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***SUPPLY CHAIN DISRUPTION &
PLAUSIBLE SOLUTION IN THE
SCENARIO OF COVID-19 PANDEMIC***
“Forging a Pandemic Adaptive Supply Chain”

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ABSTRACT

Barshan Sen Gupta: Supply Chain Disruption & Plausible Solution in the Scenario of COVID-19 Pandemic

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While there is no way to forecast when the vaccination program for the COVID-19 pandemic will initiate, almost every organization has been trying to redesign its process and structure to live coherently with the new unique situation. However, due to the very structure of its globally spread supply chain and its deeply spread web of suppliers, this process is not well explored. Although some companies were prepared better than others, the confidence in global supply chain operation came under vigorous questions when its true agility and resilience were analyzed. To that end, the core concept of this research has been to analyze the different dimensions of supply chain disruption initiated by the COVID-19 pandemic, for developing a guideline for rebuilding it in a more pandemic proof manner.

First, through a comparative analysis, the extreme risks related to the pandemic and similar events are discussed from the theoretical viewpoint. Then, through a detailed analysis of the available resources on the topic matter, seventeen different suggestions from distinguished supply chain experts were identified. Following this, five different strategies were also crafted from these seventeen action plans and a Delphi study consisting of twenty-five supply chain experts as participants asserted strong support for them. The reliability and the authenticity of these suggestions are beyond doubt as they are either famous experts or practitioners on the topic matter. Furthermore, a suggestion like utilizing the Kraljic matrix for defining the extent of supplier relationship management has also come to vicinity through this Delphi research.

Analysis of the published reports brought out the fact that nobody was prepared for such a global disruption. Having said that, the very ideations of efficient and cost-effective supply chain construction principles have been identified as guilty. Overconfidence in existing operations and too much focus on cost-efficient activities has made supply chains susceptible to external risks. Furthermore, in most cases as the true overall visibility of a supply chain was absent, short cited supply chain risk management schemes were in place. All these coupled with the randomness of different national policies and lack of coordination among government and private sectors have resulted in the global supply chain disruption. At the same time panic buying and the sudden spike in demand developed inventory stockouts and raised the question of relying too much on popular supply chain management policies like lean management and just in time inventory management.

The executed research opened some new windows for future research, one of them is to analyze the interrelation among the seventeen action plans and up to what extent they are synergic or divergent. Although it is in the hand of the supply chain managers that how they want to implement the suggested strategies or what will be their sequence; the effectiveness of every one of them has been justified through the study. Successful management of disruptive scenarios requires both proactive alertness and reactive measures so organizations should start rebuilding their supply chain as soon as possible.

Keywords: Coronavirus, COVID-19, Pandemic, Supply Chain, Supply Chain Disruption, Delphi Study, Supply Chain Risk Management, Supplier, Sourcing

The originality of this thesis has been checked using the Turnitin Originality Check service.

PREFACE

This thesis has been written as a requisite for completing the master's degree programme in Industrial Engineering and Management. This journey of achieving my dream would not be possible without the inspiration and support of some wonderful persons. I would like to express my gratitude from the bottom of my heart.

I am grateful to my parents for always making me believe that hard work along with self-confidence can make one achieve greatness. I love you Maa and Baba.

The invaluable support and guidance of my two highly respective supervisors, Asst. Prof. Mohammad Moshtari and Prof. Jussi Heikkilä have stimulated this research throughout the journey. The learning process would not be that much comfortable without their cordial supervision.

Finally, I would like to express my adoration and indebtedness to my beloved wife Indrani Nag, for inspiring me throughout the whole research process.

Tampere, 09 October 2020

Barshan Sen Gupta

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LIST OF SYMBOLS AND ABBREVIATIONS

AI	Artificial Intelligence
BOM	Bill of Materials
COVID-19	Coronavirus Disease 2019 (WHO, 2020a)
EOC	Emergency Operation Centre
IS	Identified Suggestion
JIT	Just in Time
SC	Supply Chain
SCD	Supply Chain Disruption
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
SRM	Supplier Relationship Management

1. INTRODUCTION

The year 2020 has simulated a unique scenario for the whole world as it has been passing through an unprecedented global pandemic. The extent of this Coronavirus disease 2019 (COVID-19) pandemic on human health is yet to be understood fully but surprisingly no cure has been confirmed yet. Furthermore, this pandemic has inflicted serious havoc on businesses around the world and its widespread global supply chain (SC). Business experts have been vigorously investigating the dimension of economic losses but yet to realize completely what has been done wrong or what could be done better.

To that end, this research investigated the extent of supply chain disruption (SCD) due to the COVID-19 pandemic and scopes of rebuilding it in light of different expert opinions. A detailed analysis of the significance of SC risks incurred by low probability, high impact events like pandemic has also been done through available theoretical resources. This research is directed towards the completion of the Master of Science thesis in developing a pandemic adaptive SC. The target of the study is to finalize a well-founded guideline for the supply chain managers so that they can rebuild their pandemic scourged SC in such a manner that holds promises of endurance towards a similar scenario in the future.

In this chapter, a brief discussion on the motivation behind this study along with the research objectives and questions has been presented. The last part of this chapter will explain how the whole thesis has been constructed so that readers can have a clear understanding of its contents. A very decent number of magazine articles, interviews, blogs, webinars, reports, and journal articles have been scrutinized to define a set of strategies consisting of several action plans so that SC practitioners can immediately start their work on tweaking their SC construction. The study also has been strengthened by the Delphi research consisting of twenty-five SC experts from highly renowned institutions.

1.1. Background and Motivation

COVID-19 pandemic outbreak has dramatically changed the overall picture of our modern world. Every possible institution was either forced to shut down or minimize operation for limiting virus spreading. Furthermore, restrictions on movement and any type of gathering pushed almost every type of transportation medium into a halt. In no

such way, the decisiveness of this pandemic outbreak and its adverse effects could be predicted. The total amount of financial and economic losses is yet to be figured out as the pandemic is far from over. Among all of these, the issue of preparedness of the modern SC and excessive focus towards maintaining its high efficiency came into vicinity.

According to the Deloitte Survey (2014), almost 79% of companies achieving a higher revenue possess a high performing SC (O'Byrne, 2019). However, according to the Institute for Supply Management (2020), around 75% of companies reported their SCD due to worldwide transportation restriction and border lockdown. Furthermore, those strengths which always have been considered as the backbone of an efficient supply chain such as "Just-in-time (JIT)" and "Inventory in Transit" have become an issue of weakness (Rodrigue, 2020). It also needs to be understood that a balanced and efficient supply chain acts as a source of competitive advantage for an organization and it also cannot be developed overnight. Hence, organizations operating globally need to think beyond generic lean and green supply chain management (SCM) paradigm for evolving their SC into a more resilient and agile one, adaptive towards tackling a global pandemic outbreak.

Even before the COVID-19 pandemic outbreak different disruptive innovation, ever-growing worldwide economic interdependence and different geopolitical tensions were threatening the global business as well as their widely spread SC. Additionally, it was beyond anybody's wildest imagination that how badly a global pandemic can hit us. Most of the corporate giants were focused more on revenue generation rather than focusing on long term value creation (Scoblic, 2020). The COVID-19 pandemic outbreak has initiated different high-profile bankruptcies, cancellation of big financial deals, and drastic cost-cutting strategies in companies like Brooks Brothers, JCPenney, Ford, GM, Hertz (Caniato et al., 2020). Additionally, businesses all around the globe are also facing a terrible crisis as their suppliers are feeling the first wave of the financial crisis and getting out of business (Caniato et al., 2020). Hence, it is the high time that we look back on the construction of modern SC and rethink its stressful nodes.

According to Keskinocak (2020), because of the worldwide shutdown, tightened travel restriction, increased number of absenteeism from work and panic purchases the ongoing SCD was well expected. Furthermore, as the second wave of the pandemic outbreak has already started, SC practitioners need to act as swiftly as possible. Thoughtful investment in SC right now is not only crucial for ensuring proper distribution of essential products but also for maintaining the effective function of society (Keskinocak, 2020). Considering all these facts the author decided to proceed with

exploring different published journals, magazine articles, news, webinars, and reports for understanding the magnitude of supply chain disruption. During this phase of the research when the suggestions from different supply chain practitioners and experts came to the vicinity, it generated the motivation for researching an ideal structure for the pandemic adaptive SC.

1.2. Research Objectives and Questions

If one looks back at the past, it is visible that pandemics have hit the world several times and in every case distress of human life along with disruption of any regular activity is common. With COVID-19 the situation is knottier because the advancement in modern medical science has kept everyone blindsided from the fear of a pandemic. Moreover, the intertwined global business along with its deeply rooted SC was not at all ready for such a shock of this magnitude. However, an initial inspection of the available resources from different scientific journals depository suggested that the number of scientific researches executed on pandemic-related SCD is surprisingly rare. Furthermore, the rareness of such an event also has not motivated the practitioners and experts for detailed research on the said topic matter. Then again, modern global business is ever-evolving, and drawing a comparative picture considering available historical information would be very irrational. To that end, the objective of this study has been decided...

...to analyze the disruptive effect of COVID-19 pandemic on the global supply chain and identify plausible solutions.

The specified objective of this study has also introduced two very definite research questions (RQs), these are

RQ1. How global SC has been disrupted due to the COVID-19 pandemic?

RQ2. What would be the ideal structure of a supply chain considering preparedness for similar events in the future?

It can be easily understood that answers of RQ1 and RQ2 have the potential to fulfill the stated research objective. However, without understanding the breadth of SCD developed from the COVID-19 outbreak, a suitable restructuring guideline cannot be developed. Hence, these two research questions have been answered briefly in chapter 4.1 and 4.2 consecutively. Chapter 2 will discuss the whole research methodology and Chapter 3 discusses the intensity of SCD on the theoretical ground. To improve the understanding of the structure of the research, the next chapter will be discussing the structure of the thesis.

1.3. Thesis Structure

The structure of the thesis has been explained through the following Figure 1

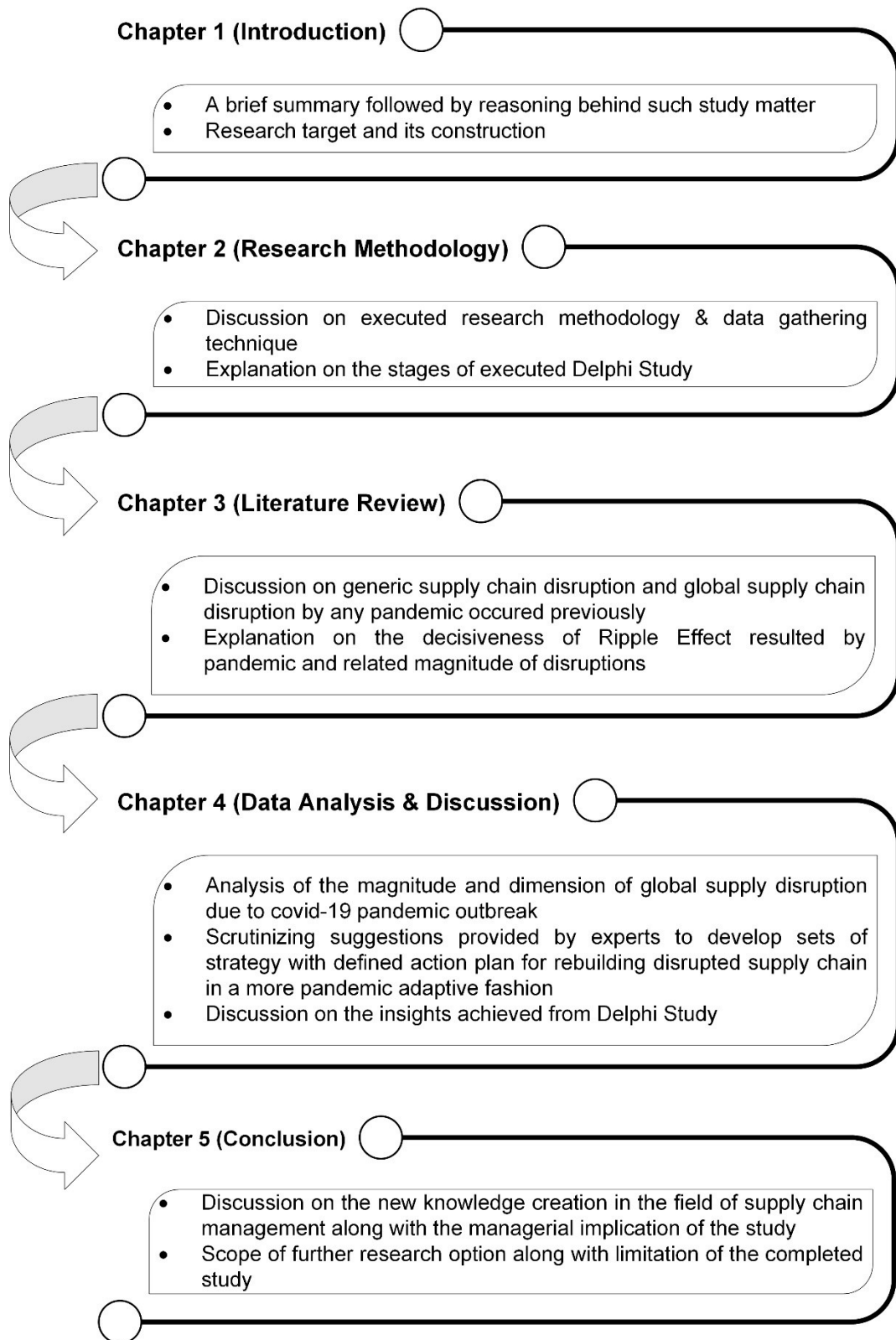


Figure 1. Structure of the thesis

Figure 1 is self-explanatory, and it can be easily understood how the thesis has been constructed. The content of every chapter has been discussed briefly in Figure 1. Other parts of this thesis are its References and Appendix. Appendix B, with finalized sets of strategies along with defined action, represents the total result of the thesis through a well-structured table. These action plans have been acknowledged as “Identified Suggestion (IS)”, as they are the direct suggestions from the Delphi research participating SC experts. Having said that, a summarized picture of the suggestions given by these SC experts are provided through the Appendix A. Credibility of the Delphi research participants has been proved through Appendix C as it contains a list of Delphi researchers along with the link of their white papers on the topic matter.

2. RESEARCH METHODOLOGY

This chapter will be shedding light on the details that how the total research has been executed along with the theoretical arguments behind the taken approaches. Furthermore, there will also be a discussion on data gathering techniques, data processing stages, and the planned timeline for it.

2.1. Research Method

Research by its very nature regardless of the discipline is very complex because the interpretation of results and understanding the impacts are its core objectives (Adler and Ziglio, 1996; Gustafson et al., 1975). According to Delbecq et al. (1975), research is a systematic approach to discover something new or to confirm or refute prior assumptions and this is done by asking significant questions whose conclusive answers were not previously available. The process of proper research also includes collecting and interpreting data from these inquiries (Delbecq et al., 1975; Gustafson et al., 1975). Hence, it can be assumed that the significance of any research is very much dependent on the inquiry along with the observation of the researcher.

In many cases when the research topic lacks sources of proper information from previous scientific ventures, the Delphi method is considered to be a well-suited research instrument for exploring opportunities through soliciting expert opinion (Czinkota and Ronkainen, 1997; Halal et al., 1998; Skulmoski and Hartman, 2010). Furthermore, the Delphi method can also be used as a powerful tool even when the identified problem or phenomena is a novel one, having incomplete knowledge and understanding (Linstone and Turoff, 1975). The said method can also be utilized as a decision making and forecasting tool for program planning and strategic decision making (Krantz and Reips, 2017). In a nutshell, the Delphi method is an influential research tool for understanding and analyzing unknown phenomena, their effects and probable solutions (Tranfield et al., 2003).

To that end, considering the research topic a very novel one, it has been assumed that the research would be executed through the Delphi method and also could be benefitted from the intuitive personal view of individuals on a collective basis (Queiroz et al., 2020). Following this, a three-phase research methodology was accepted for the whole research. The research methodology has been explained through the following Figure 2.

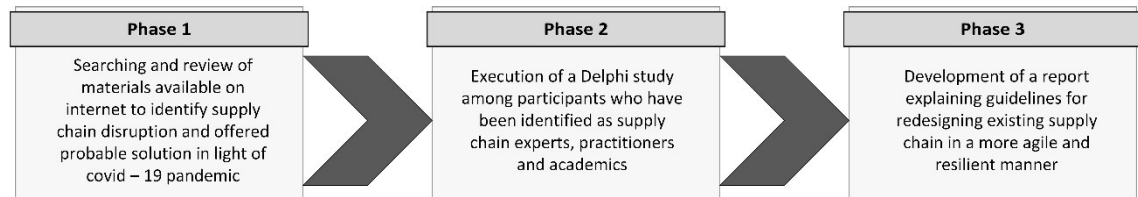


Figure 2. Research methodology

Phase 1 of the research can be considered as one of the most critical parts as it was associated with the identification of acceptable documents related to SCD and offered solutions by different SC experts and practitioners. Specific keywords and searching protocols were maintained throughout the information surfing to ensure credibility. The data gathering method has been explained in the following subchapter in detail. Phase 2 consists of the Delphi method-based research execution processes. During the selection of participants for the Delphi study, it was always kept in mind to select experts from the supply chain management (SCM) and design paradigms, such as academics, professionals, and other experts. Phase 3 is all about developing a report based on the outcomes of the Delphi study. The core ideology behind developing the report was to ensure that it could be turned in to actionable approach by any organization so that future similar struggles can be overcome. Details of the reports have been explained at the very end of the thesis.

