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A Technology Enabled Framework for Mitigating Risk during Supply chain Disruptions in a Pandemic Scenario

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Abstract

At present supply chains are dynamic and interactive in nature which integrates suppliers, manufacturers, distributors, and consumers. An important objective of supply chain management is to ensure that each supply chain partner is in the coordination with others so that supply chain potential and enhanced surplus can be realized in sales. In general, this coordination breaks due to distrust, misinformation, poor logistics and transportation infrastructure; however, in specific cases like Covid-19, it arises due to uncertainties caused by various types of risks such as delays and disruptions. During pandemic Covid-19 global supply chains have been distorted badly due to multiple lockdowns and country specific decisions to contain the spread of coronavirus. For dealing with such pandemic situation in future, we have learned and proposed some of the strategies from literature and practice that a supply chain manager can think of to minimize supply chain disruptions during a pandemic. These supply chain strategies include Resilience, Outsourcing/Offshoring, Agility, and Digitalization. For helping in decision making to the practitioners, we have applied Best Worst Method (BWM) to evaluate these strategies during pandemic times and found that Digitalization strategy (0.574) has been most differentiating among the proposed four strategies in a pandemic scenario; whereas, Outsourcing/Offshoring strategy is most hampered/ineffective during such times.

Keywords: Supply chain management; Pandemic; Disruption; Risk mitigation; Multi-criteria decision making.

1. Introduction

Modern Supply Chain Management has become very vulnerable to global events. It is mainly due to its dynamic nature where systems and business environment are changing continuously. In past few years world has witnessed many epidemics and pandemics. Covid-19 outbreak in December 2019 has took the entire world like a severe storm. The severity and the intensity of spread of Covid-19 is many times more than all virus attacks that human beings have ever experienced. About 95% of the top companies experienced significant disruption in supply chain (Ivanov 2020). Due to several months of lock own there is a huge impact on all the aspects of supply chains. The entire logistics came to standstill due to closure of all economic activities (Bhattacharya, 2020). Such pandemics have impacted businesses of entire world due to massive fluctuations in supply and demand. Many business units could not bear such shocks and were closed due to heavy financial loss. There is a growing need of superior risk mitigation strategies to counter such situations in future (Strange, 2020).

It has been also observed that epidemics and pandemics not only causes excessive business losses but also results in excessive threats to human life. Pandemics like H1N1, Bird flu, smallpox, plague, HIV and recently COVID 19 have become a huge threat to human life all across the world. According to the World Health Organization (WHO) Epidemic outbreaks have become very frequent in last two decades due to various causes resulting in a major threat to not only mankind but also to businesses. The recent outbreak of COVID 19 virus that started in November 2019 in Wuhan China has now engulfed the entire globe and still continuing to show its devastating impact. According to WTO report, world trade is expected to decline in the range of 15% to 30% in the year 2020 in the wake of COVID 19 pandemic.

1.1. Background of the study

Due to widespread lock downs, such pandemics have impacted global supply chain in a big way. As a result, there is a need for more resilient and agile Supply chain. The visibility issue in the supply chain becomes very crucial in such times as original equipment manufacturing (OEM) companies. Although speed and flexibility is considered very important in achieving supply chain responsiveness during normal production but how to handle supply chain disruptions during pandemics and epidemic times also become very crucial. After pandemic, organizations need to revisit the way they handled risks and redefined strategies to ensure smooth flow of supplies in such pandemic situations. Emphasis on technology, digitalization and outsourcing can be beneficial in mitigating supply chain disruptions in pandemic situation. Majorly, the literature discusses about risks in supply chain management in normal circumstances but it lacks to identify best suited strategies, irrespective of the product type a supply chain deals in, during abnormal times like pandemic Covid-19. This study focuses on two major research questions regarding the supply chain risk mitigation during pandemic, that is;

- What are different mitigation strategies to manage the risk in supply chain due to pandemic disruptions?
- Which strategy is best suited for Supply Chain Risk Mitigation in current pandemic situation?

