	5	7	3	5	7	5	7	9	3	5	7	5	7	9
5	7	9	3	5	7	5	7	9	5	7	9	5	7	9
5	7	9	5	7	9	3	5	7	5	7	9	5	7	9
5	7	9	3	5	7	5	7	9	3	5	7	5	7	9

Table 15 and Table 16 show the criteria and strategies according to numerical rating.
The process is continued for 8 responses.

Step 2: Calculate the aggregated fuzzy weights for criteria and the aggregated fuzzy ratings for alternatives. Table 17 shows the combined decision matrix.
Aggregate fuzzy rating $xij = (aij, bij, cij)$ of ith alternatives w.r.t jth criterion is obtained as follows

$aij = \min\{aij^k\}$, $bij = \frac{\sum_1^k bij^k}{k}$,$cij = \max\{cij^k\}$ (3.1)

Aggregate fuzzy weight Wj =(Wj1, Wj2,Wj3) for the criterion Cj are calculated Cj are calculated by formulas

Wj1=min $\{wj1^k\}$, wj2=$\frac{\sum_1^k wj2^k}{k}$, $wj3 = \max\{wj3^k\}$ (3.2)

Table 17. Combined Decision Matrix

0.224551266			0.156412476			0.247205156			0.197759446			0.174071655		
Combined Decision Matrix														
1	6.4	9	1	6.4	9	1	5.6	9	3	6.8	9	5	7.8	9
1	5.6	9	1	6.2	9	3	7	9	1	6	9	1	6.4	9
3	6	9	1	5.6	9	3	5.8	9	1	6	9	1	5.6	9
3	6.8	9	1	6.4	9	3	6.6	9	1	6.4	9	1	5.6	9
1	4.8	9	1	5	9	1	4.6	9	1	5	9	1	5	9
1	6.8	9	3	6.8	9	1	6.6	9	3	7.4	9	3	7	9
1	6.8	9	1	6.8	9	3	6.6	9	1	6.6	9	1	6.2	9
1	5.8	9	1	5.8	9	3	6.8	9	1	6	9	1	6.4	9

Step 3: Do the normalized fuzzy decision matrix calculation. The normalized fuzzy decision matrix R=[rij] where

$rij = \frac{aij}{cj*}, \frac{bij}{cj*}, \frac{cij}{cj*}$ $and\ cj *= max\{cij\}(benefit\ criteria)$ (3.3)

rij $= \frac{aj-}{cij}, \frac{aj-}{cij}, \frac{aj-}{cij}$ $and\ cj-= max\{aij\}(cost\ \ criteria)$ **(3.4)**

Table 18. Normalized fuzzy matrix decision

Normalized fuzzy decision matrix														
0.224551266			0.15641247			0.247205156			0.197759446			0.174071655		
flexibility of delivery systems to meet the customer needs			Shorter order cycle			Cost competitiveness			Prompt response toward variable customer needs			Strengthen the supplier partnership		
0.11111111	0.711111	1	0.1111111	0.15625	1	0.111111	0.622222	1	0.111111	0.147059	0.333333	0.1111111	0.128205	0.2
0.11111111	0.622222	1	0.1111111	0.16129	1	0.3333	0.777778	1	0.111111	0.166667	1	0.1111111	0.15625	0
0.33333333	0.666667	1	0.1111111	0.178571	1	0.333333	0.644444	1	0.111111	0.166667	1	0.1111111	0.178571	1
0.33333333	0.755556	1	0.1111111	0.15625	1	0.333333	0.733333	1	0.111111	0.15625	1	0.1111111	0.178571	1
0.11111111	0.533333	1	0.1111111	0.2	1	0.111111	0.511111	1	0.111111	0.2	1	0.1111111	0.2	1
0.11111111	0.755556	1	0.1111111	0.147059	0.33	0.111111	0.733333	1	0.111111	0.135135	0.333333	0.1111111	0.142857	0.333333
0.11111111	0.755556	1	0.1111111	0.147059	1	0.333333	0.733333	1	0.111111	0.151515	1	0.1111111	0.16129	1
0.11111111	0.644444	1	0.1111111	0.172414	1	0.333333	0.755556	1	0.111111	0.166667	1	0.1111111	0.15625	1

Here, Table 19 is used for computing the weighted normalized fuzzy decision matrix mentioned in Table 18.