The research process was initiated in May 2020 when the COVID-19 pandemic was creating havoc worldwide and has been raised from the level of the epidemic to a pandemic. The author's interest was developed due to the immense agitation created through this turmoil period. Furthermore, upon initial exploration, it also became evident that the number of researches done on this topic is scarce due to its novelty factor. Then again, different prevailing articles, webinars, reports, and news on the internet fuelled the thought on the creation of proper actionable guidelines to make SC more adaptable to similar pandemic scenarios in the future. The timeline of the research along with the research phase is explained in Figure 3 below.

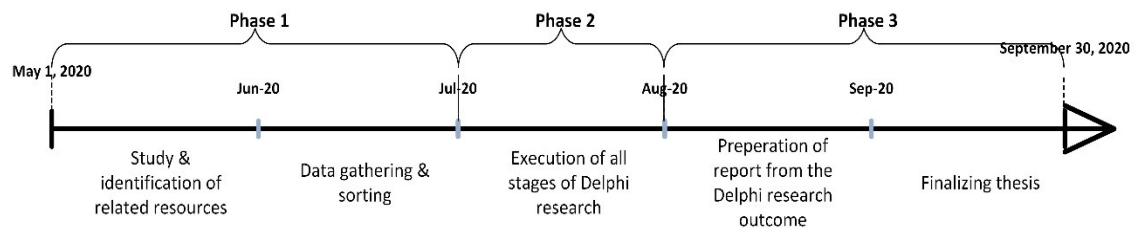


Figure 3. Research timeline

In early May 2020, with very generic ideation of COVID-19 pandemic related SCD, the research initiated. However, it was evident from the very start of the research that very little number of academic researches have been published on this subject matter. Hence, an internet-based systematic review of materials related to this research topic has been executed. Protocols and other details related to the analysis of research material has been explained in the next sub-chapter. Documentation developed from the Delphi research has been extensively analyzed to sketch a final report which will also be discussed in-depth in the upcoming chapters. Finally, an executable guideline for reconfiguring the pandemic scourged SC in a pandemic adaptive, agile, and resilient manner has been proposed by the end of September 2020.

2.2. Data Gathering Techniques

The availability and easy interface of the internet have pushed the boundary of its usage in many different sectors. Although there have been many debates regarding the reliability and validity of the web yielded researches, but none could deny the fact that it could ease complications related to a limitation of laboratory facility (Hasson et al., 2000; Linstone and Turoff, 1975). Furthermore, we also must consider the fact that the research topic and condition are so novel that the scarcity of published journals on this is very high. To that end, during the very beginning stage of the research, it was decided that internet-based materials such as different articles from online newspapers, blogs, interviews, transcripts of the webinar, conference, statistical data, etc. will be used as research materials.

Covid-19 pandemic has created worldwide chaos and panic. Due to its high contingency nature, the world came to halt and almost all types of physical interactions are suspended until the invention and circulation of proper medication and treatment arrive. The SC paradigm is one of the most affected fields due to this outbreak. Hundreds and thousands of news and other types of information-based materials are being published every day on different websites. Misinformation and confusion have clouded the judgment of simple citizens all around the globe. Hence, a suitable research protocol needed to be developed with a clear definition of scope, subject, and nature of discipline (McPherson et al., 2018).

During the designing of the research protocol, the collection of valid data was given the most priority. The Source of the information has always been verified and it has been ensured throughout the study that used pieces of information are always from experts or practitioners in the associated field. However, the duration of the range of publication due to the novelty of the scenario was very low, and it impacted the number of identified

sources also. The summary of the research protocol is explained through the following Table 1.

Table 1. *Research protocol (adopted from Cantrill et al., 1996)*

RESEARCH PROTOCOL	DETAIL DESCRIPTION
Research Database	Boston Consulting Group, Harvard Business Review, Fisher College of Business (Ohio State University), UCLA (Anderson School of Management), McKinsey & Company, Supply chain management review, Supply chain 24/7, Supply chain trend, Supply chain shaman, Supply chain insights, Kinaxis, Supply chain movement, SCMDOJO, Supply chain brain, Supply chain digital, YouTube and Google
Publication Type	Different articles and news from online newspapers, blogs, interviews, transcripts of webinar, conference, statistical data, etc. which has been developed by researchers or practitioners of supply chain based on information provided by experts on the said field
Language	English
Date Range	1 st February 2020 to 30 th June 2020
Search Field	Titles, Keywords
Search Terms	Several combinations of terminologies like Coronavirus, COVID, COVID-19, Pandemic, Supply Chain, Disruption, Design, Future, Supplier, Sourcing, Opportunity
Inclusion Criteria	Articles discussing supply chain disruption and possible
Exclusion Criteria	Articles having no valid sources on their claims or suggestion and not developed by the related field of experts
Data Extraction	Information related to a different type of supply chain disruption and suggestions for overcoming those
Data analysis & synthesis	Experience and knowledge of the author

The initiation phase of the research can be considered as a critical one because of the presence of hundreds of news articles on the internet regardless of the specified searching terms. A handful but quality data was gathered considering the strict following of inclusion criteria and exclusion criteria. However, the analysis and synthesis part of the whole data gathering technique was established on the author's understanding and reasoning capacity on the subject matter. In most of the cases, the clarity of the published articles was very decent, and the simplicity of language helped to speed up the process.

After completion of the initial data gathering part, a pretty good number of proposals on rebuilding the pandemic disrupted SC were pinpointed and they have been termed as “Identified Suggestion (IS)”. The high number of ISs represented an opportunity to develop a set of different strategies from them. Moreover, it was much visible that many of the ISs are closely related and could be considered together under a singular strategy. To that end, all the ISs were processed for a final time to create a set of strategies consisting of the ISs. This process improved the clarity of suggestions from supply chain experts. The complete data processing system is explained in Figure 4 below.

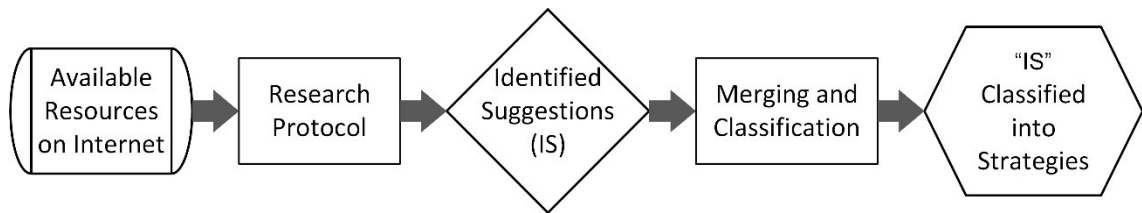


Figure 4. Data processing stages

It can be understood easily from the figure above that how the available resources on the internet are processed through the research protocol and different ISs are determined. The ISs were then processed through the “Merging and classification” stage where several ISs are merged into a more refined set of ISs. During this merging and classification stage, interrelation and similarity among the ISs were kept into consideration. Such grouping of ISs made it easier to define a strategy and accommodate them in it. Finally, these seventeen ISs were classified into five different strategies which increase the overall clarity of the suggestions from experts. The detailed discussions on the ISs are presented in sub-chapter 4.2.

These finalized strategies consisting of all the ISs are then circulated among the Delphi researchers through a structured table-based report (Appendix B) along with a forward letter (Appendix D). The main reason behind the Delphi study was to refine the set of strategies and suggestions incorporated among them. Different stages of the Delphi study along with its outcome are discussed in the following sub-chapter.

2.3. Delphi Method

For producing an effective and meaningful decision through a consensus methodology, where the probability of contradiction is high and the level of availability of information is low, the Delphi research technique comes very usefully (Linstone and Turoff, 1975). The

Delphi method was developed by Dalkey and Helmer in 1963 and in most of the cases its early utilization was related to answering strategic military questions but with time it evolved and started to be utilized in understanding social, economic, and technological researches (Galliers et al., 1994; Gottschalk, 2000; Olsen et al., 1998). According to Golan et al. (2020), Delphi methodology can draw a compelling conclusion through increased creativity among totally isolated individuals. Hence, it has been decided to introduce Delphi methodology for justifying the “ISs” and “strategies”, and developing a refined set of strategies and action plans for rebuilding the COVID-19 disrupted SC.

According to Gurnani et al. (2012), Delphi methodology is suitable for certain scenarios, where,

- Current and historical data is absent due to the rarity of such an event
- Evaluation and exploration of planning options or even the structure of a model is needed
- Identifying the pros and cons of some ideation is required
- Low scope of precise analytical evaluation
- In need of a group communication method

From the above-stated points, the application of the Delphi method for this research is very justifiable. However, it has been also decided to select only those experts as participants whose suggestions have been considered mainly to create the list of ISs. The credibility of the Delphi research participants has already been ensured in the data collection stage as they are experts on the field of supply chain management and either an academic or practitioner in the said field. Furthermore, the credibility of the Delphi research participants can also be proved from Appendix C where a brief description of their career along with the web links of materials from where the ISs have been pinpointed has also been provided. Appendix A presents a very simplified picture of what has been suggested by which experts (who are also the Delphi research participants).

However, due to the ongoing restriction on social distancing and convenience of communication, it was decided that the Delphi study will be carried through email. A sample of the email used for communicating with the Delphi researchers has been provided in Appendix D. It can be understood from the sample email that it consists of a cover letter and a table made from the ISs and strategies. As the credibility of the Delphi research participants has already been ensured in the data collection stage, the main purpose of the Delphi study was to clarify and validate the author’s standpoint on the subject of rebuilding SC in a more pandemic adaptive manner. Hence, the email was

written in such a way that it reflects the author's request for feedback on the subject matter.

Finally, the stages of each round of the Delphi study were developed according to Figure 5. It was expected that through this Delphi study a more refined set of strategies and ISs could be developed. Additionally, a specific time limit and clause for repeating the Delphi study round were also imposed for the whole Delphi research as there was a specific deadline for the author to finish the research.

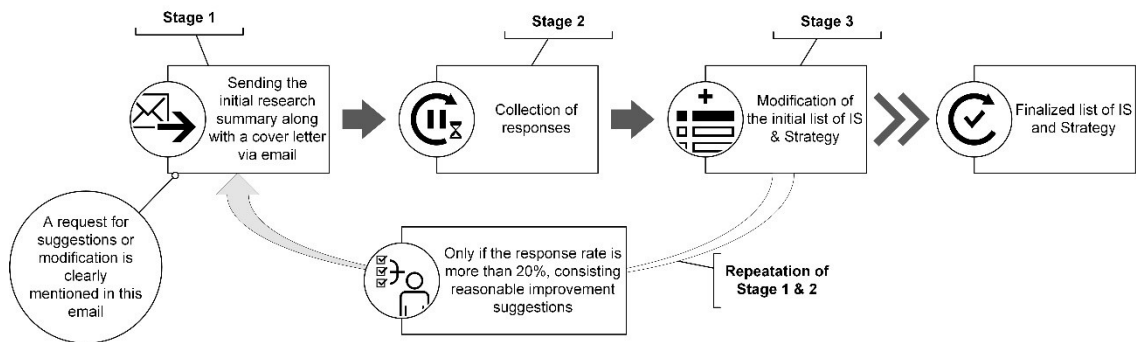


Figure 5. Stages of Delphi study round

Considering all the circumstances it has been decided that each of the Delphi study rounds will be carried through three separate stages and with the fulfillment of certain clauses and requirements the whole process could be repeated multiple times. The response rate of the Delphi participants has been considered as the main clause for repeating the whole process. However, it has been decided that the quality of the feedback from the Delphi researcher also needs to be evaluated for deciding the repetition of the Delphi process. Appendix C represents the list of Delphi researchers and the weblinks of their online materials from where the whole research ideation came to life. The credibility of selected Delphi researchers can also be proved from their detail description as all of them are either an expert or practitioners in said topic. Three stages of the study are explained in the following paragraphs.

Stage 1 of Delphi Study

The whole research process kicked off after careful study and analysis of the contents found in Appendix C and hence the table of Appendix B was developed. The first stage of the Delphi research consists of the distribution of the table in Appendix B along with a cover letter (Appendix D) explaining the scope of Delphi researchers and the core target of the said research. Considering the ongoing circumstances email communication

method has been selected as an ideal medium. The forward letter requested suggestions and modifications of the ISs and strategies and it was also explained through the letter that if the study has overlooked any suggestions and ideas, the Delphi research participants are welcomed to add those in their response. The emails were sent to the Delphi research participants during the second week of July 2020.

Stage 2 of Delphi Study

The second stage of the Delphi study consists of the collection of responses and their analysis. After dispatching the emails, the author has to wait a couple of weeks for the responses. Due to the summer vacations and ongoing turbulence caused by the COVID-19 pandemic a decent amount of time was considered. However, from the selected twenty-five Delphi research participants only seven responded within the first two weeks, which is around a twenty-eight percent response rate. As the number of responses did not increase even upon waiting for around a month, the author decided to proceed with the received ones. As it has been already ensured in stage 1 of this research that all of the twenty-five emails have been delivered to the participants' active email addresses, the author also assumed no failure in the delivery process. Although the response rate suggested a second round of Delphi research, the quality and content of the feedback also needed to be evaluated to understand the very requirement of the second stage or not.

Stage 3 of Delphi Study

Analysis of the responses from the Delphi researchers is done throughout this stage of the research. Surprisingly, all of the responding Delphi researchers have acknowledged the fact that there is nothing new to be added and they couldn't come up with new suggestions regarding rebuilding the SC in the post-pandemic scenario for a more pandemic adaptive SC. However, suggestions on reading different journals, articles, white papers, interviews, reports, and web links were provided by the respondents. The result of the Delphi study has been discussed thoroughly in chapter 4.4. Summary of all the received responses suggested that the list of ISs and drafted strategies from them would be a decent kick-off point for restructuring global SC. Hence, at the end of stage 3 of the research process, it was decided that there is no need to repeat the process as the content of responses suggested no major change or improvement from the supplied research summary.

Delphi methodology normally consists of two or more rounds, but in many cases considering the response rate and response quality even a single round of the Delphi method can be executed (Gurnani et al., 2012). Hence, after careful analysis of the

received feedbacks and suggested readings, it was very clear that the second round of Delphi would not bring that much of a meaning. To that end, the workload and scope of the last stage of the whole research, which is “Finalization of the ISs and Strategy” was very limited and the author decided to bring no change. Thus, Appendix B can also be considered as the final result of the whole Delphi research. Nonetheless, theoretical justification and support behind the data analysis process have been discussed throughout the following chapters 3 and 4.

3. LITERATURE REVIEW

This chapter will be shedding light on the global SCD and how it can affect business worldwide. The chapter will also be discussing the ripple effect for justifying the disruptive effect of a pandemic on supply chain structure and operation.

3.1. Supply Chain Disruption

According to Snyder et al. (2016), SCD is developed from accidental and unforeseen triggering events somewhere in the upstream sourcing network, downstream supply network, or even in logistics. Thus, SCD hampers the regular flow of the SC operation. On the other hand, Moritz (2020), quoted the SCD definition in terms of demand-supply mismatch and explained that generic SCD occurs only when a firm's SC is not robust and reliable. However, most of the businesses do not have a clear picture of the magnitude of the negative consequences of SCD on financial performance (Hendricks and Singhal, 2005).

According to Bode and Wagner (2015), SCD can also be coined as a scenario where a supplier or any other part of the whole SC stops functioning for a certain amount of time due to a specific reason. The reasons could be supply uncertainty, yield uncertainty, capacity uncertainty, or lead time uncertainty. However, Clay et al. (2018) and Veselovská (2020), explained that due to a strong interconnecting nature it is almost difficult to draw boundaries among these uncertainties. For instance, consider a scenario where a supply uncertainty raised from a yield uncertainty due to facility shut down, the connection among them can be understood up to some extent.

According to Hardy (2006) and Veselovská (2020), the risk of SCD is higher than ever nowadays and the reasons are explained here,

1. Increased Complexity

SC is a complex network of different sized business entities, fulfilling requirements among them through the flow of resources, products, services, knowledge, finance in both upstream and downstream (Lambert et al., 1998). In recent times, the ever-increasing number of SC nodes is the result of a global sourcing strategy. Every company is targeting cheap labor and resources and the scenario is the same for suppliers' suppliers. The web of SC is scattered and widely dispersed. Hence, coordinating across several tiers of suppliers and managing lead times at every node can be troublesome. Although many are working on self-optimization, the risks are

getting compounded as meaningful coordination among suppliers and buyers are still missing in many businesses.

2. Outsourcing and Partnership

According to Shih (2020), it is now almost impossible to find a completely vertically-integrated manufacturer due to the requirement of technical specialization. As a result outsourcing and partnership have become very normal in any generic SC. However, the lack of flexibility has turned many sourcing processes very rigid which in turn developed extreme dependencies on certain nodes. Hence, propagation of disruption in one node ripples throughout the whole network and halts the material movement, creating havoc. The true benefit of outsourcing can only be achieved through meaningful and innovation-based cooperation and information sharing. However, lack of usage of technology and IT also needs to be mentioned because without an integrated information system systematic flow of information cannot be achieved. Furthermore, identifying a supplier after proper evaluation and developing partnership based on trust and commitments take a long time and it is also not easy to achieve.