For addressing these research gaps, the following research objectives have been formulated.

- To identify Risk mitigation strategies in order to avoid or minimize supply chain disruption risk during a pandemic.
- To evaluate the importance of each supply chain strategy for mitigating risk during pandemic Covid-19.
- To identify most suitable strategy for Supply Chain Risk Mitigation in a pandemic situation.

Hence, the paper identifies all possible strategies that are applicable under such scenario and also develops a framework to prioritize strategies using multi-criterion decision making technique, thus surfaces most important strategies that can be used in effective risk mitigation.

Next section of paper discussed about literature review followed by research methodology and case application. Further, next section demonstrates the findings and discussion and finally, conclusion, future research directions, and limitations are appended.

2. Literature Review

Most of the literature available in the knowledge domain focuses on either risks or its mitigation strategies in supply chains. Review of literature highlights the contributions of scholars in this area to identify the existing gap in the knowledge world. In the area of risk management strategies there are large number of studies which provide direction to choose suitable risk management strategy as per the global supply chain environment (Manuj and Mentzer, 2008). They proposed models for risk management model using several multi-discipline approaches in different functional area of management. Chopra and Sodhi (2014) in their research identified that single strategy is not effective in all scenarios of supply chain disruption. They also advocated that traditional methods of risk mitigating will lower efficiency in operations. Tang (2006) focused on two major categories of “robust” strategies based on efficiency and resilience during major disruptions. A cost-benefit analysis is necessary for to decide about strategy for identified risk (Tummala and Schoenherr, 2011). Tomlin (2006) has classified risk strategies into financial, operational, and operational contingency (Tomlin, B. 2006). Depending upon the severity of risk different strategies can be employed (Norrman and Jansson 2004). Supply chain contracts such as Revenue Sharing contract in multi-company supply chains (Cao et al., 2013, Dubey., 2015), risk recovery strategies in flexible supply chain (Ivanov and Sokolov 2019, Dubey et al. 2015, Gunasekaran et al. 2016) and redesign supply chain network (Sheu and Kundu, 2018., Ivanov, 2020) are some of very effective strategies during COVID 19. Simulation-based decision support system (DSS) can also be used for real-time risk management (Güller et.al. 2015, Ivanov, 2020).

There are number of research papers which discuss about risk in supply chain and provide risk assessment framework utilizing different risk management methodologies (Tummala, 2011, Christopher, 2016). In addition to this, it is also found that wider the supply chains, more is the risk. It is obtained that higher degree of resilience as new priorities during formulation of risk strategies. He emphasized the need of more collaborative supply chain relationships between channel partners that should be based on far greater transparency of information. There is another study which categorized the risk in Preventable, Strategy and external risks. These can be managed by monitoring operational processes, design of risk-management system and identification and mitigation of impact of natural and economic disasters (Kaplan, 2012, Kaplan & Mikes, 2012).

Risk in supply chain is studied and explained by different researcher through study of variation in supply chain outcomes, probability, frequency etc. Recognition these pattern can be useful in mitigating the risk (Jüttner, Peck, & Christopher, 2003, Harland et al., 2003, Hallikas et al., 2004, Manuj & Mentzer, 2008b). Kar (2010) categorized SC risks into two groups: Systematic risks due to environmental factors like demand-side variations, changes in supply-side, legal, regulatory and bureaucratic etc. cannot be avoided whereas non-systematic risks can be handled (Kleindorfer, P.R., G.H. Saad. 2005). Most of the research publications and articles focus on either disruptions risks due to natural calamities like Tsunami, earthquake, Cyclones, floods, fires etc. or operational risks due to uncertain demands, supply, and costs. Very few paper discussed about disruption related strategies in supply chain during epidemics and pandemics as we are witnessing these days. Extensive literature review and discussion and interview conducted with industry expert provided insight about the important risk mitigation strategies which can be utilized. Based on compiled insight, we have identified four major strategies to manage supply chain disruptions.

