

## Supply Chain Disruptions: Challenges and Mitigation Strategies in Manufacturing Companies

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### Abstract:

*In recent years, the majority of companies have faced supply chain disruption which this disruption can influence daily operations, and financial as well as competitive development. The main explanation for this trend is organizations did not create dynamic skills or invest in disruption mitigation strategies to make their supply chains more robust and resilient. Previous research has primarily relied on the factors that contribute to the occurrence of supply chain disruption. Therefore, considering that making rapid decisions, and taking immediate actions was important to prepare for future supply chain disruptions. Hence, the purpose of this research is to identify the challenges faced by the supply chain during disruption and to determine suitable strategies to minimize the supply chain challenges. This study will employ a qualitative study using face-to-face and online interview methods. Researcher has collected data from 10 managers or employees who are proficient in supply chain management. Software "Excel" was used to code and analyze the collected data. The result shows companies face 14 challenges from 3 sides of supply chain, which is supply side, demand side and logistics side. The study further suggests 5 mitigation strategies to prepare for supply chain disruptions in the future. Finally, in this paper researcher provide guidelines and strategies for manufacturing companies to reduce the risk of supply chain disruption effectively.*

**Keywords:** Supply chain disruption, Supply chain challenges, Supply chain strategies, Strategies during disruption

### 1. Introduction

A supply chain is the network of people, companies, resources, activities, and technology involved in the manufacturing and distribution of a product (Lutkevich, 2020). On the other hand, the supply chain refers to the core manufacturing enterprise, which starts with raw materials or components and produces intermediate or final products. Moreover, delivers those products or services to customers through the sales network, linking suppliers, manufacturers, retailers, and end-users into a unified functional structure (Surbhi, 2018). Besides, the element of the supply chain begins with receiving an order from the customers and ends with fulfilling the requirement of the customer. Therefore, product development, marketing, operations, distribution networks, financing, and customer service are among these functions (Kenton, 2021).

Supply chain management (SCM) is the management of goods, information, and money as they flow from supplier to manufacturer to wholesaler to retailer to customer (Lutkevich, 2020). Besides, supply chain management is the management of the flow of products or services and it encompasses all procedures that transform raw materials into the final item. Thus, it relates to actively streamlining a company's supply-side processes to optimize customer value and obtain a competitive edge (Fernando, 2022). Besides, SCM is a critical part of all organizations. This is because supply chain management entails coordinating and integrating these processes both inside and across businesses, and there are numerous connections in this chain that necessitate ability and knowledge (Kenton, 2021).

#### 1.1 Research Background

Supply chain disruption can be categorized as an unknown risk. Besides, the timing and location are unexpected under this type of risk (Paul et al., 2021). In recent years, statistics show an increase in the number of unforeseen incidents and disasters. For example, Elliott et al. (2019) have recorded and reported such instances at an all-time high of 76.7% in recent years. These occurrences are called disruptions, and they range from mild to severe (Pavlov et al., 2019). These disruptions will affect the return on sales and profit, stock return, brand reputation, firm employment, the safety of buyers, and overall supply chain performance (Chowdhury et al., 2019). Although the majority of firms have a strong awareness of supply chain risk which is around 80% of firms are concerned about supply chain resilience, but over 60% of firms said they have not yet created and implemented appropriate supply

chain risk management strategies (Katsaliaki et al., 2022). As a result, risk management is an essential topic in supply chain management and has been the focus of research via reviews.

According to Yueh et al. (2019), reported the majority of firms will follow the disruption management process which includes discovery, recovery and redesign when a supply chain disruption happens. Therefore, this disruption management process is useful and aided by the company's previous risk management approach, which includes risk identification, assessment, mitigation, and monitoring (Tummala & Schoenherr, 2011). On the other hand, two useful strategies have been conducted by Messina et al. (2020), which are mitigation strategy and recovery strategies. A mitigation strategy is a countermeasure that must be prevented to deal with future disruptive events. While, recovery strategy is the action taken during the disruption for quick recovery.