3. Single Sourcing

For many industries manufacturers have been highly dependent on a few suppliers. The most impeccable example of this can be the case of the supplier of cast iron rail wheels for North America, which has reduced from thirty-five to only one (Paranikas et al., 2015). Reasons for such a situation fall on both suppliers' and buyers' shoulders. In many cases, suppliers have pushed their competitors out of the market with cheaper prices and higher quality or the buyer with a consolidated demand, forced suppliers to decrease the price, resulting in the survival of only the fittest (Paranikas et al., 2015). Although single sourcing has reduced administrative costs and burdens but developed a risky dependency over singular suppliers throughout the supply chain. The cost-efficient notion of SCM has pushed every manager to identify most fit suppliers but also increased the risk of disruption if that very supplier fails to fulfill commitments on time.

4. Limited Buffers

According to Simchi-Levi et al. (2014), the traditional SC risk management is mostly designed to tackle generic events like forecast error, transportation breakdown, or poor performance of suppliers. Additionally, modern manufacturers are also disdaining the idea of maintaining safety stock for the sake of decreased costs, increased efficiency, and effectiveness (Bhargava, 2017). However, history shows this type of popular notion always came to question under low-probability, high-impact events. For example, viral epidemics like the 2003 SARS outbreak, Hurricane Katrina in 2005, Fukushima

earthquake and tsunami in 2011, and the ongoing COVID-19 pandemic or any major blackout due to unexpected events such as natural or man-made disaster, fire hazard, and political shakeout. Although, JIT inventory management has ensured efficiency and optimum cost management but cutting off excess capacity and not maintaining healthy inventory have left very little room for buffering out any spike in demand. Businesses around the globe need to identify critical items and their safety stock amount for managing any disruption related stock out, demand spike, or supply failure.

5. Focus on Efficiency

Maximum efficiency with a minimum possible cost has increased profitability but also introduced risks of SCD. To generate a scale of economy ensuring high speed and low-cost SC, suppliers deliver products only in a specific volume or lot size to reduce transportation time, costs of freight, and recurrence deliveries. Hence when there is a rise in demand for a particular item without any warning, suppliers fail to fulfill the demand regardless of having them in their stock (Simchi-Levi et al., 2014). Popular SCM strategies most of the time fail to correlate and manage the interrelation between efficiency and risk and hence become vulnerable towards SCD.

6. Over concentration of operation

The hunger for achieving economies of scale, volume discount, lower transactional cost, and lowest possible wages have pushed organizations towards sourcing from certain geographical locations. Clusters of such sourcing zones have been created throughout the world but surprisingly their numbers are very limited. To that end, any geopolitical clashes, regional problems, or environmental calamity in those specific clusters can lead to severe complexity of sourcing, leading towards SCD.

7. Poor planning and execution

Along with the increase of complexity in the modern days, SC needed to be more technology savvy but the absence of real-time information and meaningful visibility over the operating SC have restricted SC managers and decision-makers. Such short cited poor planning and execution capabilities result in demand-supply mismatches. Furthermore, due to the fluidity and efficient nature of modern SC, most of the management-related planning has been reactive rather than proactive which also has reduced the overall preparedness for any scale of SCD. For this reason, Heikkilä (2002), suggested that the core concept of SCM should initiate from customers' end, focusing on demand chain management, where the need of the customer is understood and fulfilled through proper information flow between customers and suppliers.

3.2. Global Supply Chain Disruption by Pandemic

Along with extensive breadth of disruption and massive spreading across the globe, a pandemic tends to generate extreme shifts in demand, supply, and logistic operation. With such characteristic's pandemics can create global havoc in SC operation and proves its qualitative difference from any other SCD (Veselovská, 2020). As the total picture of the COVID-19 pandemic's effects is yet to be known, the Spanish Influenza Pandemic (1918-1919) is still considered most horrific, claiming around 30 million lives (Golan et al., 2020). Due to its significant havoc throughout the society, insights gained from it are still used as a reference (Bhattacharya et al., 2013). However, the structure of business was very different during the 1920s' and the SCs around the globe were mostly localized and also were not interconnected like present day's, hence the modern SC is very different and almost incomparable to a 100 years old one (Bhattacharya et al., 2013; Golan et al., 2020).

Most of the existing literature based on SCD has marked infectious disease and natural disasters in the same category (Sheffi and Rice Jr., 2005). However, Sheffi and Rice Jr. (2005), also differentiated the reasons for SCD according to load types and according to this classification, infectious diseases have a distributed load pattern. SARS outbreak (2003), Mad Cow Disease, Anthrax attack (2001), Swine Flu (2009), and COVID-19 (2019-) can be an example of infectious disease connected pandemics (Ivanov, 2020). On the other hand, Mussell et al. (2020), mentioned any flu pandemics as SC risk and speculates that its very nature can ruffle the movement of people and goods. As a matter of fact, Ivanov (2020) and Queiroz et al. (2020), pointed out the spreading nature of a pandemic's impact through different country and industry and sharply separated it from any localized SCD.

Ivanov (2020), specifically characterized SC risk by epidemics by three speculations: **(i)** unpredictable scaling along with long-term disruption, **(ii)** ripple effect (i. e. simultaneous disruption propagation throughout the SC network and pandemic propagation (i.e. spreading of an epidemic in the population) and **(iii)** disruptions in supply, demand, and logistics infrastructure at the same time. This type of human disease crisis impacts our behavior and movement in a very unpredictable way because of the disease caused fear and hence develops inefficiencies and disruptions (Ivanov, 2020). However, in terms of business, intuitive expectations could only be made up to some extent as scientific literature analyzing the probable impact of the epidemic on SC is very scarce to find (Ivanov, 2020). Ivanov (2020), also implies that a decrease in operative performance, shortage of raw materials, stockout, and price fluctuations are some of the plausible outcomes in an epidemic related scenario.

SCD negatively affects profits but lead time increases proportionally with disruption length (BSI, 2014). However, a positive outcome can be gained if the opening of different facilities spread across the SC network can be synchronized (BSI, 2014). Then again, according to BSI (2014), the most adverse effect can be observed if the facility downtime along with demand disruption is very long in the downstream SC network, regardless of upstream SC healthiness. To that end, it can be considered that an epidemic outbreak is a very unique type of SC risk.

During the Ebola outbreak of 2014, SCD was visible in both virus affected and non-affected countries (BSI, 2014). However, Ebola was an epidemic and COVID-19 is a pandemic, so the extent of its tremor is well expected to be greater. Regional disruption of flight and freight due to heightened measures for preserving public health is pretty common in disease spread disruptions. Brazil and Argentina had to keep arriving vessels offshore for ten to twenty-one days for avoiding the spread of the virus which might be incubated throughout the vessel (Queiroz et al., 2020). A similar security scenario and a contingency plan were also taken for air and ground transportation. The incoming cargos were only accepted after receiving green signals from responsible health officials. Hence, it can be assumed that similar types of delays in logistics management would be a death sentence for organizations being not ready for such SCD.

The Ebola outbreak of 2014 also developed an artificial crisis for specific commodities such as oil, minerals, ores, and different agricultural products moving to and from West Africa (Chopra and Sodhi, 2004). The mining of such natural resources was severely affected as the epidemic continued to spread throughout the region. Such disruption developed a downstream effect in depending industries (BSI, 2014). To that end, it is also understandable that depending on any singular supplier for critical items is always risky and organizations need to develop redundancy for certain processes that are critical for their effective operation (Chopra and Sodhi, 2004). Additionally, organizations not having a proper picture of their SC network was not quick enough to identify and understand, which suppliers were under risk or how many suppliers they have in those affected regions (Baz, 2020; Dolgui et al., 2018; Dolgui et al., 2020; Golan et al., 2020; Ivanov and Dolgui, 2020; Mckinnon, 2020; Snyder et al., 2016).

Queiroz et al., (2020), specifically mentioned the disruption of materials flow as a result of SCD. Additionally, building inventory and maintain redundancy in the procurement function are two suggestions from Queiroz et al., (2020), for tackling such a scenario. However, Dasaklis et al., (2017), raised the issue of holding the cost of such big inventory, For this reason, it can be argued that the organizations have to make strategies and decisions regarding the size of inventory and also for the management of

alternative suppliers so that demand spikes can be tackled. The decision of redundancy can vary by either product or by the level of the supplier (e.g. tier 1 or tier n).

Pandemic and epidemics can disrupt global SC (Snyder et al., 2016). However, considering actual researches based on the case of a pandemic disruption and its effect on global SC, they are hard to find (Bode and Wagner, 2015; Gurnani et al., 2012; Hendricks and Singhal, 2003, 2005). Dolgui et al. (2018) and Snyder et al. (2016), suggested only one literature where even the scope of SCD was measured across only transportation and distribution capacities. Organizations facing even the smallest of SCD face a considerable amount of loss in sales, stock returns, and also affecting shareholders' wealth (Ivanov et al., 2014, 2019; Sokolov et al., 2016). Moreover, this type of disruptions regardless of its intensity tends to linger for at least the following two years (Dolgui et al., 2018; Ivanov et al., 2017).

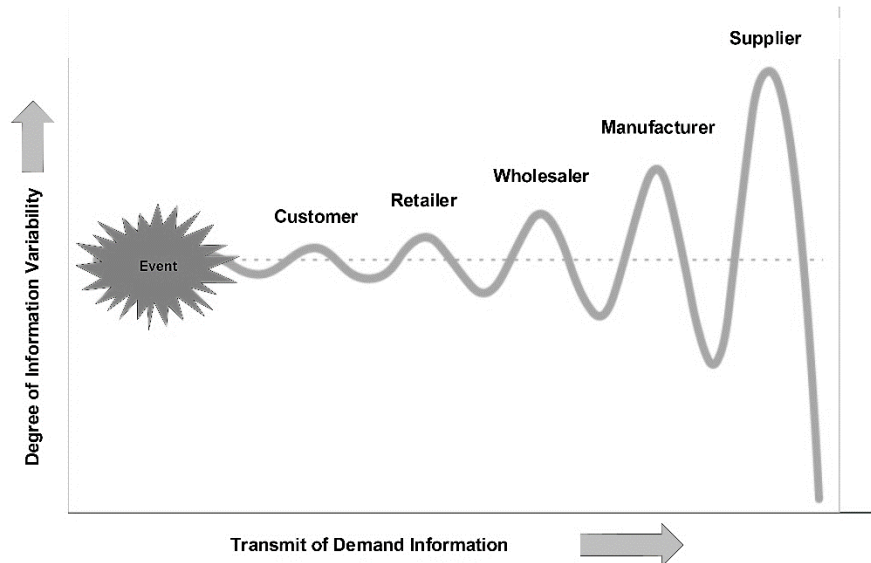
According to Dolgui et al. (2018) and Ivanov et al. (2017), the "Bull Whip Effect" and the "Ripple Effect" can be identified as the probable result of SCD caused by disruptive risks. The Ripple effect is developed from a low frequency, high impactful event (Sokolov et al., 2016) and pandemic can be considered as such an event. Hence, as the research is based on developing pandemic adaptive SC, the ripple effect will be discussed with more priority in the next chapter along with its proper reasoning.

3.3. The Ripple Effect

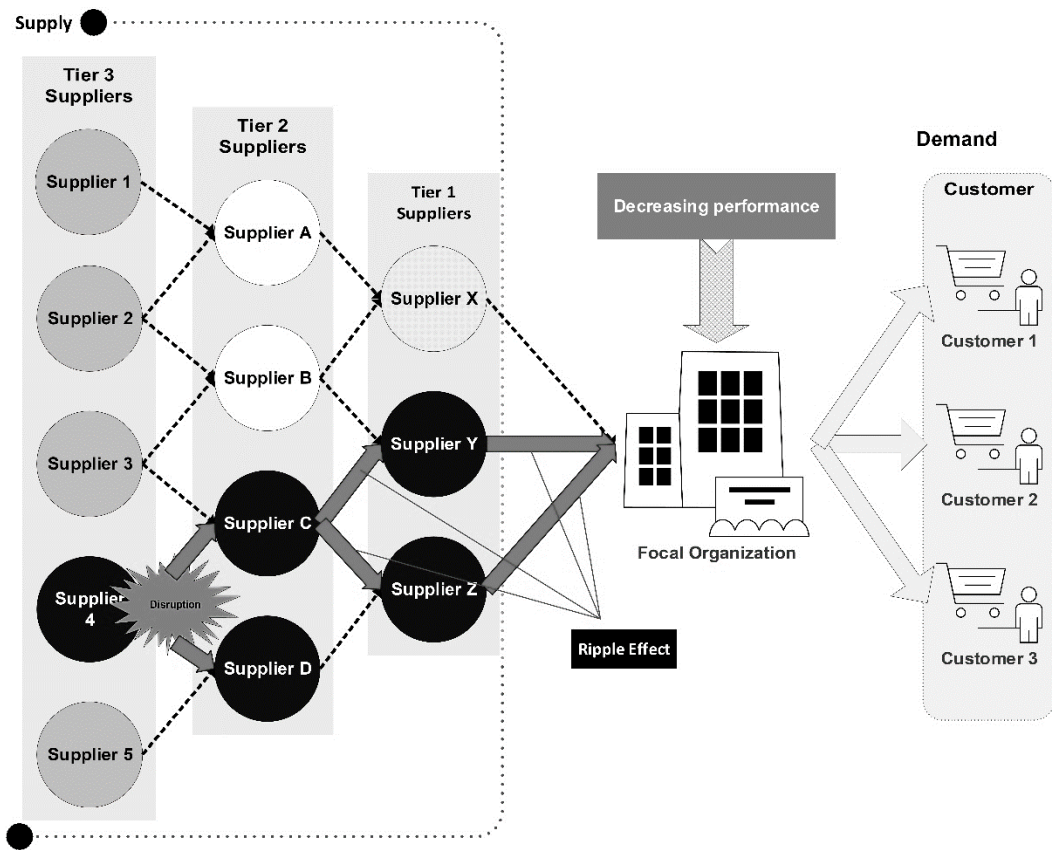
The ripple effect develops when an SCD progresses downstream rather than being confined or even contained (Hendricks and Singhal, 2005). However, Hendricks and Singhal (2005), also explained that management of such a scenario is dependent on proactive actions, such as designing and planning robust and resilient SC along with sturdy recovery policies. The Ripple effect is generated from low frequency and high impact disruptions, in other words, exceptional risks (Ivanov et al., 2019). According to Dai et al. (2017), the Ripple effect also might arise from SC vulnerability and instability, and the recovery may take longer periods, impacting the output performance of a firm, such as revenue.

The rippling effect of downstream progression of SCD impacts the overall business by inflicting loss of revenue and market share, delays in delivery, and damaging reputation (Dai et al., 2017; Dolgui, Ivanov and Rozhkov, 2020; Sucky, 2009). Hence regardless of its low probability, the higher impact of it needs to be considered. According to Dolgui et al. (2018) and Ivanov et al. (2014), the Ripple effect normally starts through a severe disruption and as it propagates downstream through the SC network, it might temporarily

shut down the operation of nodes on its path. The Ripple effect is just the opposite of the bullwhip effect and the difference will be presented through Figure 6.



A. The Bullwhip Effect (adapted from Dai et al., 2017)



B. The Ripple Effect (adapted from Ivanov et al., 2019)

Figure 6. Bullwhip & Ripple Effect

The top portion (A) of Figure 6 represents the Bullwhip effect and the bottom portion (B) represents the Ripple effect. According to Ivanov et al. (2019), the Bullwhip effect

hampers the process chain for transmitting order information to the SC upstream. The Bullwhip effect restricts the suppliers positioned at upstream SC from getting the true information of demand at SC downstream (Ivanov et al., 2019). Hence, causes overstock or understock or operational inefficiency. Furthermore, it is also understandable from Figure 6 that how a small fluctuation on the demand side can transform into a bigger issue for the supplier. To that end, it can be argued that the upstream suppliers should always try to manage a buffer inventory, large enough to tackle such a scenario.

The Ripple effect is different and much more damaging than the Bullwhip effect. According to Dolgui et al. (2018) and Ivanov et al. (2014), the Ripple effect creates a structural disruption of SC and the fluctuations of operational parameters are observed due to the Bullwhip effect. The magnitude of disruption causing the Ripple effect is always higher than the Bullwhip effect. The Ripple effect propagates through the SC causing even temporary shutdown, but the bullwhip effect generated through operational deviation amplifies only towards upstream SC (Dolgui et al., 2018; Ivanov et al., 2017). The breadth and magnitude of pandemic related SCD developing the Ripple effects are greater from every angle than the Bullwhip effect. Table 2 explains why the Ripple effect can be severe for SC rather than the more common Bullwhip effect.

Table 2. Comparison between Ripple effect & Bullwhip effect (adopted from Ivanov et al., 2017 and Queiroz et al., 2020)

Feature	Ripple effect	Bullwhip effect
Certainty	Highly Uncertain (Hazard)	Common or more certain
Risks	Exceptional (Disruptions)	Operational (e.g. issues with demand and supply)
Affected areas	Structure of supply chain and its critical parameters (such as supplier unavailability, loss of revenue, hamper in required service level, and increase in total costs)	Operative parameters such as lead time, inventory level, demand forecast, reorder point, etc.
Prevention	Proactive redundancy and flexibility	Management of coordinated information
Recovery	Longer period; requires extended coordination, investments, and data collection	Shorter time and with balancing demand-supply scenario
Performance impact	Output performance such as annual revenues, profits, etc.	Current performance of a firm such as optimum inventory level maintenance, quality of product and service

It is understandable from Table 2 is that the bullwhip effect is a more common business risk scenario and its regular nature has pushed SC managers to define proactive and reactive action plans. However, due to the absence of bigger disruptive events, most of the SCRM fails to cover the devastating effect like pandemic related SCD (Myers, 2020; WHO, 2020b, 2020c). To that end understanding the effects of ripple effect is much more crucial for developing a pandemic adaptive SC network. Following Table 3 will be shedding a brief light on some ancillary causes which can facilitate the ripple effect.