2.1 Resilience

The term resilience has been defined as "The ability of a company to quickly respond to disruption and achieve normalcy i.e. the speed of acquiring levels of normal performance" (production, services, fill rate, etc.). (Kleindorfer, 2005).
Resilience can be achieved majorly by building flexibility, and changing the corporate culture (Skipper, 2009). While redundancy approach can also be used but has limited utility in terms of cost; the others are essential. To achieve built-in flexibility and cultural change, following strategies can be adopted:

a) *Stocking of essential commodities at strategic locations:* Risk mitigation can work very effectively if essential commodities like food, medicines, fuel etc. are stocked at several strategic locations that can meet the requirement of effected people quickly and easily. Warehouse, logistics and distribution centers may act as strategic locations where certain inventories can be hold to manage Supply Chain disruptions.
b) *Transportation Flexibility:* Transportation flexibility can be increased by having Multi modal transportation. It provides flexibility to companies if there is any disruption in the sea, air or road. Another way of transportation flexibility is to go for multiple routes. This will enable companies to quickly move to alternative routes if main route shuts down.
c) *Activate alternate sources of supply:* Multi- sourced companies have the advantage to quickly switch supplies from one supplier to another in the event of any disruption. Over-reliance over any single supplier or country can be very damaging if problem occurs at its end.
d) *Mapping entire Supply Chain***:** Mapping gives a complete, comprehensive detail of the entire supply chain and its current status. Not only Mapping of own supply chain is essential , but mapping of suppliers chain is also very important to understand the possibility of disruptions and time to recover at supplier end. Mapping is very essential for not only large but small suppliers also who are supplying critical components. Full electronic connectivity with suppliers ensures companies to move quickly in the scenario of disruptions.
e) *Cultural change:* There is a need to have a culture of taking initiatives and decisions on its own by the employees without depending on the directions from the management of the company**.** A continuous communication among informed employees is also very essential. Role of top management become very crucial to mitigate disruptions in such adverse conditions.
f) *Adapting Standard and Concurrent operation process:* using interchangeable and generic parts in production process helps in achieving flexibility in managing operations. Concurrency in operation speeds up the turn-around time as well as recovery phase of supply after any disruption.
g) *Postponement:* Taking in to consideration aggregate demand production of generic product can easily be understood. Customize of the generic product can also be looked upon at later stages as per actual demand. It has been observed as one of the effective strategy as well as cost-effective mass customization tool in regular or irregular demand fluctuations. This strategy is employed by several global companies such as Dell, Hewlett Packard (HP) and Asian Paints, United colors of Benetton etc. Postponement strategy achieves delayed differentiation in products and services.

2.2 Outsourcing and Offshoring

Outsourcing and offshoring is commonly used since two decades to bring efficiency and flexibility in operations. Sometimes company lack knowledge/ skills to develop the technology or the design of the product and sometimes they lack the required capacity to build or create the product or services.

Following Framework for Make/Buy Decisions provides clarity in taking a call on when to go for outsourcing and offshoring and when not to go for it. Fine (1998) categorized product as Integral and Modular. He developed a matrix based on these two dimensions: Dependency on knowledge or capacity and nature of product.

Table 1. Framework for Make/Buy Decision.

Product	**Dependency on both knowledge and capacity of firm**	**Independent of knowledge, dependent on capacity of firm**	**Independent of both knowledge and capacity of the firm**
Modular Nature of Product design	Outsourcing is not advisable	Outsourcing is an opportunity to the firm	Firm has the opportunity to reduce its cost of production through outsourcing
Integral nature of product design	Outsourcing is not at all advisable and can be very risky	Outsourcing can be one of the options.	Advisable to keep production internal

Source: Fine (1998)

