

# Decision-making models for a resilient supply chain in FMCG companies during a pandemic: A systematic literature review

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**Abstract** - Decision-making during a crisis impacts the performance of an entire organization. Due to the COVID-19 pandemic, many organizations had undergone supply chain disruptions due to the forward and backward propagation of disruptions in the global supply chain networks, implying the importance of building up resilience in the supply chain networks. This study intends to systematically review the existing literature to determine the impact of optimal decision-making during crises to build up supply chain resilience. The paper has focused on the need for evaluating the impact of the COVID-19 pandemic on the FMCG industry and how supply chain resilience would improve in performance during such crises. The study also assessed the existing decision support systems for resilience in a supply chain network and their applicability during a crisis. Some of these models could be used to facilitate decision-making during an epidemic as well. Precisely determining resilience factors affected during an unexpected circumstance would enhance the value of the decision support system in use. Furthermore, it was concluded that the use of quantitative models should be further investigated, as most published work focuses on the conceptualization of a restricted number of resilience factors instead of the development of integrated, comprehensive approaches.

**Keywords** - decision-making, fast-moving consumer goods, resilient supply chains

## I. INTRODUCTION

The pandemics are of rare business calamities, but clear thinking and optimal decision-making with less reliable information are required for an organization to stay in operation, serving the highly fluctuating demands while harvesting the atypical advantages of competition during an epidemic outbreak. Mike Crum, a professor of supply chain management at Iowa State University, had stated to FM magazine once, 'The most resilient companies were the ones who had really embraced risk management planning, and had visibility into their whole supply chain network, not just their immediate suppliers' [1].

With the advent of e-commerce, cross-border business, and short-term delivery, organizations' supply chains have become increasingly complicated, global, and fragile. Numerous failures in the supply chain have been identified, exposing organizations to risk amid dynamic changes in client demand as well as the adoption of new technology breakthroughs. Earthquakes, floods, storms, factory fires,

machine failures, hurricanes, and other natural disasters are only a few examples of typical business disruptions [2].

During the COVID-19 pandemic, global supply networks are confronted with both a supply shortfall and a shrinking demand, resulting in disruptions propagating forward and backward. For example, the pandemic forced China to suspend operations in February and March 2020, significantly disrupting US and European manufacturers and shops due to supply shortages [3]. According to a report published by Fortune Magazine, 94% of the Fortune 1000 companies have been confronted with supply chain disruptions due to the pandemic during early 2020[4]. According to the reports from WHO, there had been 1438 epidemics reported between 2011 to 2018 [5]. Nevertheless, disruption due to COVID-19 pandemic is considered drastic, diverse, more acute, and harshly challenging compared to previous outbreaks such as SARS in 2003 and the H1N1 epidemic outbreak, which took place in 2009 [6]. This explains the challenging nature of the COVID-19 pandemic in every aspect of disruptions it has caused. Therefore, building strategies towards absorbing the impact promptly, would ensure that the organization can withstand any uncontrollable risk by reducing its impact.

Risk identification is usually the first step in traditional supply chain risk management, followed by various solutions for managing the identified risks. This strategy works well when dealing with ongoing or foreseeable disturbances, but it fails when dealing with sudden or unexpected situations. For the latter, it is critical for businesses to develop resilience that allows them to better prepare for and respond to unforeseen events [7]. Risk management decision-making is a process of selecting the best alternatives or ranking the alternatives for a specific risk management goal. The goal is to create, protect and enhance shareholder value by managing uncertainties influencing the achievements of the firm's objectives [8]. In practice, determining the best level of resilience is a crucial decision since over-capacity incurs unnecessary expenditures, and under-capacity exposes businesses to hazards [9].

Decision-making in large-scale organizations often gets restricted due to many reasons such as bounded rationality, confirmation bias, increase of commitment, process conflict and relationship conflict etc.[10], thus controlling the space for an optimal decision to be made. Out of many such reasons, unexpected events such as the pandemic of COVID-19 may implicate such restrictions in making the optimal decisions on behalf of an organization.

Therefore, the objectives of the study are to understand the concept of resilience in the domain of supply chain, to critically evaluate the relevance of decision making and its impact on building resilience in the supply chain and to evaluate existing decision models for supply chain resilience during normal times and times of crises for identifying their suitability to handle uncertainties during a pandemic.