Table 3. *Ripple effect reason and countermeasures (adopted from Zanni and Lanman, 2020)*

Reasons	SCM impact	Ripple Effect Impact	Countermeasures
Complexity	<ul style="list-style-type: none"> - Geographical specialization - Globalization - Decentralization - Multi-stage SCs 	<ul style="list-style-type: none"> - Evaluation of the financial impact of disruption may take time and resource - Without proper visibility, pinpointing risks and disruptions will be tough 	<ul style="list-style-type: none"> - Simplified supply chain structures - Avoiding geographical clustering of suppliers - Global supply chain risk management policy - Supplier ranking and critical supplier identification - Increased supply chain visibility - Coordinated contingency policy - regional fortification (Fit supplier with active supply chain risk management)
Leanness	<ul style="list-style-type: none"> - Very effective for normal condition - Single sourcing - Low inventory - Inflexible capacity 	<ul style="list-style-type: none"> - Stockout during demand spike - Lack of flexibility can result in supply chain node shutdown - Longer reaction time 	<ul style="list-style-type: none"> - Maintaining buffer for Inventory and capacity - Supply redundancy

The table stated above analyses two very important aspects of modern SC construction in light of their importance in SCM and adverse effects faced due to disruption bred Ripple effect. This chapter tried to analyze the core concept of SCD caused by uncertain and high impactful events and hence came such comparison. According to Mussell et al. (2020), a resilient SC along with proper proactive and reactive action plans can adverse the negative effect of the Ripple effect. However, due to the complicated and interlinked structure of modern SC, a coordinated central strategy is needed. To that end, the importance of management of information and real-time picture of the overall SC cannot be ignored at all because without proper visibility nothing can be planned or executed.

4. DATA ANALYSIS & DISCUSSION

This chapter will be shedding light on the details that how the COVID-19 pandemic outbreak has impacted the global SC and why it has developed a unique predicament. The chapter will also be discussing in detail, different proposed action plans by experts so that similar disruptions can be avoided in the future.

4.1. Global Supply Chain Disruption Due to COVID-19

COVID-19 is causing severe illness related to respiratory infections and due to its high contingency nature, it has spread throughout the world from Wuhan, China, infecting more than 21 million people, marking it as a pandemic (JHU, 2020; WHO, 2020a). Till now this pandemic has cost the world more than 0.75 million lives (Veselovská, 2020). Due to COVID-19's easy and quick spreading nature, most of the countries throughout the world needed to embrace international and local lockdown procedures. Consequently, more than 90% of organizations from the list of Fortune 1000 have been facing terrible SCD (Veselovská, 2020). The following Table 4 explains how the SCD due to COVID-19 is different from other generic SCD.

Table 4. *The dimensions of SCD (adopted from Helo, 2020)*

DIMENSION	TYPICAL DISRUPTIONS	COVID-19
Geography	Local or regional	Widespread & global
Scope	Limited, only a few industries could get affected	Widespread and impacted both goods and services. Restricted mass gathering
Demand vs. Supply	Mostly impacts supply and sometimes demand	Impacted both demand and supply
Prior Planning & Experience	Available	Absent
Financial System	Lightly correlated with the global financial system	Highly correlated with global financial system
Term	Needs short-term emergency services	Requires Longer-term emergency services
Human Impact & Behavior	Localized human impact with limited duration but risks are visible	Widespread human impact. The breadth and duration are yet to be known. Risks are unclear

Table 4 discusses the comparative analysis between a typical and COVID-19 pandemic related SCD. It is visible here that how enormous the effect of COVID-19 is in comparison to any other type of SCD caused by natural disaster or manmade crisis, only because of its pandemic nature, having no geographic boundary. Furthermore, if we look at the overall business scenario, it is also visible that SC of both goods and service industries have been affected harshly by COVID-19. The pandemic has crippled millions financially, hence a worldwide sharp fall in demand has already been observed, which is not normal in other types of disruption. Finally, we still do not know when this epidemic is going to finish and almost every other day a new complicacy is developing, which cannot be defended through traditional planning and experience.

Absenteeism from work due to sickness and lockdown measures has affected the overall efficiency of almost every possible work sector (Hobbs, 2020; Mussell et al., 2020). However, in mid-Europe, most of the agricultural SC and grocery stores did not face any disruption (Goddard, 2020; Hobbs, 2020; Mussell et al., 2020). Whereas some construction companies faced around 67% decreased in suppliers and service-based businesses faced revenue reduction even over 75% (Goddard, 2020; Hobbs, 2020; Mussell et al., 2020). Most of the delays in the SC has developed due to excessive handling of items at the border crossing (Mussell et al., 2020). However, the popularity of online shopping has increased a lot as mobile apps are linking customers with brands and groceries (Mussell et al., 2020).

The food SC is facing shock from the demand side due to changes in customer's purchase patterns, stockpiling attitude and panic buying but the supplier side shock is mostly due to labor shortage and disruption in the transportation and supply network (Yu et al., 2020). Almost 30% of the money previously spent due to eating habit outside the home such as restaurants were shifted to grocery stores as people were confined at home and restaurants were not able to serve customers at their premise due to lockdown and social distancing policies (Dolgui et al., 2018; Dolgui, Ivanov, Potryasaev, et al., 2020).

Generally, food security can be ensured if the pandemic is not started from the agri-food system (Ivanov, 2020). However, the exceptionally long agri-food supply chain with numerous intermediaries developed several points of vulnerability only because of its controller (i.e. the humans) has been affected by COVID-19 (Ivanov, 2020; Jabbour and Jabbour, 2020). Another important issue is the management and proper disposal of vastly growing medical waste and disposed face mask which could bring another catastrophe if not done quickly (Feinberg, 2020; Garner, 2020; Hoberg, 2020; Jabbour and Jabbour, 2020; Kraft, 2020; Mussell et al., 2020).

A disruptive event like the COVID-19 pandemic can affect the operation of modern SC both directly and indirectly but the Ripple effect generated from its large scale propagation can increase severity by folds, especially for the ones with a global, multi-tier organizational network (Feinberg, 2020; Haren and Simchi-Levi, 2020; Hobbs, 2020; Hoberg, 2020; Keegan, 2020; Moritz, 2020; Mussell et al., 2020; Nagurney, 2020; Piller, 2020a; Wiedenmann and Größler, 2020). An epidemic outbreak or pandemic is one of the very special cases of SC risk having long term disruptive propagation feature along with a wide spectrum of uncertainty, which is also known as the Ripple effect (Feinberg, 2020). The randomness of facility shutdown in different nodes of the SC, spreading throughout various geographical locations, plays a vital role in the total timeline of Covid-19 pandemic disruption duration and propagation (Sheffi, 2020). However, specialist and academics from different corners of the world have shared their viewpoints on different types of SC disruptions due to the COVID-19 pandemic. A detailed review of these identified issues will be provided in the following discussions.

1. Sudden Spike in Demand

The supply chain of the whole world has been significantly ruffled by the global panic buy resulting sharp rise in demand for several types of staple foods, medicines, hand sanitizer, medical protective and testing equipment and even for toilet paper (Garner, 2020; Keskinocak, 2020; Nagurney, 2020). Panic buying created an inflated demand peak which is beyond the capacity of any generic system or its buffer limit (Haren and Simchi-Levi, 2020; Rodrigue, 2020; Sheffi, 2020). Interestingly, most of the consumers are not that much aware of the sourcing nature of items, which also have generated misconceptions and panic buying (Keegan, 2020; Mussell et al., 2020; Rodrigue, 2020; Volkin, 2020). Spreading of wrong information among customers also drove superfluous buying spree and many governments failed to control it timely (Volkin, 2020). In many countries, local governments also have withheld proper information about the real status of the pandemic, which in result develops anxiety and misguidance among the mass population (Goldberg, 2020).

2. Supply Shock

Supply shock kicked in the very moment when COVID-19 was flagged as a pandemic and several regulations for social distancing along with international border control initiated (O'Leary, 2020; Rodrigue, 2020; Simchi-Levi and Simchi-Levi, 2020; Ward, 2020; Wieland, 2020a). Border restriction around the globe developed a huge competition for logistic services and many companies failed to acquire them on time, resulting in an unforeseen failure in contractual obligation, creating a massive shortage

of products or raw materials at different demand nodes (Gray and Wynstra, 2020; Gray, 2020; Mckinnon, 2020; Pisch, 2020). Moreover, most of the manufacturing plants relying on labor-intensive processes have been disrupted due to the requirement of social distancing (Snyder et al., 2016). Then again, Linton and Vakil (2020a), pointed out the unnecessary stockpiling attitudes of customers, which resulted in unexpected stock out of certain products.

The most popular JIT inventory management scheme also has been identified as another reason for product shortage because it requires the maintenance of the lowest possible inventory level (Goldberg, 2020; Nagurney, 2020). JIT operation philosophy has increased the risk of SCD only because of its tightly optimized nature (Feinberg, 2020; Goldberg, 2020; Hedwall, 2020; Simchi-Levi and Simchi-Levi, 2020). JIT normally works smoothly but due to its highly efficient work structure, it has left no room for buffer.

3. Overconfidence in Modern SC's Operation

It has been imprinted in common organizational thinking that the modern global SC is almost fluid but unfortunately the traditional contingency planning of SCRM was not enough for such an extreme scenario (Goldberg, 2020). Also, the absence of critical events in recent years has made modern businesses unaware of the loopholes in the system (Betcheva et al., 2020; Jabbour and Jabbour, 2020). Furthermore, with the hyper-specialization of production and distribution chain, most of the organizations achieving targeted profit margin also have not considered a modification of identified loopholes, because everything was running smoothly (Feinberg, 2020; Jabbour and Jabbour, 2020; Keegan, 2020; O'Leary, 2020; Rodrigue, 2020). As a result, the probabilities of irrational decision-making prevailed and nobody was prepared for such global-scale disruption.

4. Overshoring

Most of the organizations have shifted different operational and manufacturing activities to easily accessible, low-cost overseas suppliers and have become highly dependent on them by losing capability, proprietary knowledge, innovation, and even skilled labor (Banker, 2020; Calder, 2020; Choi et al., 2020; Goldberg, 2020; Hoffmann, 2020; UNCTAD, 2020; Wieland, 2020a, 2020b). As a result, the risk of losing innovation capability as a competitive edge is increasing day by day. Additionally, this absence of technical know-how required for making critical humanitarian relief items and medical equipment made them extremely vulnerable (Banker, 2020; Choi et al., 2020; Hoffmann, 2020; Piller, 2020a; Simchi-Levi and Simchi-Levi, 2020). Different free trade agreements and similar different global trade contracts have been leaving the impression that different countries should only focus on what they do best (Betcheva et al., 2020;

Christopher and Peck, 2004). As a result, the global SC running on outsourcing and thin margin with geographically concentrated major suppliers for critical items and raw materials broke down severely (Choi et al., 2020; UNCTAD, 2020).

5. Short-cited SCM

COVID-19 pandemic has revealed a very ugly part of our generic business structure and it showed everyone clearly that giant organizations and even their top executives have not yet thought beyond making money (Choi et al., 2020). For too long, businesses have been too focused on developing a low-cost lean SC rather than building a revenue assuring resilient one so that minimum cost of operation and maximum profit can be ensured (Banker, 2020). Such a notion also made businesses dependent on single suppliers for certain critical items (Linton and Vakil, 2020a). It is the high time that we should take care of all the stakeholders of a business so that in times of distress better collaboration can be ensured. Then again, most of the managers are habituated with reactive response rather than being prepared with proactive planning (Choi et al., 2020; Nagurney, 2020; Pisch, 2020; Seric et al., 2020), which has affected decision making efficiency sharply. Almost nobody has learned from the historical data that how to be prepared for such global-scale disruption (Gray and Wynstra, 2020; Kaplan, 2020; Keegan, 2020), so the disruption of global SC was eminent.

6. Limited Visibility of SC

It has been observed that most of the organizations do not have a clear picture of their complexly structured SC, hence it has been almost impossible for them to identify critical items and their suppliers (Seric et al., 2020; Trebilcock, 2020; Whitfield, 2017). Furthermore, most of the companies are facing trouble with scrutinizing and selecting alternative suppliers as they do not have a clear picture of suppliers below tier 1 and are also blindsided by the impacts on these suppliers' suppliers (Nagurney, 2020). In reality, sourcing decisions come from upstream SC and they are not mindful of the long and complicated sourcing chain, hence when the disruption kicked in most of the managers failed to coordinate quickly with their suppliers (Rodrigue, 2020).

7. Coordination Gap Among Government and Private Sectors

Governments around the world sometimes are not aware of the importance of different nodes of the national supply chain, which is also a part of the global sourcing web (Rodrigue, 2020). Hence, it is also not possible for them to understand which are the critical suppliers of essential products like staple food items, important chemicals, medical equipment and humanitarian relief products. As a result, sourcing of many critical and life-saving items got stuck due to political decision making (Wiedenmann and

Größler, 2020). Countries throughout the world have seen a severe lack of information and uncoordinated reactive actions from both the private and government sectors, resulting in national supply disruption and panic buying (Wiedenmann and Größler, 2020).

8. Demand Shock and Deferred Demand

Global border control and regional lockdown processes have limited customers' movement and due to the severity of the crisis, everyone has to change their priority of demand, which in turn created demand shock for varieties of products and services which are normally not that much popular (Sneader and Singhal, 2020). Moreover, a negative deferred demand scenario developed because of the decline in economic activity, public income, and bankruptcies of both customers and industries (Simchi-Levi and Simchi-Levi, 2020; Whitfield, 2017). A sudden change in lifestyle and shopping behavior created a Bullwhip effect on the food and pharmaceutical supply network, disrupting it severely (Nagurney, 2020). On the other hand, Hobbs (2020), also mentioned the holistic collapse of tourism and commercial transportation network due to border shutdown and immigration control.

COVID-19 crisis has revealed modern SC's vulnerability to export restrictions and external shocks (Gray and Wynstra, 2020; Hart, 2020; Kaplan, 2020; Sneader and Singhal, 2020). Moreover, due to the novelty of the situation and the absence of historical data, conventional demand forecasting and generic production planning methods failed (KPMG, 2020a). Different geopolitical reasons have been also interrupting the efficient sourcing of critical items along with humanitarian relief products (Choi et al., 2020; Wieland, 2020a). Strong speculation for long-term demand-driven SCD has also been made as there is a sharp fall in consumers' income and they are getting too price-sensitive (Garner, 2020; Hart, 2020; Kaplan, 2020). Correspondingly this will take a toll on the supplier-buyer relationship affecting suppliers' profit margin and retailers' product basket

COVID-19 cases are affecting different parts of the world in diversifying nature. The effect of the pandemic and the way local governments are controlling the overall scenario is widely varying. Many countries have even imposed national emergencies to introduce quick adoption of different laws and restrictions. For this reason, in many regions of the world, the lockdown is still in process and in some places, the emphasis is on developing herd immunity. Hence, identifying alternative sources of supply is also becoming complicated (Choi et al., 2020; Feinberg, 2020; Gray and Wynstra, 2020; Kraft, 2020). Furthermore, due to the pandemic, there is a constant variation in demand and for many

of the cases, generic forecasting methods have proven obsolete. The identified SCDs along with their core reasons are presented in Table 5.

Table 5. Summary of supply chain disruption due to COVID-19 Pandemic

Supply Chain Disruptions		Reasons
1	Sudden Spike in Demand	<ul style="list-style-type: none"> - Panic buying - Customers' lack of proper sourcing information - Misinformed customer - Governments curbing real picture
2	Supply Shock	<ul style="list-style-type: none"> - Social distancing - International border control - Scarcity of logistics service - Shortage of product and material - Shut down of manufacturing facilities - Unnecessary stockpiling at customers end - Depleted inventory - Just in time inventory method
3	Over Confidence in the Modern Supply Chain's Operational Structure	<ul style="list-style-type: none"> - Efficiently running modern supply chain - Absence of critical events in recent years - Negligence about existing system's loopholes
4	Overshoring	<ul style="list-style-type: none"> - excessive offshore subcontracting - Ever decreasing profit margin for the suppliers - Geographically concentrated suppliers - Losing technical capabilities and competencies
5	Short-cited Supply Chain Management	<ul style="list-style-type: none"> - Lack of vision beyond revenue generation - excessive lean operation - Excessive lean operation - Not taking care of suppliers - Reactive management paradigm - Not learning from experience and Historical data
6	Organizations Possessing Narrow Picture of their Supply Chain	<ul style="list-style-type: none"> - Lack of understanding of complete supply chain - Ignorant of Tier 2 and suppliers beneath - Top-down decision making
7	Lack of Coordination Among Government and Private Sector	<ul style="list-style-type: none"> - Governments understanding of national supply chain - Ignorance of critical items and their suppliers - Lack of coordination with private sectors
8	Demand Shock and Deferred Demand	<ul style="list-style-type: none"> - Restriction on movement - International border control - Change in customers' demand priority - Decline in customers' economic activity
9	Other	<ul style="list-style-type: none"> - Unpreparedness of the modern business - Novelty of the scenario - Absence of historical data - Failure of conventional forecasting techniques - Geopolitical clashes

All the identified issues of Table 5 echoes the same chant and that is nobody was prepared enough for this crisis. This complicated and stressful circumstance can also be considered as a unique platform to analyze flaws and struggles of modern business's strategic operation and SC structures (Garner, 2020); so that a more resilient structure can be constructed (Gray and Wynstra, 2020; Keegan, 2020; Wiedenmann and Größler, 2020). To that end, understanding the nature and diversity of disruption along with the probable ideal allocation of resources and its distribution process emerged as a very crucial topic (Bärtle, 2020).