Outsourcing/Offshoring Strategies are as follows:

a) *Focus on cost cutting:* Outsourcing & offshoring can bring down cost as companies do not require creating its own capacity building. This is especially very useful during pandemic conditions when purchasing power of customer gets weakened. Outsourcing also eliminates the need to hire individuals in-house; bringing down the fixed operational cost.

b) *Risk-sharing strategy:* can be of great benefit especially during emergency situations. Outsourcing helps is sharing risk as certain responsibilities are shifted to the outsourced vendor. Thus achieving risk-mitigating in a better way. Demand uncertainty in supply chain can be handled through contracts of different type like revenue or profit sharing, buyback, quantity etc. (Tang, 2006).

c) *Focus on Swiftness and Expertise:* During pandemic situation certain tasks are outsourced to vendors due to quick requirements like PPE kits, sanitizers etc. Sometimes there is a lack of expertise required for performing certain functions, forcing organizations to outsource.

2.3 Agility

Ability to respond swiftly during disruptions in demand or supply is termed as Supply Chain Agility (Christopher, 2004). Many organizations are at risk because they are not agile. Agility has two main drivers: visibility and velocity. Advance recognition and fast response enables the organization to get proper view of inventories at different levels, situation of demand and supply and purchasing as well as production schedules. Supply chain velocity can be improved by making processes streamlined, lead time reductions and eliminating non value adding processes to save time.

Following are the strategies used for achieving Agility:

a) *Utilizing Technology to Gain Visibility:* Using technology like RFID help shippers to become more risk avert by alerting stakeholders of possible disruptions. Supply chain disruptions have become more frequent in last one decade. Use of technology can be useful to provide the visibility as well as reduction in time to respond in case of disruptions. Greater visibility between the SC levels help in fast sensing a problem and fast responsiveness (Stecke and Kumar, 2006, Ji and Zhu, 2008).

b) *Responding to demand in real time**:*** It has been observed that agility in demand driven companies is more as compared to forecast driven. Technology has made organization to respond quickly as information is being captured from the point-of-sale. It requires Good supplier relationship than only real time demand can be captured. Well planned and actual information about inventory lead to make accurate delivery promises (Stecke and Kumar, 2006, Ji and Zhu, 2008, Goh et al. 2013).

c) *Collaborative Forecasting and Replenishment (CPFR):* To reduce inventory reduction and achieve efficiency in transport and logistics planning by aligning sales and planning activities keeping customer as a focal point can be easily done by utilizing collaborative approach. The more collaboration and information sharing can lead to an effective SC risk management (Schröderet al. 2014; Goh et al. 2013; Kirilmaz and Erol 2017)

d) *Training & Education of manpower:* Well-trained employees can better handle any unplanned event like natural disasters. Training brings flexibility in the employees through learning that enables manpower to do challenging and diverse types of job (Goh et al. 2013; Kirilmaz and Erol 2017).

2.4 Digitalization

A digitized SC makes data available through digital and lead to better risks visiblilty (Goh et al. 2013). Digitization, modern technologies and SCRM tools improve information certainty, increase visibility in supply chain and to act proactive or react more quickly to Supply Chain risks (Schröderet al. 2014; Fan et al. 2016; Güller et al. 2015; Fan et al. 2017; Goh et al. 2013; Niesen et al. 2016).