Step 4:

Table 19. Compute the weighted normalized fuzzy decision matrix

Weighted Normalized fuzzy decision matrix														
0.224551266			**0.15641247**			**0.24720515**			**0.197759446**			**0.174071655**		
flexibility of delivery systems to meet the customer needs			**Shorter order cycle**			**Cost competitiveness**			**Prompt response towards variable customer needs**			**Strengthen the supplier partnership**		
0.02495014	**0.159681**	**0.224551**	**0.017379**	**0.0244439**	**0.156412**	**0.027467**	**0.153817**	**0.247205**	**0.021973**	**0.029082**	**0.06592**	**0.019341**	**0.022317**	**0.034814**
0.02495014	**0.139721**	**0.224551**	**0.017379**	**0.0252228**	**0.156412**	**0.082402**	**0.192271**	**0.247205**	**0.021973**	**0.03296**	**0.197759**	**0.019341**	**0.027199**	**0**
0.074850422	**0.149701**	**0.224551**	**0.017379**	**0.0279331**	**0.156412**	**0.082402**	**0.15931**	**0.247205**	**0.021973**	**0.03296**	**0.197759**	**0.019341**	**0.031084**	**0.174072**
0.074850422	**0.169661**	**0.224551**	**0.017379**	**0.0244439**	**0.156412**	**0.082402**	**0.181284**	**0.247205**	**0.021973**	**0.0309**	**0.197759**	**0.019341**	**0.031084**	**0.174072**
0.024950141	**0.119761**	**0.224551**	**0.017379**	**0.03112**	**0.156412**	**0.027467**	**0.126349**	**0.247205**	**0.021973**	**0.039552**	**0.197759**	**0.019341**	**0.034814**	**0.174072**
0.024950141	**0.169661**	**0.224551**	**0.017379**	**0.0230002**	**0.052137**	**0.027467**	**0.181284**	**0.247205**	**0.021973**	**0.026724**	**0.06592**	**0.019341**	**0.024867**	**0.058024**

0.024950141	**0.169661**	**0.224551**	**0.017379**	**0.023002**	**0.156412**	**0.082402**	**0.181284**	**0.247205**	**0.021973**	**0.029964**	**0.197759**	**0.019341**	**0.028076**	**0.174072**
0.024950141	**0.144711**	**0.224551**	**0.017379**	**0.026968**	**0.156412**	**0.082402**	**0.186777**	**0.247205**	**0.021973**	**0.03296**	**0.197759**	**0.019341**	**0.027199**	**0.174072**

Step 5: Calculation of the Fuzzy Positive Ideal Solution (FPIS) [Table 20] and the Fuzzy Negative Ideal Solution (FNIS) [Table 21].

A*= (v^*, v^* ……vn*), where $vj = \max\{vj3\}$:; (3.6)
A^-= ($v1$, v2-………… vn), where $vj- = \max\{\underset{*}{vj}1\}$; (3.7)

Table 20. Calculation of the Fuzzy Positive Ideal Solution (FPIS)

Distance from FPIS				
0.02938049	0.003951	0.038715	0.076357	0.080723
0.033597876	0.003496	0	0.003806	0.100596
0.011523976	0.001935	0.01903	0.003806	0.002154
0	0.003951	0.006343	0.004995	0.002154
0.040743409	0	0.049543	0	0
0.028809941	0.060393	0.032345	0.076477	0.067246
0.028809941	0.004781	0.006343	0.005536	0.00389
0.032210493	0.002491	0.003172	0.003806	0.004397

Table 21. Calculation of the Fuzzy Negative Ideal Solution (FNIS)

Distance from FNIS				
0.023047953	0.060209	0.015858	0.001361	0.0201
0.011523976	0.060217	0.049543	0.076203	0.002819
0.033597876	0.06027	0.036987	0.076203	0.100628
0.040743409	0.060209	0.044854	0.076156	0.100628
0	0.060393	0	0.076477	0.100759
0.028809941	0	0.031716	0	0.033532
0.028809941	0.060203	0.044854	0.076141	0.100555
0.01440497	0.060247	0.04715	0.076203	0.10054

Step 6:
Table 22. Calculate the distance between each option and the FPIS and FNIS [Illustrated in Table 22].

di-	**di***
0.120577	0.229127
0.200305	0.141496
0.307686	0.038448
0.32259	0.017443
0.237629	0.090286
0.094059	0.26527
0.310563	0.04936
0.298544	0.046076

$di^{*}=\sum_{1}^{n} d(vij, vj\ *)$ (3.8)

Step 7: Calculate the CCi (closeness coefficient) for each option

$CCI = \frac{di^{-}}{di^{-}+di^{*}}$ (3.9)

Step 8: Rank the alternatives.