4.2. Proposals by Experts

Business in the post COVID-19 situation needs to counterbalance the wrongs of the past with sturdy planning for the future (Hobbs, 2020; Kaplan, 2020). However, a certain degree of agility, adaptability, and alignment needs to be developed throughout the organizational structure so that an overall strengthened preparedness can be gained for a better future (Gray and Wynstra, 2020). COVID-19 can also be considered as an opportunity for figuring out new opportunities within any business's current operating model. The next Table 6 summarizes the different proposals by SC experts from different parts of the world.

Table 6. *Experts suggestions on rebuilding the supply chain*

Sl.	Expert's Suggestion	Description
IS1	Developing Ecosystem (Thinking Beyond Costing)	Developing a healthy relationship with suppliers, based on trust and goodwill, ensuring end-to-end value creation and optimization
IS2	Considering the Ecosystem	Consideration of suppliers' business environment (i.e. social, political, geographical factors and values of the local community) along with collaboration with local government
IS3	Supplier's Fitness Testing	Contractor's risk management program as a requirement of contract eligibility and regular monitoring of it
IS4	Keeping Suppliers Afloat	Faster invoice payment, increased deadline, and relaxed payment terms, loans, or other financial support packages for SMEs

Sl.	Expert's Suggestion	Description
IS5	Supply Chain Redundancy & Multishoring	Ensuring strong legal contract with multiple suppliers and ensuring their geographic diversity
IS6	Next-shoring	Being alert of new sourcing opportunities based on innovation, geopolitical issues, access to new resources, and developing competitive advantages
IS7	Development of Ramp up Capacity	Development of ramp up capacity of locally manufactured critical products in a time of distress
IS8	Hybrid Supply Chain System	Domestic supply chain and global supply chain running parallelly
IS9	Stockpiling Humanitarian Relief Products	Arrangement of a suitable stockpile of humanitarian relief products so that in time they can be accessed quickly
IS10	Supply Chain Stress Test	Identify a supply chain's ability to sustain and recover from the disruption of various length and intensity
IS11	Critical Item and Supplier Identification & Local Sourcing of Critical Items	Maintaining resiliency and quick adaptability for critical item's supply chain
IS12	Reduced Offshoring & Localizing Supply Chain	Developing local suppliers' capacity through collaboration so that critical items can be manufactured locally
IS13	Active Supply Chain Risk Management along with Crisis Management Taskforce	Maintaining supply chain risk management processes led by a specific team for monitoring risk factors for every value-generating node
IS14	Thorough Mapping of Supply Chain along with Supplier's Asset Mapping	A full and detailed mapping on the supply chain for ensuring improved geographic diversity and increased visibility over their operation and assets

Sl.	Expert's Suggestion	Description
IS15	Supplier Ranking	Ranking suppliers by their impact on revenue so that supports can be allocated accordingly
IS16	Integrated IT and ERP System	Establishing an integrated IT and ERP system to improve visibility and communication with suppliers
IS17	Innovation & AI	Implementing 3D printing, Robotics, Autonomous delivery, and transportation, IoT, Data analysis, and AI-based decision support system

Suggestions from different experts have been marked as “Identified Suggestion (IS)” in the table above. These “ISs” are explained in the following discussion:

IS1 – Developing Ecosystem and Thinking Beyond Costing

Organizations need to employ the “Thinking beyond costing” ideology when choosing suppliers (Feinberg, 2020; Nagurney, 2020; Sheffi, 2020; Trebilcock, 2020; Wieland, 2020a). An easier, faster, and cheaper sourcing strategy should not be the only criterion in supply chain designing (Volkin, 2020). Maintaining a trust-based, healthy relationship with the suppliers opens possibilities of future collaboration (Feinberg, 2020), which in return builds up supplier’s capability and optimizes end-to-end value creation (Choi et al., 2020; Hedwall, 2020; Linton and Vakil, 2020a, 2020b; Seric et al., 2020). However, collaboration with the supplier also needs to be transparent and ethical, to safe-keep the interest of all the associated workers (Choi et al., 2020). Having said that, Total Value Creation (TVC) can be emphasized along with proper consideration of all the ethical issues (Banker, 2020; Feinberg, 2020; Gray and Wynstra, 2020; Jabbour and Jabbour, 2020; Kaplan, 2020; Linton and Vakil, 2020b).

IS2 – Considering Ecosystem

In light of organizations being a key part of the economic activities of a region, consideration of the supplier’s ecosystem for building a stronger relationship is necessary (Hoffmann, 2020; Jabbour and Jabbour, 2020; Schumer, 2020). Consideration of the ecosystem also requires maintaining a good relationship with the supplier’s local govt, understanding existing trade wars, and related political policies (Garner, 2020). Due to the lack of grasp on the suppliers' ecosystem and associated different geopolitical clashes many lucrative global resourcing options cannot be even considered (Sneader and Singhal, 2020). Keeping an eye on sustainability and with a

clear understanding of national and global socio-political issues, private organizations need to work closely with different government agencies so that coordinated action plans can be developed for rebuilding the supply chain in the post COVID-19 scenario (Feinberg, 2020; Sheffi, 2020). Furthermore, government intervention along with adequate incentives for such ventures can even act as a strong catalyst (Feinberg, 2020).

IS3 – Supplier's Fitness Testing

The fitness of suppliers along with a detailed risk planning scheme needs to be included as a must condition in the supplier selection process (Feinberg, 2020). It means that the supplier needs to develop a sturdy SCRM scheme of their own, incorporating all its disruption related metrics. Such documents also need to be reviewed yearly by both supplier and contractor, for rooting out loopholes and identifying the scope of improvements. Suppliers' risk management process also needs to specify how agile and resilient they are for tackling different disruption (Baz, 2020; Feinberg, 2020; Kilpatrick and Barter, 2020).

IS4 – Keeping Suppliers Afloat

Faster invoice payment, increased and relaxed payment terms, loans or financial support packages for suppliers need to be in places to keep suppliers afloat (Stevenson and Spring, 2007; Ward, 2020). This concept emphasizes that taking care of suppliers' financial distresses also ensures the maintenance of the social and human rights standards of those suppliers' workplaces (Garner, 2020). This unique step paves the scope of developing a very strong relationship among suppliers and contractors where suppliers generally payback with loyalty, discounts, critical market intelligence (related to pricing, demand, and forecast) and develops scope of innovation-based disruption (Jabbour and Jabbour, 2020; Steeman, 2020).

IS5 – Supply Chain Redundancy & Multishoring

Redundancy means having a backup of suppliers and multishoring ensuring geographic diversity. Multishoring improves redundancy because it involves selecting suppliers from different regions according to their unique advantages and other associated benefits. Diversifying suppliers based on their geographic location reduces regional risks and being dependent on any singular supplier (George and Ramaswamy, 2014). However, organizations also need to develop flexibility meaning preparedness, and the ability to shift to a newer supplier (Calderone, 2017). Flexibility also refers to the capability to adapt a system quickly and efficiently, to tackle any SCD (Calderone, 2017). Then again, as a quick retaliation plan, organizations can develop emergency response agreements

with their suppliers so that a sudden spike in order can be endured (Simchi-Levi and Simchi-Levi, 2020).

IS6 – Next-shoring

A plan for next-shoring always should be kept in mind so that different sets of strategies can be developed and used as a competitive advantage (Simchi-Levi and Simchi-Levi, 2020). This perspective allows for, identification of future sourcing options based on “proximity to demand and proximity to innovation” (Simchi-Levi and Simchi-Levi, 2020). The Next-shoring strategy consists of diversified plans such as always being aware of promising new production locations, a good number of innovation-oriented partnerships, and a mindset favoring technical skills (Banker, 2020; Volkin, 2020).

IS7 – Development of Ramp-up Capacity

Production ramp-up capability can normalize the stress on demand for certain critical items, during the high demand phase or the unexpected scarcity of the critical items. Organizations can use their different Bill of Materials (BOM) to identify critical items (Choi et al., 2020; Sheffi, 2020; Sneader and Singhal, 2020; Wiedenmann and Größler, 2020; Wieland, 2020b). Additionally, the required partnership among govt. and private sectors for fulfilling this plan can introduce innovation related to production planning, process, efficiency and material management (Feinberg, 2020; Ward, 2020).

IS8 – Hybrid Supply Chain System

Hybrid Supply Chain System represents the notion of a domestic supply chain and global supply chain running parallelly. However, to make it a success national encouragement for developing local capabilities needs to be developed (Choi et al., 2020; Sheffi, 2020). A strong localized supply chain needs to be running in parallel with a country’s global supply chain so that any disruption can be tackled with redundancy. According to, USAID (2018), effective cooperation among government and local companies needs to be developed to achieve this.

IS9 – Stockpiling Humanitarian Relief Products

Humanitarian relief items and health service supply chains should be focused on with more priority (USAID, 2018) and strategic stockpiling could be considered as an important solution for tackling this global SCD (USAID, 2018). According to Feinberg (2020) and USAID (2018), strategic stockpiling and efficient management of them is crucial for managing pandemic related SCD. Efficient stockpile management of critical and commodity items improves any country’s response efficiency in a time of emergency. Strategic stockpiling could be regional or national or central, but storage infrastructure

and location need to be carefully selected (Feinberg, 2020). Responsible personnel can investigate the existing storage system to understand storage regulations for designing new ones with adequate capacity (Alicke et al., 2020; Feinberg, 2020). Different critical items can be identified and stockpiled in strategic locations through this strategy. However, proper training of responsible management, regular auditing, and optimum level of stockpiling need to be ensured for making this plan a success (Piller, 2020a; Ward, 2020).

IS10 – Supply Chain Stress Test

The government needs to strategies a stress test campaign for all the organizations operating in its territory (Goldberg, 2020; Wieland, 2020b). Simchi-Levi et al. (2014), has proposed an analytical method based on identifying the vulnerability of the SC nodes. This SC stress test process is focused on understanding the total effect of a disruption regardless of its source. According to Simchi-Levi et al. (2014), an organization can use this process to collect data based on two key factors, TTR (Time to Recover) and TTS (Time to Survive) from their sub-tier supplier for understanding the probable impact of disruption on its operation.

According to Hobbs (2020), such a test reflects an organization's resiliency. TTR represents the time duration for a node of SC to return in its best possible functionality after a disruption. TTS is the maximum time duration when the supply chain can match supply with demand after a facility disruption. According to this test, if TTR is greater than TTS, the supply chain will not be able to balance supply and demand unless a strong backup plan exists and vice versa. Furthermore, this test will quantify disruption in terms of currency so that mitigation plans can be developed (Gray and Wynstra, 2020).

IS11 – Identification of Critical Items & Suppliers

Critical item and supplier identification & local sourcing of these can develop flexibility in SC (Gray and Wynstra, 2020). Medical, humanitarian and basic food items should be considered as a critical item and prioritized (Keegan, 2020; Piller, 2020b; Wiedenmann and Größler, 2020). According to Gray and Wynstra (2020), a long-lasting change is developing in the food SC as the notion of localizing it is getting popular. BOM can be a quick start point for identifying critical items (Garner, 2020; Sheffi, 2020). Countries need to focus more on improving the onshore capacity of manufacturing these to achieve the competitive advantage of speed and reliability (Garner, 2020; Kaplan, 2020). Additionally, a detailed understanding among govt. agencies and private enterprises must be developed for ensuring such capability (Linton and Vakil, 2020a). More than that, an extra addition of cost with this strategy can bring tons of comparison data in

terms of other international manufacturers and benchmarks can be achieved (Keegan, 2020). Then again, SC structure and its management process for critical items need to be according to their fit, and urgency of needs (Choi et al., 2020; Gray, 2020).

IS12 – Reduced Offshoring & Localizing Supply Chain

The widely spread manufacturing and sourcing facilities of modern businesses have made organizations vulnerable to several geopolitical risks and natural calamities (Choi et al., 2020; Christopher and Peck, 2004; Gray and Wynstra, 2020; Haren and Simchi-Levi, 2020; Keegan, 2020; Linton and Vakil, 2020a; Piller, 2020a). Developing local suppliers' capacity through collaboration needs to be emphasized so that critical items can be manufactured locally or at least at a minimum level. However, there will be many items and raw materials which will not be possible to be sourced locally due to several economical, geographical, and political reasons (Linton and Vakil, 2020a; Sheffi, 2020). Having said that, the make-versus-buy decisions need to be made at some point, keeping in mind the needed amount of resources and competency (Jabbour and Jabbour, 2020; Kilpatrick et al., 2020).

IS13 – Active SCRM Along with Crisis Management Taskforce

Active SCRM along with a dedicated crisis management task force is to be placed for ensuring the quickest possible response in a time of distress (Feinberg, 2020; Sheffi, 2020). Coupled with it, a 24/7 manned Emergency Operation Centre (EOC) with specified updated guidelines and effective decision-making capacity are to be created to operate such taskforce with the least possible reaction time (Feinberg, 2020; Jabbour and Jabbour, 2020; Volkin, 2020). Active SCRM means continuous identification, assessment, and management of supply chain risks up to at least tier 2 suppliers but beyond that only a clear knowledge of the dimension of risk might also be enough (Feinberg, 2020; Linton and Vakil, 2020a). Regular exercises based on real-life case studies also should be part of this (Choi et al., 2020; Gray and Wynstra, 2020). An organization can also learn from its Corporate Social Responsibility (CSR) division on how to approach a similar humanitarian crisis (Hart, 2020; Hoffmann, 2020; Kaplan, 2020). Finally, a cross-functional team from different parts of the organization can be considered for this EOC and different dimensions of resource management will surely come to consideration through this venture (Linton and Vakil, 2020a).

IS14 – Thorough Mapping of SC Along with Supplier's Asset Mapping

Clear Visibility across the SC along with the supplier's asset mapping needs to be considered as a vital stage for SC redesigning (Kaplan, 2020; Linton and Vakil, 2020a, 2020b). This exercise will help organizations identify supplier's suppliers (secondary and

tertiary level suppliers) along with their stakeholders (Betcheva et al., 2020; Choi et al., 2020; Keegan, 2020; Kilpatrick et al., 2020; Nagurney, 2020; Wieland, 2020b). Although it is a labor-intensive process, help from specialized experience firms and even utilization of the BOM can be considered for such a task (Keegan, 2020). Mapping of supplier's assets such as manufacturing plant, warehouse, office, distribution sites to ensure their geographical diversity is an extensive part of this project (Linton and Vakil, 2020a). Furthermore, visibility over its operation and assets also needs to be maintained to identify anomaly and risk (Banker, 2020). Hence, every organization needs to develop a proper picture of their SC, so that issues can be pinpointed and resolved quickly, saving precious time for becoming a winner, in such a scenario in the future (Mohanty and Gahan, 2013). However, this type of exercise is always biased by relationships among suppliers and buyers and in most cases, true information about a supplier gets lost when their responsible handler changes responsibility or job place (Michael, 2018; Sheffi, 2020). Hence organizations also need to focus on maintaining a proper meaningful database of their suppliers.

IS15 – Supplier Ranking

Ranking of suppliers by their impact on revenue is very important to understand how their specific risks can affect the overall SC (Garner, 2020). Supplier ranking could be a by-product of SC thorough mapping. By the same token, critical items and supplier identification process also could be achieved through this exercise. This drill can dictate in allocating resources for their monitoring and risk management purpose (Garner, 2020; Hedwall, 2020; Nagurney, 2020; Piller, 2020b; Sheffi, 2020). Several quantitative criteria (e.g. cost, quality, technical and financial capability, and compliance issues) and qualitative criteria (e.g. Level of trust, commitment, reliability, loyalty, responsiveness, management process, and reputation) could be considered to identify the most suitable suppliers for deeper collaboration (Sanders, 2014).

IS16 – Integrated IT and ERP System

Integrated IT and ERP systems along with the utilization of all the modern means of communication and different SRM or purchase management software need to be in place for maintaining quick and effective communication (Garner, 2020). Integrated systems like this create transparency in inventory, production, and order management among manufacturers and distributor (Keskinocak and Ozkaya, 2020). With the help of such technological advancement and their utilization organizations can improve their visibility over supplier operation and hence communication along with decisions can be

made faster by being well informed (Betcheva et al., 2020; Garner, 2020; Hart, 2020; Kaplan, 2020; Sheffi, 2020).

IS17 – Innovation & AI

Technology will be playing a valuable role in redesigning SC in the post COVID-19 scenario (Gray and Wynstra, 2020). Many organizations have already turned the table by utilizing big data analytics for understanding customer insights and creating new forms of value (Sheffi, 2020). Further utilization of machine learning, 3D printing, robotics, autonomous transportation, and IOT could solve many of the problems we are facing during this pandemic (Kaplan, 2020). Data driven and AI-based supplier monitoring and decision support systems also could be included for quicker decision making (Bärtle, 2020). Most importantly, a partnership among govt. and private sectors are required to access vast resources enabling path towards innovation and digitalization (Kaplan, 2020).

SCM should not be too focused on supply redundancy or excess inventory (Jabbour and Jabbour, 2020). SC needs to be more agile and flexible than being just only lean so that trade-offs between cost and preparedness can be made effectively (Kilpatrick et al., 2020). However, lean management also focuses on continuous improvement and being customer-focused (Kraft, 2020). Alternative sources of suppliers and transportation also need to be in places to tackle shortage or blockade of regular freight carrying system or even for relocating stocks quickly (Steeman, 2020). Training of staff to develop such a system is a must and different courses of universities along with historical data and learnings from SC practices can also provide valuable insights for future SC practitioners (Steeman, 2020). Effective communication and meaningful collaboration with suppliers enable innovation so every business should start immediately Piller (2020b).