a) *Focus on Emerging Technologies:* New technologies are completely revamping existing business models. These technologies are very useful to mitigate disruptions in supply chain during pandemic/epidemic situations. The emerging technologies are discussed below:
b) *Internet of things (IoT)* is a remote monitoring IT system connected over internet for mutual data transfer. The touch free replenishment of supplies from point of production to directly at customer's doorstep can be achieved through IoT devices.
c) *Drones* also known as Unmanned Ariel Vehicle (UAV) can deliver packets on the ground and difficult terrain where normal deliveries are not possible. It is equipped with a user interface and remote control and critical deliveries of health supplies.
d) *Collaborative robotics* (Cobot) is different type robot without human contact. This is especially very advantageous during Pandemics. Cobots can work along with people, and even learn through the use of AI without requiring any complex programming.
e) *3-D Printing* enables manufacturers to print many any design of product. It could simplify and customize printing to a great extent. Complex supply chains can be easily simplified using 3-D printing. Driverless vehicles can revolutionize the present Logistics by providing a much better increased. This is especially helpful during lock-down situation.
f) *Supply Chain analytics and big data:* It can assist managers in understanding SC risks and improving SC transparency, flexibility and profitability with the help of data. It will improve in the operational efficiency and effectiveness at all level like strategic, operational and tactical. (Ittmann2015; Akter et al. 2016; Wang et al. 2016; Schlüter and Sprenger 2016)
g) *Simulation***:** In the context of today's supply chains, simulation is seen as "among the most promising paradigms for detailed investigations and reliable problem solving of complex real-world supply chains". Simulation helps to estimate risk with the help of creating appropriate model and recording its behavior over long run. Hence, simulation allows companies to evaluate situations of dynamic nature.

3. Research Methodology

A qualitative approach of multi-criteria decision making (MCDM) is used for data analysis. In order to identify best and worst Supply Chain strategy, best-worst method (BWM) is used to solve MCDM problems. In an MCDM problem, a number of alternatives are evaluated with respect to a number of criteria in order to select the best alternatives (Chauhan et al., 2020). According to BWM, the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important) criteria are identified first by the Supply Chain Professionals. Pairwise comparisons are then conducted between each of these two criteria (best and worst) and the other criteria.

First, the best (e.g. most important), and the worst (e.g. least desirable, least important) criteria are identified and then the best criterion is compared to the other criteria. Similarly, the other criteria are compared to the worst criterion. A non-linear minmax model is used to identify the weights such that the maximum absolute difference between the weight ratios and their corresponding comparisons is minimized. The weights of the alternatives with respect to different criteria are obtained using the same process (Rezaei, 2015, 2016). The final scores of the alternatives are derived by aggregating the weights from different sets of criteria and alternatives, based on which the best alternative is selected.

There are different techniques which can be employed to calculate weights in case of multiple criteria decision making. All the steps starting from problem definition to determination of weight are almost similar in these techniques. (Terrados et al., 2009). Criteria weights have very important role in decision making. Most conventional technique which is being employed by most of the research is AHP. To calculate the weights initial step in this techniques is to collect information using pairwise comparisons of the selected criteria. One of the complicated problem of this technique is inconsistency in capturing the opinion (Rezaei, 2015). To handle this problem of inconsistency Rezaei (2015) introduced new method known as "Best Worst Method" (BWM) which is highly effective. In this technique initially need to identify the most desirable and the least desirable criterion. Then pairwise comparisons need to be conducted between these criteria and the others and employ maximin model to compute the weights. (Mou et al., 2016). BWM reduces number of comparisons significantly compared to other methods. (Rezaei, 2015). In addition, this method also provides a structured pairwise comparison and final outcome becomes highly consistent (Rezaei, 2016). To get consistency and simplicity, BWM is most preferred and employed techniques now a day in many areas like supply chain management, healthcare management, investment opportunities, web service selection, medical tourism development, technological innovation Development, research and development, green supplier selection and urban sewage sludge, etc. (Mou et al., 2016, Ahmad et al., 2017, Ghaffari et al., 2017, Ren et al., 2017, Serrai et al., 2017, Askarifar et al., 2018, Abadi et al., 2018, Salimi and Rezaei, 2018).

Sampling Plan: A qualitative research using in-depth interview is conducted by targeting seventeen senior managers in Supply chain management from different industries namely FMCG, IT, Logistics, and Garment industry having 15 years or more experience. Five of them agreed for the interview for the three round of interviews to avoid any bias and anomaly

in their responses. Since, BWM is an expert based method; therefore, we concluded our findings based on the responses of five respondents which were received through the mentioned procedure.
Figure 1 shows the flow of this study.