## II. METHODOLOGY

The methodology introduced by Barbosa-Póvoa et al. [11] is adopted, and the following steps are followed to conduct a systematic literature review on the defined domain of study: Definition of study topics; examination of previous literature reviews; material-gathering; descriptive analysis; category selection; and material evaluation. Following research questions were defined to guide the study within the selected scope of decision-making towards supply chain resilience in FMCG companies during a pandemic.

### A. Research questions

1. How did COVID- 19 pandemic impact the global supply chain network?
2. How COVID-19 pandemic affected the FMCG industry within a developing economy?
3. What are the different characteristics of decision-making during uncertain times vs. normal times?
4. How does supply chain resilience support organizations during a crisis, such as a pandemic?
5. How can decision-making be impacting supply chain resilience?
6. What are the existing decision-making models which support supply chain resilience, and how are they applied?

### B. Previous literature reviews

The scientific publications here analyzed and studied in detail are the result of a search performed on the Scopus, IEEE Xplore, and ScienceDirect databases under the keyword searches; “supply chain” AND “resilience” AND review; “supply chain” AND “decision-making” AND review. Following literature reviews were analyzed in-depth in search of more relevant literature.

- M. S. Golan, L. H. Jernegan, and I. Linkov, “Trends and applications of resilience analytics in supply chain modeling: systematic literature review in the context of the COVID-19 pandemic,” *Environ. Syst. Decis.*, vol. 40, no. 2, pp. 222–243, 2020, doi: 10.1007/s10669-020-09777-w.
- Pires Ribeiro, J., & Barbosa-Povoa, A. (2018). Supply Chain Resilience: Definitions and quantitative modeling approaches – A literature review. *Computers and Industrial Engineering*, 115(May 2017), 109–122. <https://doi.org/10.1016/j.cie.2017.11.006>

After a content analysis, it was decided to exclude several papers at this stage, eliminating those that

did not cooperate explicitly with SC Resilience or were not classified as reviews.

### C. Material collection

The related studies were mainly selected using Scopus and ScienceDirect databases. Initially, a collection of 83 literature was found through keyword searches, including: “supply chain” AND resilience; “supply chain” AND resilience AND decision-making models; “supply chain” AND resilience AND decision support systems; “supply chain” AND decision-making models; “supply chain” AND resilience AND decision optimization models, etc.

### D. Descriptive analysis

An in-depth analysis of content was conducted to restrict the selected literature strictly to the defined domain. The intersection of each publication's content with the set conditions was made possible through the content analysis, and the relevance of each paper was determined. This resulted in a selected number of articles, totaling 47.

### E. Category selection

To collect information from many sources and positively approach the research questions, the information from the analyzed literature must be compatible with the research objectives. Therefore, the analyzed publications were organized into three categories,

1. Scope of supply chain disruption discussed (pandemic, epidemic, general disruption)
2. The approach of the study towards supply chain resilience (Qualitative, Quantitative, Case Study etc.)
3. Decision level the model supports (Strategic, Managerial, Operational)

## III. RESULTS OF THE LITERATURE REVIEW

This section focuses on systematically reviewing the existing literature on the following four subcategories: (a) Impact of the COVID- 19 pandemic on the overall supply chain and FMCG industry. (b) Decision-making during uncertain times and its specialties. (c) Resilience concept in supply chain. (d) A review on existing DM models for crisis management or resilience in the supply chain.

### A. Impact of the COVID- 19 pandemic on overall supply chain and FMCG industry

COVID- 19 is categorized under low frequency, high impact risks in the risk matrix. During the COVID-19 pandemic, global supply networks are confronted with both a supply shortfall and a shrinking demand, which could result in disruptions propagating forward and backward [3].

Reference [12] examined the effects of the COVID-19 pandemic on food supply networks, concluding that demand and supply shocks resulting from a pandemic are caused by a shift in consumer behavior. For example, demand shocks were generated by the quick panic buying shift to ready-meals, which resulted in labor shortages and transportation network disruptions. Further supply-side shocks to food supply chains were caused by restrictions on cross-border goods movement. As a result, it is plausible to expect COVID-19 to have a long-term impact on consumer behavior and supplier chains [13]. Hence, there is enough evidence to determine that a considerable percentage of

consumers would be comfortable in e-commerce practices in the long run thus, resulting in re-engineering of traditional supply chain practices and building up readiness models towards strong e-commerce networks to adjust and sustain in the e-commerce markets. This would be majorly applicable for large-scale FMCG companies which inherit complex traditional supply chain networks.