A strong prediction of a chaotic cycle of economical fall and rises has not at all affected the intense pressure for re-opening international business (Kilpatrick et al., 2020; Nagurney, 2020). Furthermore, it is also difficult to bring in a change in the business model where customer movement has been restricted and organizations need to develop capabilities for retail service (Piller, 2020b). Hence, keeping in mind the time constraints, a meaningful plan needs to be developed so that an efficient and pandemic proof system can be developed. Resiliency needs to consider as a priority for building-back the SC in a better way (Piller, 2020b). Piller (2020a), also implied that improvements should be defined more broadly so that recovery time can be lessened and the ability to withstand crisis can be strengthened. Finally, aspects of the global green SC and circular economy also need to be considered for redesigning the new and better SC (Piller, 2020b). A clear

picture of experts' suggestions based on the identified literature has been provided through Appendix A.

4.3. Defining Strategy

Any crisis passes through three stages, they are response, recover, and thrive. Hence, it could also be assumed that if the disrupted supply chain can be responded in time, a proper recovery and thriving future is obvious (Veselovská, 2020). Recovery from the COVID-19 SCD depends on a wide range of collaboration and coordination across the globe (Bode and Macdonald, 2017). However, it has been predicted by consultancy firms like Mckinsey that the global GDP will decline, and the economic crisis will have several waves affecting in stages (Bode and Macdonald, 2017). Hence, keeping an eye on the present and probable long-term effect of the COVID-19 pandemic the best possible way is to define actionable strategies so that the rebuilding of the supply chain can be done swiftly (Baz, 2020).

SC managers can't foresee every possible risk and most importantly not all risks can be avoided, such as pandemic and natural disasters. However, possessing proper reactive management capabilities could improve the efficiency and effectiveness of the response. To that end, Baz (2020), suggested that organizations need to develop capabilities to accurately assess and solve the issues during SCD, and accelerated recognition results in faster reaction and hence lessened the disruptive effects. However, investment in information management is required to ensure the quality which in turn improves response time. Piller (2020a), also argued that the most crucial stages of recovering from an SCD are recognition and implementation.

Michael (2018) revealed that organizations that have not invested in the disrupted SC, also have not managed to create a new market whereas organizations cutting investments even lost revenues. Hence, the rebuilding of SC needs to be started as soon as possible. On the other hand, according to Kraljic (1983), culture also plays an important role in how people perceive disruptions caused by pandemic and regions having previous experiences of such phenomenon adapt and react quicker than the others. Considering this fact, the structure of SC and breadth of SCRM practices could also vary from country to country (EY, 2020; Sen, 2020; Weissman, 2020). Hence, the theme of future SC needs to be developed with a global consideration as the web of true global SC is spread deeper than our initial understanding. To that end, the five strategies have been defined from the seventeen ISs for rebuilding SC and they have been presented in the following Table 7.

Table 7. *Defined strategies for rebuilding supply chain*

Sl.	Strategy		Suggestion (IS)
1	Improved Supplier Relationship Management	IS1	Developing Ecosystem (Thinking Beyond Costing)
		IS2	Considering the Ecosystem
		IS3	Supplier's Fitness testing
		IS4	Keeping suppliers afloat
2	Supply Chain Capability Improvement	IS5	Supply Chain Redundancy & Multishoring
		IS6	Next-shoring
		IS7	Development of Ramp up capacity
		IS8	Hybrid Supply Chain System
		IS9	Stockpiling Humanitarian Relief Products
3	Supply Chain Risk Management	IS10	Supply Chain Stress Test
		IS11	Identification of Critical Items & Suppliers
		IS12	Reduced Offshoring & Localizing Supply Chain
		IS13	Active Supply Chain Risk Management Along with Crisis Management Taskforce
4	Supply Chain Visibility Improvement	IS14	Thorough mapping of supply chain along with Supplier's Asset Mapping
		IS15	Supplier Ranking
5	Utilization of Technology & Innovation	IS16	Integrated IT and ERP system
		IS17	Innovation & AI

A true aligned and performance-optimized supply chain can only be achieved through adjustment of interest of retailers, suppliers, and manufacturers (Krause et al., 1998). Hence, strategies for constructing pandemic adaptive SC also need to be drawn by managing SC risks from all the stakeholders' perspective. Although from the discussion of the previous chapter it cannot be confirmed that all the mentioned ISs are safekeeping stakeholders' interest, many of them are drafted to rip long-time benefits, considering probable favorable outcomes from both supplier and purchaser. The crafted strategies are explained below

1. Improved Supplier Relationship Management

SRM in its simplest form refers to the management of third-party vendors who are supplying goods, materials, and services to the organizations in a cost-efficient process, maximizing the value of their relationship (Larson and Kulchitsky, 2000; Martin and

Grbac, 2003). In modern business, this generic concept has evolved from a general operating function to a strategic one (Krause et al., 1998; Michael, 2018; Wins, 2019). Even during the COVID-19 pandemic, management of the strong relationship with the suppliers has been identified as a success factor (Liker and Choi, 2004). To that end, from the identified seventeen ISs', IS1-developing ecosystem (thinking beyond costing), IS2- considering ecosystem, IS3- supplier's fitness testing, and IS4- keeping suppliers afloat have been considered as four action plans for fulfilling the strategy "Improved supplier relationship management".

SRM can be of two types, reactive and strategic (EY, 2020). However, from the existing SCD faced throughout the world, it is very evident that the reactive approach has its adverse effects, and this is the high time that every organization considers the "improved supplier relationship management" strategy as a prioritized proactive one. To that end, organizations need to select their suppliers after considering their ecosystem along with a consideration of their fitness and risk management activities. The core target for this strategy needs to be developing an ecosystem where relationships will be built beyond the consideration of cost. However, it has been already explained that how an organization can initiate SRM right now by ensuring the financial stability of its supplier which in return develops lower lead time, loyalty, responsiveness, and future scope of greater collaboration (Cepeda and Vera, 2007; Helfat and Peteraf, 2003).

A solid agreement ensuring all scopes of sustainability, dedicated SRM program, and regular review of the performance of such program develops promising opportunities and boost relationship (Teece, 2007; Teece et al., 1997). However, such information should be shared with suppliers intensively but selectively throughout the SRM process so that competitive advantages and business secrets can be preserved (Murray, 2020). Based on suppliers' capability and breadth of desired partnership, organizations have to decide either they want to develop a transactional, performance-based, or outcome-based relationship and prepare appropriate contracts accordingly, such as vertical integration, relational or transactional contract (Purvis et al., 2016). Sustainable innovation followed by the development of unique competitive advantage can be achieved through this strategy if the contractual obligations benefit both supplier and purchaser.

2. Supply Chain Capability Improvement

The superior performance of any organization depends on two types of capability, namely dynamic capability, and operational capability (Smith, 2020). Dynamic capabilities are the learned ones which in turn develop or modify existing operational practices and thus gain novel competitive advantage (Johansson and Jensen, 2011).

According to Keith Oliver, the supply chain as a single entity needs to evolve with market circumstances (Johansson and Jensen, 2011). Hence, it can also be assumed that the failure of existing flawlessly working SC is very much connected to its reluctance towards change or any modification. To that end, from the seventeen ISs five action plans have been selected for executing the strategy “supply chain capability improvement”, they are, IS5- supply chain redundancy & multishoring, IS6- next-shoring, IS7- development of ramp up capacity, IS8- hybrid supply chain system, and IS9- stockpiling humanitarian relief products.

SC robustness as a requirement for achieving resiliency can be ensured by maintaining redundancy (Iswara, 2020). Multishoring and maintaining a higher level of inventory for emergency medical and critical items have also been proposed as developing resilience to tackle similar scenarios like the COVID-19 pandemic (Williams, 2014). On the other hand, production ramp-up capability during SCD can be achieved through effective integration with suppliers or even by using outsourcing (Calderone, 2017). Moreover, a systematic integration followed by concurrent engineering with suppliers can reduce the time of concept to delivery by 50% and lower cost by 30% (Kärkkäinen, 2020). Then again, it has been already observed that with proper government support ensuring stable money exchange rates, adequate raw materials, and machinery local manufacturers can easily ramp-up production (Michel, 2013).

Next-shoring means being aware of emerging markets, innovations, access to resources so that re-shoring of manufacturing facilities can be done quickly without even shifting the main operation (Jawhari et al., 2020). The next-shoring capacity allows SC to be closer to the market which in turn improves delivery time and overall control on SC (Kilpatrick and Barter, 2020). On the other hand, a hybrid supply chain (i.e. running local SC parallel with global SC) also improves the organization’s capability to buffer unexpected spike in demand and ensures reliability of delivery, SCM flexibility, overall lower cost, and reduced deadstock (Kilpatrick and Barter, 2020). Therefore, organizations need to focus on redundancy leading to improved capabilities first to reduce risk and then only should focus on optimizing capacity (Anstey et al., 2020).

3. Supply Chain Risk Management

According to Rice Jr. (2020), almost 20% of the firms worldwide do not have a defined SCRM, 50% of firms follow reactive SCRM and only 5% have a dedicated SCRM unit. Hence, IS10- supply chain stress test and IS13- active supply chain risk management along with crisis management taskforce have been considered as action plans for executing the strategy “supply chain risk management”. Furthermore, many suppliers of

critical items have not yet fully resumed full-fledged operation due to local lockdown and over-dependency on them needs to be reduced (Kilpatrick et al., 2020). IS11- identification of critical items & suppliers and IS12- reduced offshoring & localizing supply chain have also been included in this strategy.

With the knowledge gained from the ongoing pandemic, SC stress tests for the different breadth of epidemic scenario needs to be executed for identifying loopholes and bottlenecks (Cordon, 2020). Organizations need to stress test their SC for cost, speed, and money (Corser, 2020; US Chamber, 2020). Then again, due to the dynamicity of modern days risks, stress testing needs to be incorporated within the active SCRM process and reviewed regularly. However, EOC or crisis management taskforce needs to come out of the corporate boundary and operate on a deeper level according to predetermined action plans for communication, coordination, and decision making, involving all possible suppliers and even customers (Tampere University, 2020). Finally, the convenience of SCRM also needs to be kept in mind, so that it does not become too cumbersome for execution (Mericle, 2020).

COVID-19 has proved that we are very much dependent on many geographically clustered suppliers for certain products like medicine and electronics (López-Gómez et al., 2020). For tackling such ongoing SCD, a national effort to produce critical items inhouse has already gained popularity in different countries (Kilpatrick and Barter, 2020). According to Professor Jussi Heikkilä, regionalization of production has already been a popular notion for maintaining quality, commitments, and sustainability (Tampere University, 2020). To that end, first, a combined effort from government and private sectors needs to be in place for identifying critical items related to healthcare, grocery, technology, and even related raw materials. Then, it also requires government policies, support, and sharing of intellectual property and capability among internal manufacturer of a country to gain the capability to manufacture such critical items. The government can also initiate an in-depth survey to identify local manufacturers' capability and maximum production capacity for critical supplies and proceed instantly (Chen et al., 2020). However, repurposing existing facilities to utilize their idle capacity for manufacturing critical items can be expensive, time-consuming, and even substandard Choudhury (2018).

4. Supply Chain Visibility Improvement

According to MH&L (2020), organizations having meaningful visibility over their entire SC can sense and respond or even predict risks through the extended network. To that end, IS14- thorough mapping of supply chain along with supplier's asset mapping and

IS15- supplier ranking have been considered as two action plans for executing the strategy “supply chain visibility improvement”. According to (Hinton, 2020), SC visibility represents increased inward awareness of a company’s SC activities and related events via technical means. Visibility over SC assists in tactical and strategic decision making and can be executed through a specified combination of the process (Hinton, 2020). On the other hand, systematic supplier ranking, and selection paves the way for sustainable supplier development and value cocreation (Steinberg, 2020).

Visibility over an SC is required for three core reasons, namely the rising complexity of SCM, fulfilling customer demand, and meeting compliance and regulatory demand (Chopra and Sodhi, 2004; Steinberg, 2020). Mapping of supply chain along with developing a complete picture of even suppliers’ assets ensure understanding of the different risks based on geopolitical and environmental factors. BOM, help from experts, and existing knowledge of suppliers can be used for developing a clear picture of the SC network. Technology can improve visibility over the supply chain and mitigate risk by developing a digital supply network and removing functional silos (Keegan, 2020). Furthermore, visibility over SC’s regional and international nodes also enables quick and efficient redeployment of resources in an ever-changing scenario like the COVID-19 pandemic (Hinton, 2020).

Visibility over the entire operating SC network also helps an organization to assess risk and conduct several dimensions of what-if scenario planning Kilpatrick et al. (2020). Hence, Ivanov and Dolgui (2020), expressed many of the recovering business entities are facing trouble only because of lacking end-to-end visibility of their supply chain. SC visibility tools can be utilized to identify capacity and capability constraints for all tier of suppliers (KPMG, 2020b), but it also needs to be a continuous collaborative approach with an eye over the future needs (Laluyaux, 2020). According to (Kilpatrick and Barter, 2020), meaningful visibility over the SC will play a major role in its recovery and rebuilding from the ongoing disruption by keeping decision-makers aware of every possible player of the entire SC network. To that end, the development of a computerized SC model representing the network’s real-time state has been proposed for effective decision making (Hedwall, 2020; Sanders, 2014).

5. Utilization of Technology & Innovation

According to Lyall et al. (2018), a digital foundation in SC, it is much easier for any organization to collect, analyze, integrate, and interpret high-quality, real-time data. Such data bred information can excel in process automation and opens new windows of opportunities in robotics and AI-based decision support system (Lyall et al., 2018).

According to Sanders (2014), global SCD has exposed gaps in the digital capabilities of many organizations and embedding technology across the SC will bring agility in many industries by making their SC more resilient towards disruption. It has been already identified that there are still some gaps in understanding actual demand and required production throughout modern SC and technologies could bring a very effective solution (Hedwall, 2020; Laluyaux, 2020). To that end, IS16- integrated IT and ERP system and IS17- innovation & AI have been considered as two action plans for executing the strategy “utilization of technology & innovation”. However, due to the increase in remote working culture and flexible work hours, organizations also need to focus on system stability, data security, and network robustness (Santosh, 2020).

Though many organizations have already utilized technology as big data analysis for efficiently managing SC, it still needs coordinated efforts for achieving competitive efficiency (Hinton, 2020; Pederson, 2020). Furthermore, Ivanov (2020) and Steinberg (2020), also claimed that businesses around the globe yet to figure out how they can rip the benefits of data collection and utilization throughout the different stages of a supply chain. Cognitive technology can be utilized as an AI-based decision-making tool where even human minds could mimic the wrong approach due to peer pressure or situational excitements, such as organizations buying or storing unnecessarily and raising prices unethically (Hinton, 2020). As a matter of fact, according to recent statistics around 68% of industries are ready to invest in technology to match ongoing disruptive changes (KPMG Australia, 2020).

Technology enabling real-time data visualization can also be utilized to track and manage freight across the supply chain to identify instantaneous storage capacity, delivery timeline so that rerouting is possible when needed, resulting in better agility (KPMG Australia, 2020). Moreover, technologies like AI and machine learning (ML) enable self-correcting workflows detecting disruptions and evaluating alternative action plans for users which also increases the system’s response time and overall agility (Adler and Ziglio, 1996). However, this type of technology also needs to be designed by keeping in mind the end-user so that the data collection process along with information articulation can be in laymen’s terms, and a responsible person can be trained and incorporated into the system easily (Kraljic, 1983). SCD due to COVID-19 has caught organizations off-guard but thoughtful investment and utilization of technology will be critical for sensing, monitoring, and adapting to unseen future issues (Kraljic, 1983).

4.4. Result of the Delphi Study

An email communication-based Delphi research methodology has been utilized for this research for bringing out the subjective opinions and responses from a group of credible participants. A possible scenario of the Bandwagon effect has been avoided through such research methodology and a plausible qualitative outcome can be generated for decision making (Kraljic, 1983; Webb, 2017). However, the interest and commitment level of the participants cannot always be ensured which might result in shorter rounds or even a singular round of Delphi study.

The core reason for considering the Delphi research methodology for this research was to explore the ideal SC structure in a similar scenario like the COVID-19 pandemic. The said study is targeted towards developing a pandemic adaptive SC along with the invaluable views and suggestions from experts and practitioners around the globe because the scarcity of research materials on the said topic is high. To that end, the Delphi study was executed according to Figure 5 and the details of the execution stages are explained through chapter 2.3.

All of the responses echoed the support and acceptance of strategies and action plans suggested by the author and provided in Appendix B. However, the responders also suggested different research materials so that the author can gain more in-depth knowledge of the subject matter. No major modification request was received through the Delphi research methodology. To that end, the identified suggestions and drafted strategies could be considered as a guideline for developing a pandemic adaptive global SC. However, only one suggestion on utilizing the Kraljic Matrix for classifying for developing the dimensions of supplier relationship management has been given so that organizations can utilize their available resources much more efficiently and intelligently.

Kraljic (1983), guided a structure to segmentize supplier base and argued that such mapping of suppliers needs to be based on two key dimensions, namely risk and profitability. Risks represent the probability of unexpected disruptive events and the profitability of an item represents the impact of it on the business bottom line. Combining these two, a classic two-by-two has been developed by Webb (2017), which has been represented in Figure 7.