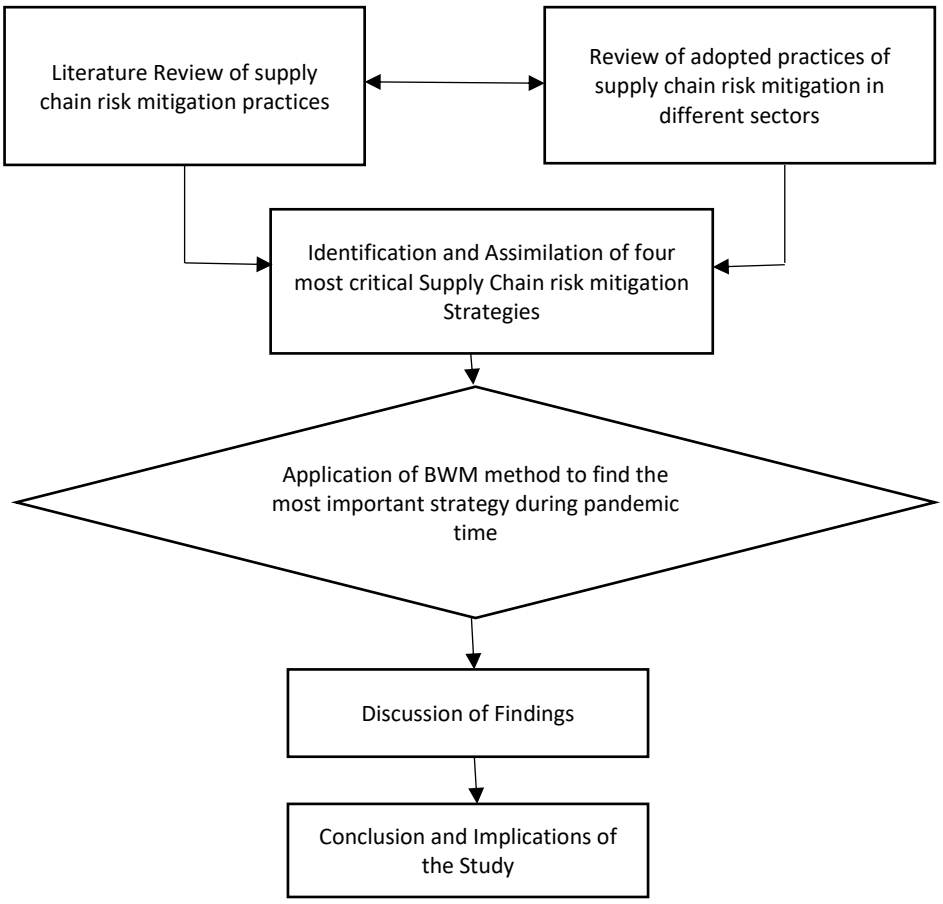

Figure 1. Flow of the Study

Best Worst Method (BWM)
In BWM technique (Rezaei, 2015, 2016), firstly, the identification of criteria is done and then the evaluation of the criteria is carried out with the help of domain experts. Review of literature reveals the successful application of this method in different areas (Rezaei et al., 2015, 2016; Wan Ahmad et al., 2017; Sahebi et al., 2017; Ahmadi et al., 2017; Vahidi et al., 2018: van de Kaa et al., 2017, 2018; Ren, 2018; Salimi, 2017; Salimi and Rezaei, 2016, 2018).
In best worst methods once criterions are finalized, there is selection of the best (e.g. the most important) and the worst (e.g. the least important) criteria by expert. Further to this, we need to get preference ranking for the best criteria over other criterions $(a_{B1}, a_{B2}, \ldots\ldots a_{Bn})$ on a scale of 1 to 9. Similarly ranking of other criterions over one worst criteria $(a_{w1}, a_{w2}, \ldots\ldots a_{wn})^T$, using a scale of 1to 9 need to be conducted. To calculate the optimal weights $(w_1^*, w_2^*, \ldots\ldots w_n^*)$ where maximum absolute differences $\left|w_B - a_{Bw_j}\right|$ and $\left|w_j - a_{jw} w_w\right|$ for all j are minimized. Optimal weights are then calculated by solving following linear programming model;