The strict restrictions imposed by the Sri Lankan government during the first phase of the COVID-19 pandemic had severely impacted the Sri Lankan trade. Thus, creating restrictions to perform on full capacity at the production facilities, halting production for some time due to infected employees, and restrictions such as fully locking down the country. 156 categories of products, including vital food staples such as rice, grains, pasta, bread products, and liquor, were subjected to import restrictions until July 2020. On a three-month credit basis, items like milk powder, palm oil, red lentils, sugar, and sunflower oil were allowed to be imported [14]. According to reference [15] report on the performance of Sri Lankan trade during 2020, FMCG value sales in general trade in Q1 of 2020 have dropped by 11% compared to 2019 Q1 performance, as shown in Fig. 1. The report further discusses that Food and Beverage (F&B) had a lower impact among the FMCG Super Categories but had a decline in General Trade. Personal & Household Care purchases were de-prioritized in favor of Food & Beverage purchases. As a result, they observed a more significant drop in General Trade [15].

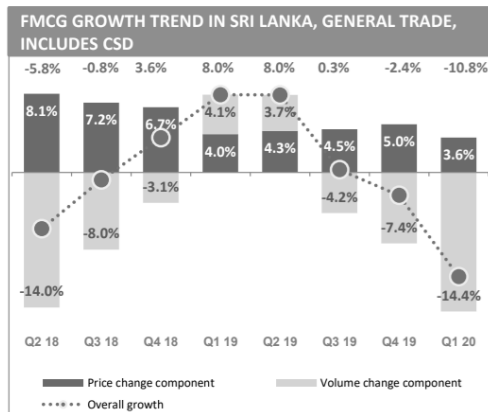


Fig. 1. FMCG Growth Trend in Sri Lanka, GT

The impact of disruption on the supply chain could be graphically represented as below in Fig. 2, where it describes there is a bounce-back period for any company, irrespective of the size of the organization [16]. Nevertheless, a company with solid financial backup and strategic background can bounce back at a high cost compared to an SME, as per the analysis.

Most of the companies faced significant difficulties in smoothing out the flow of their supply chain networks by coordinating with the suppliers, strategizing their production plans, and liaising with the government authorities on special permits to continue the logistics amidst the pandemic situation due to delays in shipments of raw material required for production, sudden closures from the end of their suppliers due to health emergencies and similar reasons.

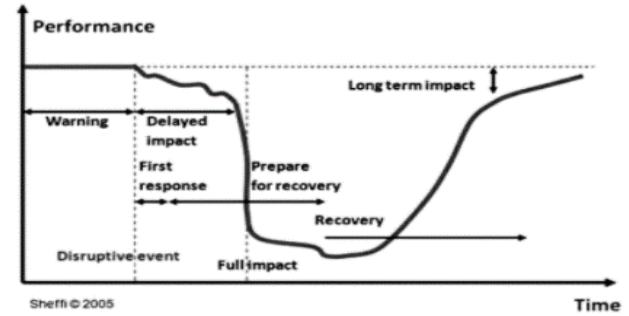


Fig. 2. Impact of disruption for supply chain

Manufacturers of beverages and foods have faced additional problems because of the COVID-19 epidemic. A lack of carbon dioxide because of lower ethanol production levels, resulting in increased carbon dioxide rates and causing disruption to beer and soda manufacturers, is one such example [17].

The extra health precautions such as random PCR tests, quarantining facilities for employees, and medical recovery support were necessary. At the same time, they incurred a vast amount of additional expense for the organizations. Hence, recovery from the COVID-19 pandemic could be relatively less chaotic for large-scale organizations due to scale and resources, given those proper recovery strategies being in place for any unexpected circumstances by utilizing the lessons learned from this pandemic.

### B. Decision making during “Normal” vs. uncertain times

A proper decision-making strategy amidst the situation is of vital importance to any business to perform better and gain a competitive advantage. The real challenge is when organizations are required to source, manufacture, coordinate with a vast network of suppliers, dealers, and retailers while operating in a low-margin market [18]. Given the “normal” business days, challenges related to a supply chain network could be predicted accurately to some extent and could be planned for but compared to disruption like the COVID-19 pandemic, “routine” decisions or objectives may not best suit the unexpected circumstances.