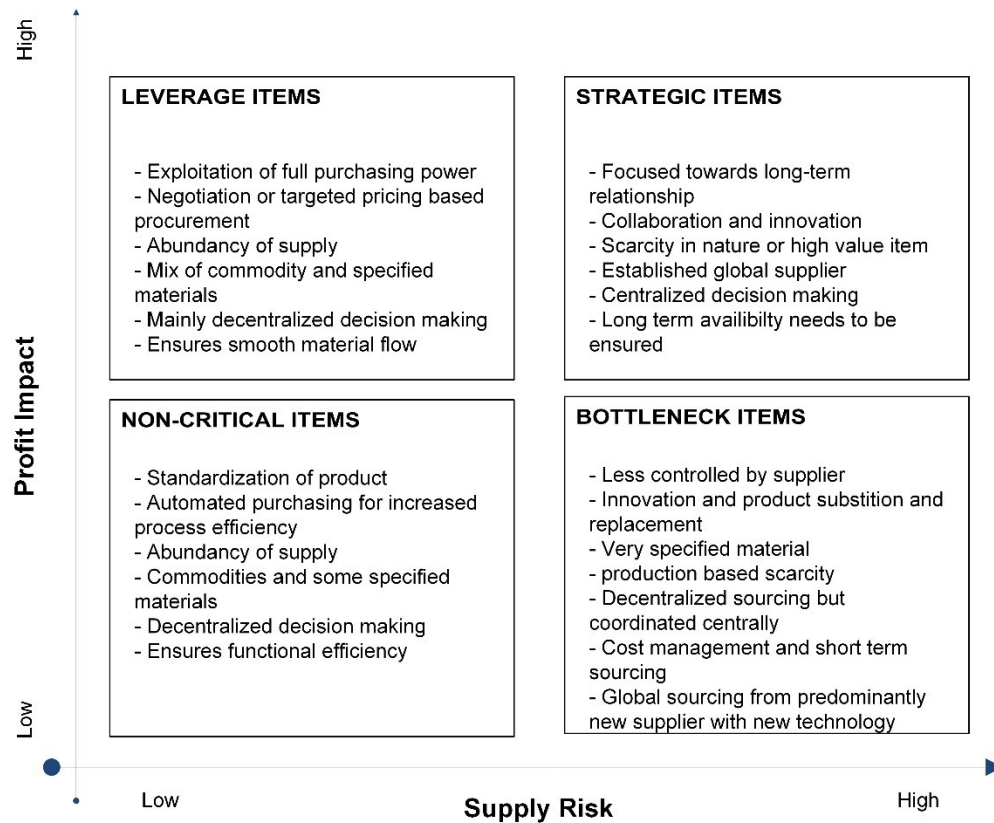


Figure 7. Kraljic matrices (adapted from Webb, 2017)

According to Webb (2017), each of the boxes represents a specific buyer-supplier relation and the supplier management strategy needs to be based on this issue. For procuring noncritical items whose risk and associated profits both are low, an automated sourcing function can be constructed. Furthermore, the very nature of such items calls for an easier and quicker system with a shifted responsibility towards suppliers. Leverage items ensure profitability however, smart businesses need to utilize this scope to unlock the innovation potential of suppliers (Webb, 2017). However, organizations also need to be very careful because sometimes too much bargaining and higher buyer power for leverage items push the supplier towards insolvency and deteriorate future chances of collaboration and innovation.

For the bottleneck item, the scenario is the opposite of leverage items. Lead times are higher for such products as the number of suppliers are few. To that end, in this case, the finer management of the buyer-supplier relationship needs to be required for ensuring the profitability of the buyer. The suppliers are always demanding for sourcing such items. Kraljic (1983), suggested that organizations need to focus on internal innovation so that such critical items having limited profitability impact can be replaced

by another leverage supplier. However, until that point, the focus should be on managing a good relationship with a supplier and search for alternative suppliers.

Most of the procurement attention needs to be focused on strategic items as they have high supplier risk and profitability impact. Furthermore, these items are damaging towards business, and long-term availability of these need to be ensured. Although the number of suppliers for such items is pretty low, ensuring a profiting buyer-supplier relationship is key to the future success of a firm (Webb, 2017). The core target of collaboration and relationship management with such strategic suppliers should be based on shared gain so that long term commitments can be gained through proactive development.

Kraljic matrix needs to deploy accurately so that the classification of items and suppliers can be done in a meaningful way (Webb, 2017). Furthermore, such exercise can also become the very start point of supply chain mapping. Followed by these, organizations can draw different supplier relationship management programs for tackling disruptive scenarios like the COVID-19 pandemic outbreak. Organizations can develop different sets of mixed suppliers for scenarios ranging from low risk to high risk based on their supplier relationship management structure and cost-benefit analysis (Kraljic, 1983).

5. CONCLUSION

COVID-19 pandemic outbreak with its alarming speed of spreading, infecting millions, has ceased the whole global economy. According to The World Bank (2020), COVID-19 generated recession is the fastest, steepest decline in “consensus growth” among all the global recessions since 1990. Along with the growing number of the human toll and economic damage it has even pushed organizations to seek a “New Normal” scenario. The SC losses resulted from this pandemic outbreak is directly related to the lockdown and control measures adopted by countries around the globe (Guan et al., 2020). Claiming the complexity of modern SC and loopholes of sourcing strategies as the most influential cause SC experts expressed that organizations should have rooted out faced issues a long time ago (Linton and Vakil, 2020a). To that end, this research has successfully developed a set of compelling strategies along with an action plan for rebuilding the injured SC in a more resilient and agile nature.

A very interesting literature analysis has been executed for analyzing the fatality of a pandemic on SC structure. Followed by this, how the COVID-19 pandemic has affected SC has also been analyzed. At the same time, a plausible set of SC rebuilding strategies and action plans were also developed through a dynamic data analysis process. The executed research process investigated the effectiveness of ISs and strategies through a single round Delphi study whose participants are all either well-renowned experts or practitioners on the subject matter. Scarcity of research documents on the previous pandemic related SCD and the novelty of the developed situation has driven the research to rely on recently published expert interviews, webinars reports from renowned organizations, and subject matter related magazines and articles. However, the feedback from Delphi research participants strongly justifies the effectiveness of drafted strategies and action plans for developing a pandemic adaptive SC. The managerial implication, the scope of future research, and limitations of the study have been discussed in the following chapters.

5.1. Contribution to Supply Chain Management

The study itself is a unique one by its very nature. This research is first of its kind in the field of development of a pandemic adaptive supply chain and it can be assumed that such a study will be a strong foundation for future exploration on the topic matter. Furthermore, throughout the whole study, it has appeared multiple times that there exists

a surprising research gap in the field of pandemic related SCD and to that end, this research successfully explored and introduced different dimensions of SCD due to COVID-19. Such analysis surely is an eye-opener for SC practitioners and also for the field of SCRM. On these notes, such inclusion of knowledge in the field of SCM is very crucial.

The crafted five strategies and associated seventeen ISs have drafted a strong guideline for developing a pandemic adaptive SC, which has never been explored before. Although many experts have conveyed similar notions multiple times previously, this is the very first research which tried to collect all the suggestions from renowned experts and practitioners and validated the final suggestions through a Delphi study. No researches till now have introduced guidelines from the practical point of view for building a true effective SC with a strong justification like this study which is an interesting addition in the world of SCM.

Issues like too much confidence in traditional highly efficient SCM schemes, excessive focus on cost management, and outsourcing have also been brought under question when the cause of SCD due to COVID-19 came under investigation. To that end, this research also introduced literacy on the fact that how a true sustainable SC should be built upon and why many actions of the generic SCM paradigms are increasing the SCD risks. The importance of critical suppliers has been echoed many times throughout the study and it has been identified that a truly agile and resilient SC should have adequate contingency plans for such supply and suppliers.

5.2. Managerial Implications

COVID-19 pandemic, just like any other epidemic has developed a unique genre of SCDs, through its pandemic outbreak propagation, unpredictable scale of impact, and simultaneous disruption propagation (Ivanov, 2020). Hence, developing an adequate reaction plan for such a scenario is very complicated. However, this pandemic has changed the global business dimension, highlighting the importance of being flexible, agile, and resilient (Hedwall, 2020). Hence, along with the passing days, eyeing towards recovery, supply chain resiliency, and risk management are being considered as key issues for long term sustainability (Hedwall, 2020). Organizations need a set of guided actionable plans so that similar adverse scenarios can be avoided in the future and SCDs' can be triumphed.

On this ground, this research has explained in the simplest possible terminology that how extremely a low frequency high impactful event like a pandemic can initiate SCD.

The comparative picture between generic risks and pandemic is very thought-provoking towards developing a well-balanced SCRM program. To that end, the literature review of the thesis successfully raised the awareness of the Ripple effect and any managers can easily understand the magnitude of risks related to events like the COVID-19 pandemic.

The ability to sense possible SCDs and analyze different scenarios of such is always lucrative for the SC managers and practitioners (Ivanov and Dolgui, 2020). However, guidance towards constructing a pandemic adaptive supply chain has not been drafted that many because of the very absence of such a global event. To that end, the proposed five strategies along with their well-justified seventeen action plans (i.e. the Identified Suggestions or ISs) can surely be proposed as a guideline for rebuilding SC in a more agile resilient and pandemic proof manner.

Most interestingly this research has brought light to the fact that excessive fondness towards many of the popular notions like outsourcing, leanness, and different cost-saving operational activities acts as catalysts for such scaled SCD. Having said that, this research has also identified that a notion of thinking beyond costing has to be developed if a business wants to be sustainable. Active SCRM and meaningful visibility over the whole SC and its operation with the effective utilization of modern technology have been proposed by most of the experts and SC managers have to focus on these as soon as possible.

The breadth of supplier relationship management and their types for different suppliers can only be figured out after achieving total visibility over SC. Hence, utilization of the Kraljic matrix for defining the extent of supplier relationship management has also been discussed. Although it can be suggested that strategies like supply chain visibility improvement and improved relationships with suppliers can be a quick kick-off point for the managers. However, it is still the responsibility of SC managers to define the scope of each strategy for their organization and also how aligned they are with existing business strategy.

Moreover, many of the suggested strategies and action plans can already be in operations for many organizations, so the management just might need to tweak them a little for a sake of the greater picture. The importance of timeliness of implementation of these strategies has also been discussed and it has been also suggested that the managers need to start rebuilding their SC as soon as possible. Proactive preparedness along with efficient reactive responses holds the key to success in a similar future scenario.

The importance of supply chain risk management (SCRM) has come to vicinity in recent months and to sustain, every organization needs to develop a sturdy SC (Hart, 2020). Strategic SC planning relating to corporate strategy can guide SC managers for efficient decision making (Piller, 2020b).

5.3. Scope of Future Research

The idea and scope of this research were bound within the exploration of the pandemic adaptive SC structure. After careful analysis of available associated resources and different suggestions from experts, a set of strategies consisting of defined action plans were developed and validated through a Delphi study. However, it was understood from the data analysis that the action plans (i.e. ISs) suggested by the experts are on many levels interrelated. For example, IS2- considering the ecosystem is a part of IS1- developing ecosystem or IS6- next shoring can be considered as an extended part of IS5- supply chain redundancy and multishoring. To that end, exploring the degree of interrelation among the ISs could be a fantastic research topic.

Furthermore, the very nature of the ISs suggests that there exists a very interesting scope of research for identifying the sequence of implementation of such. To that end, which strategies need to be adopted first or last can also be analyzed considering implementation time. For example, if an organization wants to start rebuilding its supply chain during this pandemic which strategy should get priority and why. Many ideations came into vicinity during the research but only a few white papers suggested what should be done but not their implementation sequence. To that end, the sequence of implementation of these strategies could also be a very lucrative research opportunity.

5.4. Limitation of the Study

The major limitation of this study is the absence of previous research on the subject matter. Pandemics are not a regular event and during the last pandemic, the whole structure of the business world was different than now, which also makes them incomparable. Furthermore, as the treatment of COVID-19 is yet to be finalized, and the second wave of the pandemic is taking place around the globe, a complete picture of the havoc is far from understanding. Furthermore, if the pandemic continues for a long time there would be a huge change in overall business structure and the appropriateness of this study then will surely be limited.

The study has been executed in the mid of the pandemic outbreak and most of the communication for the Delphi study has been performed through email. Considering the

social and economic strife, the lower number of responses can be justified. However, it also can be predicted that in an improved normal condition the number of responses could have been much higher along with more intuitive judgments. Furthermore, the study also has not explored the dimension of interaction among the ISs, which could have yielded a more refined picture.

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7. APPENDIX A: SUMMARY OF EXPERT OPINION

		List of Experts				
		1	2	3	4	5
Sl.	Details of Identified Suggestions (IS)	Andreas Größler	Andreas Wieland	Anna Nagurney	Bindiya Vakil	Bob Trebilcock
IS1	Developing Ecosystem (Thinking Beyond Costing)	✓	✓		✓	✓
IS2	Considering the Ecosystem		✓	✓		✓
IS3	Supplier's Fitness Testing		✓		✓	
IS4	Keeping Suppliers Afloat				✓	
IS5	Supply Chain Redundancy & Multishoring			✓	✓	✓
IS6	Next-shoring			✓	✓	
IS7	Development of Ramp-up Capacity					
IS8	Hybrid Supply Chain System					
IS9	Stockpiling Humanitarian Relief Products					
IS10	Supply Chain Stress Test					
IS11	Identification of Critical Items & Suppliers	✓			✓	✓
IS12	Reduced Offshoring & Localizing Supply Chain					✓
IS13	Active Supply Chain Risk Management Along with Crisis Management Taskforce	✓	✓		✓	
IS14	Thorough Mapping of Supply Chain Along with Supplier's Asset Mapping		✓		✓	✓
IS15	Supplier Ranking	✓			✓	
IS16	Integrated IT and ERP system			✓	✓	
IS17	Innovation & AI		✓	✓	✓	

APPENDIX A: CONT.

		List of Experts				
		6	7	8	9	10
Sl.	Details of Identified Suggestions (IS)	Christopher S. Tang	Dale Rogers	David Simchi-Levi	Famatta Mensah	Finn Wynstra
IS1	Developing Ecosystem (Thinking Beyond Costing)	✓	✓		✓	✓
IS2	Considering the Ecosystem	✓		✓	✓	
IS3	Supplier's Fitness Testing		✓			✓
IS4	Keeping Suppliers Afloat	✓				✓
IS5	Supply Chain Redundancy & Multishoring	✓			✓	✓
IS6	Next-shoring	✓	✓			
IS7	Development of Ramp-up Capacity	✓			✓	
IS8	Hybrid Supply Chain System	✓				✓
IS9	Stockpiling Humanitarian Relief Products	✓			✓	
IS10	Supply Chain Stress Test			✓		
IS11	Identification of Critical Items & Suppliers	✓	✓			
IS12	Reduced Offshoring & Localizing Supply Chain	✓				
IS13	Active Supply Chain Risk Management Along with Crisis Management Taskforce		✓	✓	✓	✓
IS14	Thorough Mapping of Supply Chain Along with Supplier's Asset Mapping	✓	✓		✓	✓
IS15	Supplier Ranking		✓		✓	
IS16	Integrated IT and ERP system					
IS17	Innovation & AI	✓				

APPENDIX A: CONT.

		List of Experts				
		11	12	13	14	15
Sl.	Details of Identified Suggestions (IS)	Goker Aydin	John Knapp	John V. Gray	Kevin Sneader	Marianne Jahre
IS1	Developing Ecosystem (Thinking Beyond Costing)		✓	✓	✓	✓
IS2	Considering the Ecosystem	✓	✓		✓	
IS3	Supplier's Fitness Testing			✓	✓	
IS4	Keeping Suppliers Afloat			✓		
IS5	Supply Chain Redundancy & Multishoring	✓	✓	✓	✓	✓
IS6	Next-shoring				✓	
IS7	Development of Ramp-up Capacity		✓			
IS8	Hybrid Supply Chain System			✓		
IS9	Stockpiling Humanitarian Relief Products		✓		✓	✓
IS10	Supply Chain Stress Test					
IS11	Identification of Critical Items & Suppliers				✓	
IS12	Reduced Offshoring & Localizing Supply Chain	✓			✓	
IS13	Active Supply Chain Risk Management Along with Crisis Management Taskforce		✓	✓	✓	✓
IS14	Thorough Mapping of Supply Chain Along with Supplier's Asset Mapping		✓	✓		
IS15	Supplier Ranking		✓			
IS16	Integrated IT and ERP system				✓	
IS17	Innovation & AI				✓	

APPENDIX A: CONT.

		List of Experts				
		16	17	18	19	20
Sl.	Details of Identified Suggestions (IS)	Nick Vyas	Peter Ward	Pinar Keskinocak	Sarah Kaplan	Shubham Singhal
IS1	Developing Ecosystem (Thinking Beyond Costing)	✓	✓		✓	✓
IS2	Considering the Ecosystem		✓	✓	✓	✓
IS3	Supplier's Fitness Testing					✓
IS4	Keeping Suppliers Afloat				✓	
IS5	Supply Chain Redundancy & Multishoring	✓	✓	✓		✓
IS6	Next-shoring					✓
IS7	Development of Ramp-up Capacity		✓			
IS8	Hybrid Supply Chain System	✓				
IS9	Stockpiling Humanitarian Relief Products	✓	✓	✓		✓
IS10	Supply Chain Stress Test					
IS11	Identification of Critical Items & Suppliers	✓	✓	✓		✓
IS12	Reduced Offshoring & Localizing Supply Chain				✓	✓
IS13	Active Supply Chain Risk Management Along with Crisis Management Taskforce	✓			✓	✓
IS14	Thorough Mapping of Supply Chain Along with Supplier's Asset Mapping	✓		✓	✓	
IS15	Supplier Ranking					
IS16	Integrated IT and ERP system				✓	✓
IS17	Innovation & AI			✓	✓	✓

APPENDIX A: CONT.