$$Min \xi^L$$

$$\left|w_B - a_{Bw_j}\right| \le \xi^L \ for all\ j$$

$$\left|w_j - a_{jw} w_w\right| \le \xi^L \ for all\ j$$

$$where, \sum_j w_{j=1}\ ,\ w_j \ge 0,\ for all\ j,\ \xi^L\ is an\ indicator of\ consistency$$

Consistency value close to zero is considered to be a high level of consistency

Table: 2 Category wise lists of Indicators used in supply chain risk mitigation strategies

Main Criteria	**Sub Criteria**
Resilience	Stocking of essential commodities at strategic locations
	Transportation Flexibility
	Activate alternate sources of supply
	Mapping entire Supply Chain
	Cultural change
	Adapting Standard and Concurrent production process
	Postponement
Outsourcing and Offshoring	Focus on cost cutting
	Risk-sharing strategy
	Focus on Swiftness and Expertise
Agility	**Utilizing Technology to Gain Visibility**
	Responding to demand in real time
	Collaborative Forecasting and Replenishment (CPFR)
	Training & Education of manpower
Digitalization	Focus on Emerging Technologies
	Supply Chain analytics, big data and predictive analytics
	Simulation

3.1 Case Application

This section discusses the application of proposed methodology to calculate the weights of criterion. For this purpose, panel consensus method is used for getting information from the experts. A panel of five experts is formed to conduct the study. All the experts are chosen after critical evaluation of their work experience in Supply Chain and Logistics industry. Discussion started with identification indicators for new framework based on extensive literature review.

After detail discussion to finalize the indicators all the panelists were asked to rate the criterion by building a common consensus and using suitable scales as mentioned in Table 2.

Table 3. Linguistic scale for best worst methodology

Scale for best worst methodology	Equally Important	1
	Equal to moderately more important	2
	Moderately more important	3
	Moderately to strongly more important	4
	Strongly more important	5
	Strongly to very strongly more important	6
	Very strongly more important	7
	Very strongly to extremely more important	8
	Extremely more important	9

Source for 9-point scale (Rezaei et al., 2014).

4. Results and Discussion

Best worst method is used for calculation of criterion weights. Among all criterion, best and worst criterion are selected by panelists through mutual consensus. Preference of best criterion over all other criterion is determined on a scale of 1-9 and similarly for others with worst criteria.

Table 4. Weights calculation using best worst methodology

Main Criteria	Weight of Main Criteria	Sub Criteria	Weights of Sub Criteria	Global Weights
Resilience	0.142	Stocking of essential commodities at strategic locations	0.371	0.052
	0.142	Transportation Flexibility	0.221	0.031
	0.142	Activate alternate sources of supply	0.147	0.021
	0.142	Mapping entire Supply Chain	0.110	0.016
	0.142	Cultural change	0.063	0.009
	0.142	Adapting Standard and Concurrent production process	0.055	0.008
	0.142	Postponement	0.033	0.005
Outsourcing and Offshoring	0.054	Focus on cost cutting	0.083	0.004
	0.054	Risk-sharing strategy	0.179	0.010
	0.054	Focus on Swiftness and Expertise	0.738	0.040
Agility	0.236	Utilizing Technology to Gain Visibility	0.511	0.121
	0.236	Responding to demand in real time	0.283	0.067
	0.236	Collaborative Forecasting and Replenishment	0.141	0.033
	0.236	Training & Education of manpower	0.065	0.015
Digitalization	0.569	Focus on Emerging Technologies:	0.644	0.366
	0.569	Supply Chain analytics, big data and predictive analytics	0.244	0.139
	0.569	Simulation	0.111	0.063