Complications, ambiguity, and failure to comprehend will be upsurge in times of calamity, while the ability to make prudent decisions will be weakened [19]. The impact of the COVID-19 pandemic on the supply chain was unique compared to other disruptions that had occurred due to its degree of unpredictability and the scope of impact. When China was first affected by this pandemic, the USA and other European countries were not expecting or rather not prepared for the ripple effect of the pandemic across the global value chain; thus, the impact was brutal. The forward and backward propagation of the impact of disruption in several nodes in the global supply chain network had adversely impacted the developing economies like Sri Lanka as well.

According to authors [20], Decisions “involve a commitment of large amounts of organizational resources for the fulfillment of organizational goals and purpose through appropriate means.”

Many businesses, large and small, will be too slow to keep up in a dynamic environment like the COVID-19

pandemic. During “normal” business days, delaying decisions to gather more information may make sense. However, when the situation is uncertain and defined by urgency and incomplete information, waiting to decide is a decision in itself. Organizations face a significant number of big-bet decisions when faced with a crisis of uncertainty, such as the COVID-19 pandemic, which arrived at breakneck speed and on a massive scale [21].

On the contrary, according to “prospect theory,” when things get rough, people’s aversion to risk decreases, causing them to make riskier judgments. The decision-making capacity might be reduced when the decision-makers are stressed. Thus emotional states of decision-makers are just as important as their reasoning ability [22]. Both studies insist on the fact that decision making during a crisis would have to be done with less information, certainly with a low degree of reliability, sometimes the usual data flow could be hindered due to many unpredictable circumstances, which then results in decision making with intuition and reasonable guessing.

The Cynefin framework in Fig. 3, which is based on mathematical theories of complex and chaotic systems, is another approach in Decision theories [22]. This is a sense-making paradigm for knowledge management that includes a typology that distinguishes between structured and unstructured decision situations. Although a pandemic is a decision context with inherent uncertainty, patterns do emerge according to this framework. Although the order cannot be predicted in advance, cause and effect can be determined after the fact. There is no emerging order in the chaotic environment, which is equally unstructured. When faced with a decision, the Cynefin framework gives a practical perspective that reminds decision-makers that the type of decision situation significantly impacts how it should be treated [22].

Nevertheless, according to reference [23], organizations that adopt clear values, are able to respond to strategic concerns, especially when faced with ambiguity, than those that rely on alternatives-focused decision-making based on clearly defined traits.

Keeney’s value-focused analysis also supports decision-making in both structured and unstructured contexts [23]. This framework is built based on principles and objectives rather than switching between alternatives (Fig. 4).

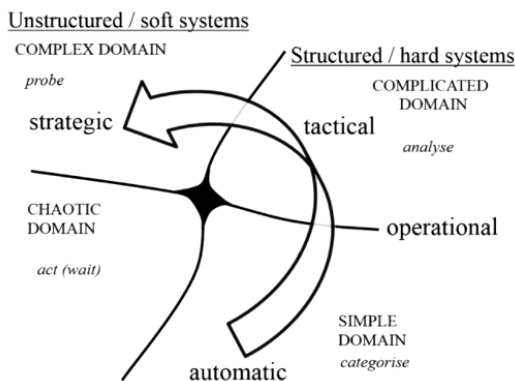


Fig. 3. Cynefin framework

As depicted by the framework in Fig. 4, if decisions are made in an unstructured manner, guiding principles or values may apply, making straightforwardness of leadership and organizational culture critical for the resilience of the supply chain.

Keeney shows that an alternatives-focus may be sufficient in structured domains. At the same time, values-focus may be useful in unstructured or complex structured domains when the cost of analysis is expensive [22]. Both the frameworks would be of importance depending on the company structure and type of crisis in consideration.

Strategies of reactive alternative-focused thinking and decision making, during an unexpected time especially, are said to be producing suboptimal results [24]. When faced with a critical decision point, even during “normal” times, many decision-makers are uninformed of all relevant objectives and the scope of the decision [25]. In the event of an unexpected catastrophe, the set of objectives is even more likely to be altered.