Table 23. The rank of the strategies

Rank	Alternatives
7	Initiative to reduce lead time across the supply chain
6	Government incentives
2	The positioning of the inventory of the supply chain
1	Logistics and Transportation
5	Arranging Health monitoring & Occupational safety
8	Digitalization
4	Supply Management
3	Using high-end-predictive analytics and continuously adjusting parameters based on practical situation

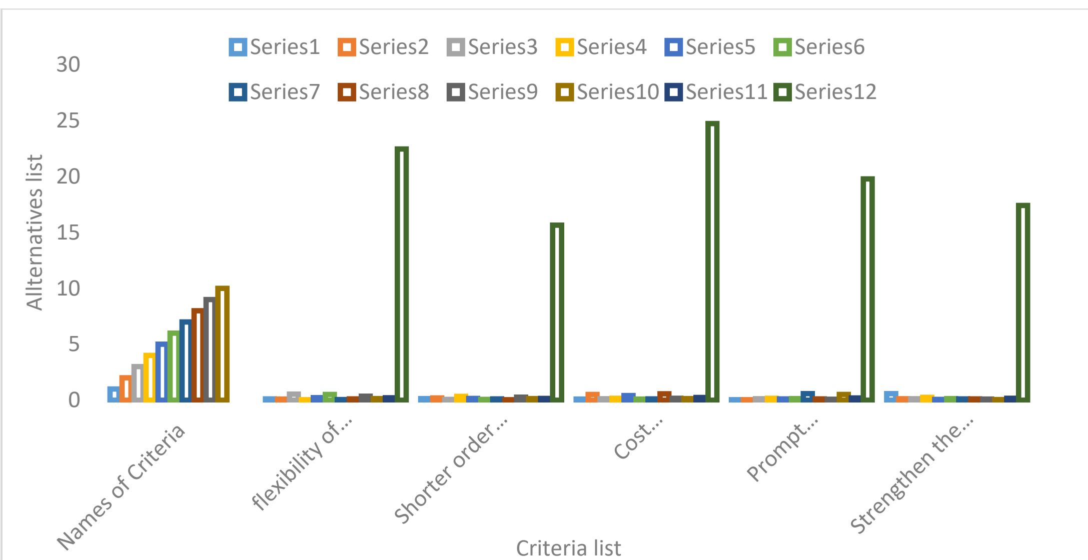

Figure 6. Output of the mean criteria weight ranking

Table 23 shows the rank of the strategies. The best alternative is the one with the highest proximity coefficient. The best criteria is the cost competitiveness, gradually second one flexibility of delivery systems to meet customer needs, third one is a prompt response towards variable customer needs, the fourth one is strengthening the supplier partnership, and worst is shorter order cycle. From the Fuzzy Topsis, I got the ranking of strategies. The best strategies are logistics and transportation, gradually positioning of the inventory of the supply chain, using high-end-predictive analytics and continuously adjusting parameters based on practical situations, supply management, arranging Health monitoring & occupational safety, government incentives, initiatives to reduce lead time across the supply chain &

last one is digitalization.From this chapter, we have obtained the best & worst criteria by BWM method and also found the strategies ranking by applying the Fuzzy Topsis method. Lastly, we found the strategies ranking graph which was plotted by MS Excel software.

5. Results and Discussion

5.1 Numerical Results

By using MCDM techniques, we are accepting to recognize the possible strategies to overcome the impacts of the COVID-19 pandemic in the steel and rolling industries supply chain and effectively rank the strategies based on different criteria using the method of Fuzzy TOPSIS and Best Worst Method (BWM). A case study of the steel and rolling industries will be toward the end of the research. I created a questionnaire and collected responses from experts in the steel industry supply chain. They are from different steel companies such as BSRM, KSRM, AKS, GPH Ispat etc. From the BWM method, I got the best criteria and worst criteria. The best criteria is the cost competitiveness, gradually second one flexibility of delivery systems to meet customer needs, third one is a prompt response towards variable customer needs, fourth one is strengthening the supplier partnership and worst one is shorter order cycle.