From Table 4, weights and rankings of all criterions of supply chain risk mitigation strategies are obtained. As decided by all panelist weights of main criterion and sub-criterion are obtained through best worst analysis and ranking of sub criterion is obtained on the basis of global weights obtained by multiplying the main criterion weight with sub criterion weight. Amongst all main criterions, Digitalization has emerged as most important strategy followed by Agility, Resilience and Outsourcing/offshoring. Further, more detail revealed that Digitalization in terms of Focus on Emerging Technologies need to be considered at priority during Pandemic/Epidemic conditions. Then we need to take advantage of Supply Chain Analytics, Big Data and Predictive Analytics followed by Responding to Demand in Real Time. Combination of other strategies can also be seen as per the priority mentioned in above table. Results obtained in this work have revealed the importance of incorporation of different criterion to understand the overall supply chain risk mitigation strategies in Pandemic and Epidemic conditions.

5. Conclusion

Supply chain disruptions have a huge impact on overall business. Break in flow of products and services have a devastating impact on the performance of businesses. If well-defined strategies are not planned to meet such disruptions, recovery becomes very slow and touch. Event major giants like Philips went out of market completely. Hence Risk Management has become very important field for any business to survive in long run as disruptions have become very frequent these days. Organizations need to invest good time and resources to formulate appropriate strategy to face such disruptions arising to due pandemics. Recent pandemic due to corona virus forced to realize the world recognize that we have a huge dependency on human interactions for most types of business operations. Businesses that are labor intensive, such as manufacturing, retailing, warehousing and logistics are the worst affected. COVID-19 has strongly pushed to rollout the utilization of robots and other emerging technologies. Organizations have to focus on the adoption of emerging technologies in the scenario where minimal touch or no-touch has become new norm of the business. The emergence of industry 4.0 has become very crucial in such adverse situations. Use of latest technologies in business operations and supply chain management has become paramount important. Internet-of-Things (“IoT”), Big Data and block-chain could

play key role to mitigate SC failures or disruptions. Establishing a more resilient supply chain management system for the future is very much possible by means of the use of such technologies. (Yin S, Kaynak O, 2015).

Internet of things (IoT), drones, driverless vehicles, 3-D printings is some of the emerging technologies that industry can effectively use to achieve no-touch requirements and thus mitigate risk in Supply Chain disruptions. So as per out study Digitalization of Supply Chains emerges out as a key strategy followed by Agility and Resilience. The focus is least on Outsourcing and offshoring. This is perhaps understandable since responsiveness becomes more important than achieving cost efficiency in Pandemics. To deal with disruption, another strategy is to have a clear idea of inventories of all kinds and at each level of supply chain (Bhattacharya, S.,2020). Companies need flexible manufacturing capabilities and capacities for ensuring sufficient supplier with their suppliers. Manufacturing firms with flexible supply chains contracts with their suppliers can be more successful in managing their level of inventories more effectively. Company's product design also requires more modularity so that last minute customization could be achieved. This could also help to bring down inventory significantly. Ability to incorporate latest Emerging Technologies could be a huge advantage during Pandemic/Epidemic conditions. Use of Supply Chain and Big Data analytics, Predictive Analytics for estimating demands in real time could be very precise and great help to management in the planning process. Some Emerging technologies harness the power of Robotic Process Automation (RPA) and Artificial Intelligence (AI) to streamline business processes. It has the potential to increase operational efficiency and productivity, strengthen relationships with suppliers and improve customer experience.

5.1 Limitations and future research directions

This paper focuses in revealing the best risk mitigation strategy for a supply chain of any sector without being specific to a product type under a pandemic scenario. Since, the study is conducted based on experts of various sectors; therefore, the findings are meaningful for general referencing in a pandemic situation. For making specific recommendations, the study shall be conducted with the help of experts from a particular sector so that industry/product specific attributes can be effectively taken into consideration. In future, researchers can conduct empirical study based on the data available with supply chain firms on their implementation of suggested strategies.

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