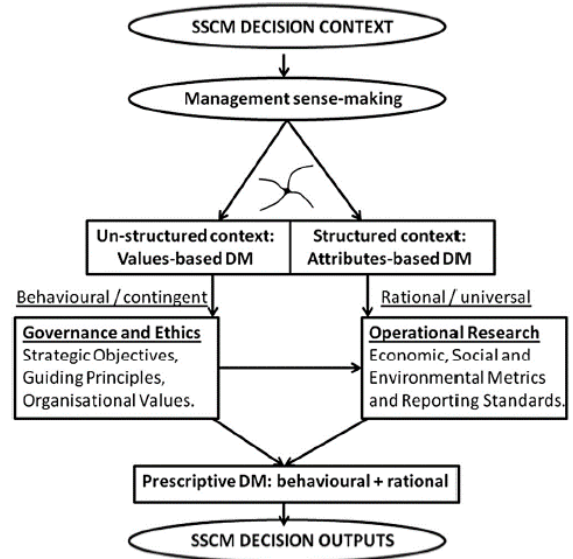


Fig.4. Keeney’s value focused analysis

Prolong suboptimal decisions would result in long recovery periods for organizations when they plan to bounce- back to normal from the pandemic. Thus, reaching optimality in decision making with available resources and information should aim for the organizations to survive another crisis.

The issues could be intensified by reactive and backward-oriented reasoning of the decision-makers [26]. A foresighted leadership is essential to support the management to recover with minimum time to normal. Hence, learned lessons should be carefully used in the strategy formulation process and in future risk management processes to improve the absorption of unexpected shocks on the supply chain network of an organization.

C. Overview of the resilience concept in “supply chain.”

There were several definitions of the word ‘resilience,’ and the following definition was selected to fit the context of the author’s research domain. Reference [27] defines resilience in the context of organizations as “The firm’s ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative

activities to capitalize on disruptive surprises that potentially threaten organization survival.” The reference [28] identified the following dimensions of resilience: efficiency, diversity, integration adaptability, flexibility, safety, mobility, and reliability which could be identified as some restorative resilience measures for a supply chain.

The robustness of a firm is also a widely discussed factor inside the domain of supply chain resilience, which describes “the ability of a supply chain to resist or avoid change” [29]. As a result, robust firms operate faster under adverse situations than less robust organizations, providing a competitive advantage. Because of the complexity and size of the supply chain in a large-scale organization, developing a completely resilient SC is a challenge. In reference [30], the authors discuss a few resilient strategies followed by some well-known global companies: Lean production with JIT delivery and low inventory, Six Sigma supply chain, increasing SC flexibility, and developing a strong corporate culture. However, not having a buffer stock when following JIT technique could be argued as not a wise choice for a resilient SC.

Furthermore, the reference [31] had highlighted the following critical factors in establishing a resilient strategy:

- Re-engineering the supply chain to build resilience into the system in advance of potential disruption.
- Establishing a high level of collaboration with supply chain parties to identify and manage risk.
- Achieving the agility necessary to respond quickly to the unexpected.
- Embedding a culture of risk management.

An embedded culture for risk management set by the tone from the top of a firm would enable a firm to plan and forecast risk with greater accuracy levels and facilitate higher business transformations such as business process re-engineering when required, in the necessary parts of the supply chain.

Resilient SCs may not be the cheapest, but they are better equipped to deal with the unpredictable business environment [32]. Enterprises that pursue a policy of ‘zero inventories,’ for example, are not resilient because they lack a stock buffer to respond to an unforeseen shortage of commodities caused by market unrest or volatility [31].

Further, the cost of reactive responses to disruption would be much more expensive than avoidance or mitigation through improved resilience in the supply chain network. Much of the previous understanding of what defines a resilient supply chain has been challenged by the severity of the business disruption caused by the COVID-19 pandemic. According to recent studies, the crisis has resulted in a rapid decline of several business and economic parameters, including productivity and global GDP [33].

As per risk identification matrices in management studies, the higher the impact and likelihood of a disruption higher the vulnerability of a system. Considering the COVID-19 pandemic, this is a high impact, less likelihood risk on the matrix, which sums up why most firms are not focused on pre-preparation for such calamities. The trick is to mitigate the adverse impact of such a calamity even at the propagating failures of other supply chains. Thus, it is

crucial to building up resilience as much as optimizing for the efficiency of a supply chain.

#### *D. A Review on Existing Decision Making Models for Crisis Management or Resilience in Supply Chain*

This section would mainly focus on reviewing existing decision support models and frameworks in the domains of supply chain resilience and crisis management in the supply chain. Thereby, the author expects to understand the gaps for research in the existing models and critically analyze factors considered, parameters used, and method of analysis in each of the models in review.