From the Fuzzy Topsis, I got the ranking of strategies. The best strategies are logistics and transportation, gradually positioning of the inventory of the supply chain, using high-end-predictive analytics and continuously adjusting parameters based on practical situations, supply management, arranging Health monitoring & occupational safety, government incentives, initiative to reduce lead time across the supply chain & last one is digitalization. There was a comparison with other researchers Tazim Ahmed applied the Baysien Hierarchical Model & got output, use of cyber-physical production system (CPPS) at 5th ranking where my model has given digitalization at 8th position. Developing omni-channel distribution and retailing strategy at 2nd position whereas supply Management at 4th position. Facilitating the financial support from the government through incentives at 9th position whereas my model gives at 6th position. Applying advanced big data analytics at 6th position whereas sing a high-end-predictive analytic and continuously adjusting parameters based on practical situations at 3rd position. de Sousa Jabbour et al. applied the TOPSIS initiative to reduce lead time across the supply chain at 3rd position whereas my model gets at 7. Naimur Rahman Chowdhury et al. the positioning of the inventory of the supply chain uses BWM to get 2nd position & my model also gives the result in 2nd position. The mean of the criteria weights is calculated in Table 24 and ranked based on the means.

Ranking based on the output of the mean criteria is shown in Figure 6. Table 25 represents the ranking among the following alternatives And ranking based on the output of the strategies is illustrated in Figure 7

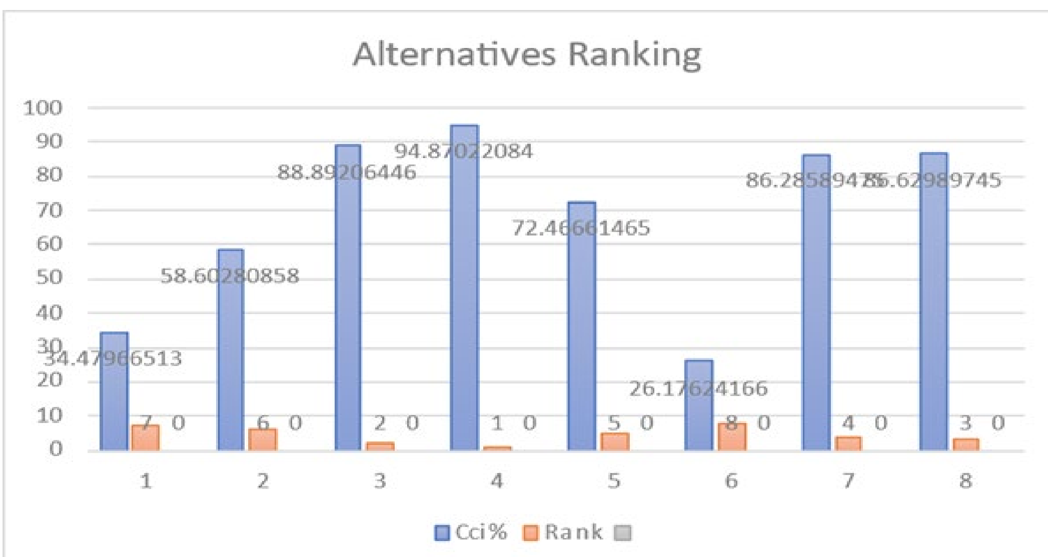

Figure 7. Output of the strategies ranking

. 5.3 Proposed Improvements
The study aims to enhance the abstract by focusing on key findings and implications, highlighting the originality of the research. The introduction should clarify the problem and importance of supply chain disruptions in a broader context, highlighting the research questions or hypotheses. We should expand the methodology section to elucidate the MCDM approaches (fuzzy TOPSIS and BWM) and their efficacy within this context.

6. Conclusion
The proposed strategy and study results can aid decision-makers in formulating tactical choices that will increase sustainability in SCs in the face of the pandemic. After systematic literature review and analysis many previous models are analyzed in the methodology section and finally using fuzzy topsis and BWM. The study will be based on questionnaire approach, so all the questionnaire are attached in the appendix section. From the responses of supply chain experts, I have found the best and worst criteria by applying the BWM method. Besides, the criteria weight was used to find the strategies ranking by the fuzzy topsis method. This study looked at adaptable SC techniques to lessen the effects of COVID-19 and modeled how these strategies relate to one another based on the opinions of experts. However, by utilizing structural equation modeling (SEM) and multiple regression based on more quantitative data, a more thorough association model can be created and validated in the future. Future comparisons between the ranking of flexible SCs tactics and other quantitative approaches are possible. Once more, the current research has investigated the adaptable strategies and combined them to recommend a single framework to enhance sustainability in the context of COVID-19.

Additionally, it has several limitations. Although the data in this case was gathered from a few well-known Bangladeshi steel industries, the results might not accurately represent the entire situation. The proposed approach's conclusions are mostly concentrated on Bangladesh's steel sector, while they are intended to be relevant to other industries as well. Future research can assess the effects of employing these tactics in emerging economies' businesses. Additionally, the proposed model was created using the Bangladeshi steel industry as an emerging economy, Future research can be done on additional industries from both emerging and mature economies to generalize the results.

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