Sl.	Details of Identified Suggestions (IS)	List of Experts				
		16	17	18	19	20
		Thomas Y. Choi	Tim Kraft	Tom Linton	Torbjørn Netland	Yossi Sheffi
IS1	Developing Ecosystem (Thinking Beyond Costing)	✓	✓	✓	✓	
IS2	Considering the Ecosystem		✓		✓	✓
IS3	Supplier's Fitness Testing	✓		✓		
IS4	Keeping Suppliers Afloat		✓	✓		
IS5	Supply Chain Redundancy & Multishoring		✓	✓	✓	
IS6	Next-shoring	✓		✓		
IS7	Development of Ramp-up Capacity					✓
IS8	Hybrid Supply Chain System			✓		
IS9	Stockpiling Humanitarian Relief Products				✓	
IS10	Supply Chain Stress Test					
IS11	Identification of Critical Items & Suppliers	✓		✓	✓	✓
IS12	Reduced Offshoring & Localizing Supply Chain				✓	
IS13	Active Supply Chain Risk Management Along with Crisis Management Taskforce	✓		✓	✓	✓
IS14	Thorough Mapping of Supply Chain Along with Supplier's Asset Mapping	✓		✓		✓
IS15	Supplier Ranking	✓		✓		
IS16	Integrated IT and ERP system			✓		
IS17	Innovation & AI			✓		✓

8. APPENDIX B: STRATEGIES & ACTION PLAN FOR SC REBUILDING

	<i>Strategy</i>	<i>Sl.</i>	<i>Suggestion</i>	<i>Details</i>
1	Improved Supplier Relationship Management	IS1	Developing Ecosystem (Thinking Beyond Costing)	A healthy relationship with suppliers-built on trust. Supporting and collaborating with suppliers to build up their capacity and ensuring end-to-end value creation and optimization.
		IS11	Considering the Environment and Politics	Global Supply Chain Redesigning considering Environmental and Political Issues
		IS12	Collaboration with the local community	Consideration and collaboration with communities associated with a different part of an organization's global supply chain is important for redesigning
		IS2	Collaboration with local govt.	Collaboration among Govt. and private sectors to draft a coordinated plan of action and maintaining it throughout their tenure of operation. Furthermore, Govt. needs to ensure incentives for all the organization so that the financial burden of reformation can be felt lessened by the organizations
		IS20	Supplier's Fitness	All the contractors need to develop and submit their Risk planning scheme (including knowing the performance, financial, and compliance record of all their subcontractors, as well as their capacity and inventories) as proof of eligibility.
		IS25	Keeping suppliers afloat	Faster invoice payment, increased and relaxed payment terms, loans or financial support packages for SMEs

APPENDIX B: CONT.

	<i>Strategy</i>	<i>Sl.</i>	<i>Suggestion</i>	<i>Details</i>
2	Supply Chain Capability Improvement	IS10	Supply Chain Redundancy	Ensuring multiple sources for procurement and maintaining a strong legal relationship with them so that suppliers can be switched quickly when it's needed. Furthermore, creating or keeping excess capacity or back-up over the entire supply chain to maintain their regular functions in the event of any untoward incident leading to disruptions.
		IS19	Multishoring	The reduction of risk by avoiding being dependent on any single source of supply.
		IS21	Next-shoring	This perspective allows for future sourcing based on proximity to demand and proximity to innovation. Next-shoring strategies encompass elements such as a diverse and agile set of production locations, a rich network of innovation-oriented partnerships, and a strong focus on technical skills. It is crucial in a world where evolving demand from new markets places a premium on the ability to adapt products to different regions and where emerging technologies that could disrupt costs and processes are making new supply ecosystems a differentiator.
		IS26	Agility	ability to quickly adjust tactics and operations within its supply chain
		IS27	Lean	Being customer focus, having short lead times, and a culture of continuous improvement
		IS5	Development of Ramp up capacity	Development of ramp up capacity of locally manufactured critical products in a time of distress
		IS6	Hybrid Supply Chain System	Domestic supply chain and global supply chain running parallel
		IS7	Stockpiling humanitarian relief products	Arrangement of a suitable stockpile of humanitarian relief products so that in time they can be accessed quickly

APPENDIX B: CONT.

	<i>Strategy</i>	<i>Sl.</i>	<i>Suggestion</i>	<i>Details</i>
3	Supply Chain Risk Management	IS13	Real-Life Case Analysis	Analysis of real-life case to explore different opportunities and through this brainstorming analysis of different options can be understood
		IS15	Crisis management taskforce	SC crisis management taskforce needs to be established to decrease reaction time with an increased capacity
		IS18	Reduced Offshoring	Improving the onshore capacity of manufacturing to achieve the competitive advantage of speed and reliability
		IS28	Supply Chain Stress Test	TTR (Time to recover)- the time for a node in SC to be restored to full functionality after a disruption. TTS (time to survive), the maximum duration that the supply chain can match supply with demand after a facility disruption. By quantifying each measure under different scenarios, a business can identify its ability to recover from a disaster. If the TTR for a given facility is greater than the TTS, the supply chain will not be able to match supply with demand unless a backup plan exists.
		IS3	Critical item and supplier identification	Identification of critical products along with suppliers (also could be Medical & humanitarian types), so that proper planning can be done for resourcing these items.
		IS4	Local sourcing of critical items	Developing supplier's capacity through collaboration so that critical items can be manufactured locally (at least in a minimum level)
		IS8	Active Supply Chain Risk Management	Including the Supply Chain Risk Management process in the organizational operational structure to ensure continuous identification, assessment, and mitigation of supply chain risks.

APPENDIX B: CONT.

	<i>Strategy</i>	<i>Sl.</i>	<i>Suggestion</i>	<i>Details</i>
4	Supply Chain Visibility Improvement	IS14	Supplier's suppliers	Increasing focus on secondary and Tertiary level supplier in SC. Visibility over their operation and assets needs to be maintained to identify anomaly and risk
		IS17	Thorough mapping of supply chain	Full and detailed visibility on the supply chain along with all its stakeholders needs to be identified
		IS22	Localizing Supply Chain	Localizing supply chains and creating more collaborative relationships with critical suppliers (digital capabilities or share freight capacity)
		IS23	Supplier Ranking	Ranking suppliers by their impact on revenue so that supports can be allocated accordingly
		IS24	Suppliers Asset Mapping	Mapping of suppliers' assets (manufacturing plant, warehouse, office, distribution sites), to ensure that they are not at one area (ensuring improved Geographic diversity)
5	Utilization of Technology & Innovation	IS16	Integrated IT and ERP system	Establishing an integrated IT and ERP system to improve visibility and communication with suppliers
		IS9	Innovation & AI	Implementing 3D printing, Robotics, Autonomous delivery, and transportation, IOT. Data analysis and AI-based decision support systems also need to be included.

9. APPENDIX C: DELPHI RESEARCH PARTICIPANTS

Sl.	Name of Delphi Study Participant	Details of Career	Content Link (Web)
1	Andreas Größler	Professor of Operations Management at the University of Stuttgart. He is involved with scientific research and teaching at university for more than 25 years. Along with consulting experience in various industries, his core competencies are on system dynamics modeling (training and consulting), sustainable operations strategy, and dynamic decision making.	https://www.researchgate.net/publication/343080982_No_back_to_normal_COVID-19_turns_Supply_Risk_Management_into_a_necessity
2	Andreas Wieland	Associate Professor of Supply Chain Management at Copenhagen Business School. His current research interests include resilient and socially responsible supply chains. He is the European Co-Editor of the Journal of Business Logistics.	https://scmresearch.org/2020/04/18/let-us-not-go-back-to-normal/ https://scmresearch.org/2020/03/18/supply-chain-resilience-and-covid-19/
3	Anna Nagurney	Nagurney is the Professor of John F. Smith Memorial, Isenberg School of Management, University of Massachusetts Amherst. She is a world-renowned expert, with over 200 journal articles and 14 books. At Isenberg, Nagurney teaches a course in humanitarian logistics and healthcare, at which she hosts practitioners who have been at the frontlines of disaster response	https://phys.org/news/2020-04-covid-chain-shortages-cold-medicine.html https://www.umass.edu/gateway/feature/covid-19-and-supply-chain
4	Bindiya Vakil	Supply chain risk management expert and innovator from Cisco, Flextronics, and MIT. Credited with bringing SCRM solutions to the mainstream since starting Resilinc in 2010. CEO of Resilinc, the world leader for supply chain visibility and resiliency intelligence and analytics.	https://hbr.org/2020/04/its-up-to-manufacturers-to-keep-their-suppliers-afloat
5	Bob Trebilcock	The editorial director of Supply Chain Management Review at Peerless Media. He has covered materials handling, technology, logistics, and supply chain topics for nearly 30 years. He is also the Executive Editor of Modern Materials Handling.	https://www.scmr.com/article/when_the_crisis_is_over_the_real_work_for_supply_chain_managers_will_begin/blogs
6	Christopher S. Tang	UCLA Distinguished Professor and the holder of the Edward W. Carter Chair in Business Administration. His research spans across different areas including global supply chain management, retail operations, and social business operations. He has co-edited 4 books, co-written 1 book, and published over 100 academic articles in research journals and management articles in the Wall Street Journal, Financial Times, and The Guardian.	https://www.anderson.ucla.edu/news-and-events/this-is-not-working https://www.youtube.com/watch?v=7MFHffFlaV4

Sl.	Name of Delphi Study Participant	Details of Career	Content Link (Web)
7	Dale Rogers	Professor of Supply Chain Management Department at Arizona State University's W.P. Carey School of Business. Dale Rogers is a leading professor in supply chain management and is the authority in the fields of sustainability and reverse logistics. Dale has extensive experience working with Fortune 500 companies in the US, as well as leading companies in Europe and South America.	https://hbr.org/2020/03/coronavirus-is-a-wake-up-call-for-supply-chain-management
8	David Simchi-Levi	MIT Professor of Business and Supply Chain Analytics and a Director of MIT Data Science Lab. He co-founded LogicTools, a provider of software for optimizing supply chains that are now part of IBM	https://hbr.org.cdn.ampproject.org/c/s/hbr.org/amp/2020/04/we-need-a-stress-test-for-critical-supply-chains
9	Famatta Mensah	Mensah is a consultant at Boston Consulting Group (BCG) for the greater Chicago region. She also worked as a senior financial analyst in P&G, Cincinnati.	https://www.bcg.com/publications/2020/cscos-transform-operations-post-covid-19
10	Finn Wynstra	Professor of purchasing and supply management in the Department of Technology and Operations Management, Rotterdam School of Management, Erasmus University.	https://www.scmr.com/article/covid-19_lessons_for_sourcing
11	Goker Aydin	Aydin is a professor of operations management at the Johns Hopkins Carey Business School whose research focuses on uncertainties in the supply chain.	https://phys.org/news/2020-04-covid-impacted-chains-world.html
12	John Knapp	Knapp is a Partner and Managing Director at The Boston Consulting Group). He is a core member of the Operations practice with specific expertise in Lean, Manufacturing, Production Systems, Network Design, and Supply Chain. His focus is on Consumer, Healthcare, and Industrial Goods.	https://www.bcg.com/publications/2020/cscos-transform-operations-post-covid-19.aspx
13	John V. Gray	Gray is a professor of operations and the associate director of the Center for Operational Excellence at the Fisher College of Business, The Ohio State University.	https://sites.utu.fi/covid-supply-chains/prof-john-v-gray-prof-finn-wynstra-covid-19-lessons-for-sourcing/
14	Kevin Sneider	The Global Managing Partner of McKinsey & Company. He has been involved in research efforts on global economic and business trends, productivity growth, and innovation in China and Asia, as well as gender and diversity.	https://www.mckinsey.com/featured-insights/leadership/from-thinking-about-the-next-normal-to-making-it-work-what-to-stop-start-and-accelerate
15	Marianne Jahre	Jahre is a logistics professor and the associate dean for the MSc in Business at BI Norwegian Business School. She has been researching and teaching in logistics and supply chain management for more than 30 years	https://www.businessbcause.com/news/coronavirus-latest/6977/3-supply-chain-lessons-coronavirus-crisis

Sl.	Name of Delphi Study Participant	Details of Career	Content Link (Web)
16	Nick Vyas	An assistant professor of clinical data sciences and operations and the academic director for USC Marshall's master's program in global supply chain management. He is a known practitioner in operations management and Enterprise excellence through the application of Blended Quality Management, emerging technologies (AI, ML, RPA, Blockchain,) and Data Analytics.	https://news.usc.edu/166804/coronavirus-global-supply-chain-economy-nick-vyas-usc-marshall/
17	Peter Ward	Professor of Operations Management and holds the Richard M. Ross Chair in Management at Ohio State University's Fisher College of Business. He is the founder of the Lean Education Academic Network (LEAN), a global community of university educators dedicated to teaching systems thinking in universities.	https://fisher.osu.edu/bl ogs/opex/2020/04/22/covid19-supplies-just-in-time-or-just-too-late
18	Pinar Keskinocak	William W. George Chair and Professor in the School of Industrial and Systems Engineering and the co-founder and Director of the Center for Humanitarian Systems at Georgia Tech. She also serves as the College of Engineering ADVANCE Professor. Her research focuses on applications of operations research and management science with societal impact (particularly health and humanitarian applications), supply chain management, revenue management, and logistics/transportation.	https://www.forbes.com/sites/stevebanker/2020/03/28/how-fast-can-the-us-go-back-to-work/
19	Sarah Kaplan	Professor and Director, Institute for Gender and the Economy, at the University of Toronto's Rotman School of Management. She is also the author of the bestseller "Creative Destruction" & "The 360° Corporation: From Stakeholder Trade-offs to Transformation."	https://www.fastcompany.com/90504151/what-it-means-for-businesses-to-build-back-better-after-covid-19
20	Shubham Singhal	Senior Partner and Global Leader of the Healthcare Systems & Services Practice, McKinsey & Company. He serves healthcare organizations and institutions on all top-management agenda topics, with a primary focus on corporate and growth strategy, business building, and large-scale performance transformation.	https://www.mckinsey.com/featured-insights/leadership/from-thinking-about-the-next-normal-to-making-it-work-what-to-stop-start-and-accelerate
21	Thomas Y. Choi	Professor of supply chain management at Arizona State University's W. P. Carey School of Business. He is co-director of Complex Adaptive Supply Networks Research Accelerator (CASN-RA)	https://hbr.org/2020/03/coronavirus-is-a-wake-up-call-for-supply-chain-management
22	Tim Kraft	Asst. Professor at Poole College of Management (NC State Univ.) and Associate Research Director at Supply Chain Resource Cooperative.	https://phys.org/news/2020-04-covid-highlights-importance-agility-chains.html

Sl.	<i>Name of Delphi Study Participant</i>	<i>Details of Career</i>	<i>Content Link (Web)</i>
23	Tom Linton	Chief Procurement and Supply Chain Officer at Flextronics. He is also an Author, Speaker, Digital Supply Chain Innovator possessing extensive global supply chain and procurement experience in international roles from Asia: Japan, Singapore, and Korea. He is a very well recognized Industry and Functional expert.	https://hbr.org/2020/03/coronavirus-is-proving-that-we-need-more-resilient-supply-chains
24	Torbjørn Netland	Chair of Production and Operations Management at ETH Zurich. He is editor of the Routledge Companion to Lean Management, a recent Shingo Research Award recipient. His research on productivity improvement is performed in close cooperation with global companies.	https://www.staufen.ag/en/company/news-events/news/newsdetail/2020/04/consequences-of-the-corona-pandemic-interview-with-eth-professor-dr-torbjoern-netland/
25	Yossi Sheffi	Dr. Yossi Sheffi is a professor at the Massachusetts Institute of Technology, where he serves as Director of the MIT Center for Transportation and Logistics (MIT CTL). He is an expert in systems optimization, risk analysis, and supply chain management, which are the subjects he teaches and researches at MIT.	https://www.scmr.com/article/covid-19-lessons-for-sourcing

10. APPENDIX D: SAMPLE EMAIL TO DELPHI RESEARCH PARTICIPANTS

Sample Cover Letter

Dear "X",

I am a master's degree student in Industrial Engineering & Management at Tampere University, Finland. For the completion of my master's degree thesis, I have been researching the topic "Supply Chain Disruption & Plausible Solutions during the COVID-19 Pandemic."

For this purpose, I have collected and compiled the opinions (including yours) of close to 30 professors at universities in Europe and the U.S. using popular magazine articles, interviews, news articles, articles in journals, and university posts to identify what supply chain practitioners and academics suggest to tackle the supply chain disruption due to the COVID-19 pandemic outbreak.

The table below briefly describes all the identified suggestions (IS). The suggestions are classified under different strategies to rebuild the supply chain in the post-COVID-19 pandemic.

To clarify and validate my conclusion, I am sharing the results with all chosen professors, including you. I would greatly appreciate it if you could kindly provide your feedback regarding mentioned "Strategies" and "IS", so that I can develop a report that will be useful for companies' managers and for further analysis by supply chain experts. Furthermore, you are also welcomed to suggest anything crucial, if I have missed any.

Thank you in advance for providing your feedback. Please do not hesitate to contact me if you need further clarification.

Table of "Appendix B"