Firstly, in reference [2], the authors propose an ontology-based decision support system towards resilient supply chains by combining supply chain resilience decision-making with a rule-based ontological framework. The ontology is an explicit specification of a conceptualization that primarily aids in structuring data to enable interaction between various firms in a supply chain [2]. The concept of ontology has been employed by scholars in various fields, including manufacturing, medicine, supply chain, and material science.

Reference [2] has considered a three-echelon supply chain network in their mathematical model, which has been optimized under threat conditions by varying pre-defined parameters by interpreting from the rule base of the ontology. Using PSO-DE, an optimization technique, the problem is solved to determine the optimum collective decision for production and logistics units in the network to meet customer demand. The practicality of the model during a pandemic where demand is readily fluctuating is questionable.

Reference [34] has used an effective fuzzy linear programming approach for supply chain planning under uncertainty. Due to a lack of knowledge, the epistemic uncertainty sources in supply chain tactical planning problems are handled using the fuzzy model. Data from a genuine automobile supply chain was used to evaluate this model. This model could be further adapted to uncertainty in demand forecasting as well as this could be utilized to predict nearly accurate demand levels during an uncertain time.

Authors in reference [34] propose a decision support framework to assess supply chain resilience. The system will aid decision-making by allowing users to run “what-if” scenarios and see how different supply chain configurations affect the system’s expected resilience behavior. Finally, the costs and benefits of utilizing different supply chain resilience methods will be weighed. This decision support system mainly focuses on utilizing simulation in understanding redundant factors in the supply chain network.

Reference [35] had proposed the measure of recovery time as a measure of resilience in the supply chain network through their proposed survival model. The new metric is based on a semiparametric model called the CoxPH model. The variables in the Cox-PH model indicate various sources of disruption, the input variable represents an event (survival or resilience analysis failure event), and the output variable is time. However, this model carries few limitations in terms of the limited number of disruptions that could be catered in, the assumption that sources of disruptions being independent of each other, etc.

The study [37] discusses ways to identify and align decision-making objectives in response to the crisis circumstances such as the COVID-19 pandemic. In the study, decision-makers are presented with guidelines for identifying intra-organizational objectives and aligning them across the supply chain and with policymakers. The study has presented examples of intra-organizational and inter-organizational goals for both normal and crises. In addition, they outlined an iterative approach for regularly updating the objectives of an organization. This study would be considered as an inspiration for further analysis to be conducted by the author.

Reference [36] has considered a port closure interruption on either the supply or demand side of the supply chain in the research and created a two-stage stochastic programming model that includes an exponential perishability function and explores various potential objectives. These objectives are the expected profit (P) maximization, the recovery level (RL), and the lost profit during recovery. Thus, they propose a new resilience metric, namely NPV-LP, which is an integration of several other matrices.

#### IV. DISCUSSION

FMCG products usually carry a low shelf life. Hence the cycle of the product-to-market logistics must frequently happen, amidst any disruption, as the name suggests, "Fast Moving Consumer Goods." During the COVID -19 pandemic, FMCG companies in Sri Lanka observed a more significant drop in General Trade [15]. The main reasons identified through the study were poor strategic preparation for uncertain situations, less experience of the decision-makers, less reliability of information collected, slow collection of data, poor predictive models, and poor organizational vision and leadership. Therefore, it is evident that routine decision-making models should be optimized to address the absorption and recovery stages during a crisis.

The analyzed decision models in the domain of resilient supply chains had primarily focused on mathematical model development to support decision-making in the supply chain. Some models had used simulation techniques to bring in the randomness and unexpected nature of the environment to enhance the relevance of the models to real-world scenarios. Therefore, the discussed models will be applicable in other low frequency, and high impact risks and generalized risk mitigation approaches.

Regarding the applicability of the discussed models for a pandemic situation, the number of constraints considered reduces the practicality of those models. Also, it was concluded that only a few resilience measures or factors had been considered in the models analyzed. It would be more comprehensive if decision support models could incorporate diverse angles of resilience which could be sorted out according to the suitability of the factors or category of factors to a particular crisis. Future research could also focus on the qualitative nature of decision-making through learned lessons in the industry during the COVID- 19 pandemic. Future analysis could also focus on strengthening resilience in each node of a supply chain network or building resilience through integration. Therefore, further understanding of the qualitative aspects of decision making during the COVID- 19 pandemic on the

supply chain of the FMCG industry is focused by the author with the expectation of supporting literature on the research area explained above.

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