## 1.2 Problem Statements

The supply chain disruptions have attracted the attention of academia and industry like the lack of readiness (Chang & Lin, 2019). According to Mitroff (2014), states that only 5% to 25% of Fortune 500 organizations are equipped to deal with crises or disruptions. As a consequence, the rest of the companies were lack of ability to deal with crises or disruptions. Supply chains as the lifeblood of every organization, and it is an ever-important cog in the gears. However, according to Crane (2022), mention the top supply chain challenges for 2021 were disruptions and shortages in the supply chain (57%), recruiting and keeping qualified employees (54%), customers wanting faster response times (51%) and situations of scarcity (48%).

The challenges of the supply chain disruption can be focused on three main perspectives, which are suppliers' perspective, buyers' perspective, and logistics' perspective (Mishra et al., 2021). From the buyers' perspective, manufacturing companies are facing limited production and delays in procuring goods and services (Butt, 2020). However, the supplying firms are facing increased lead times amid environmental disruptions. According to Raj et al. (2022), supplying firms are facing inconsistency in supply, scarcity of material, and scarcity of labor during the pandemic. From the logistics perspective, logistics companies are facing delays in delivery, vehicle unavailability and delay and constraint incapacity. Hence, the purpose of this research is to identify the challenges faced by the supply chain during disruption

In order to decrease the impact of supply chain disruption, companies have begun to engage in supply chain disruption management (Dubey et al., 2019). However, some of the firms did not create dynamic skills or invest in disruption mitigation strategies to make their supply chains more robust and resilient (Parast, 2021). According to BCI (2020), it is stated that 30% of companies do not investigate the source of supply chain disruptions. Besides, Tang (2018) states that were two reasons that caused a few companies to choose used insurance to protect their supply networks. First, due to the major disruption insurance premiums are excessively high and second is although insurance can help company stay financially viable after a severe disruption, but it cannot prevent a company from losing clients. As an illustration, Chen & Wang (2021) stated that most of the studies conducted are to determine the different discovery strategies by using a mathematical model. Thus, this research aimed to identify the strategies that are suitable for the company to minimize the supply chain challenges.

## 1.3 Research Questions

Based on the problem statement, the research questions of this research are:

- (i) What are the challenges faced by the supply chain during disruption?
- (ii) What strategies are suitable to minimize the supply chain challenges?

## 1.4 Research Objectives

Based on the research questions, the objectives of this research are:

- (i) To identify the challenges faced by the supply chain during disruption
- (ii) To determine suitable strategies to minimize the supply chain challenges.

## 2. Literature Review

The literature review examines the key concepts and approaches used in research, and there are two parts involved in this literature review. First, began with a discussion of the supply chain challenges during disruption and it will focus on three main side (supply, demand and logistics sides). Then, will focus on the suitable strategies used to reduce the risk of supply chain disruption.

### 2.1 Supply Chain Challenges During Disruption

The management of supply chain has become a huge challenge in the recent competitive business environment due to a complex international network is the result of increased supply and demand uncertainty, shorter technology and life cycles of product, market globalization, and increased use of distribution, manufacturing, and logistics partners (Panday & Biology, 2015). However, it is essential to comprehend this phenomenon since the negative impact may

worsen as the disturbance spreads. All disruption has varying degrees of impact on supply chain. The varying degrees is depending on the merit and severity of the disruption, which is either short, medium, or extended periods of disruption (Y. Li et al., 2021). Simply put, even a minor disruption can spread across whole supply chain and snowball in magnitude (Scheibe & Blackhurst, 2018).

*(a) Supply Side Challenges During Disruption*

Supply side disruption or supply-shock is an unplanned incident that disrupts the supply of a product or service, resulting in an unanticipated price adjustment. Generally, supply disruption will affect in the upstream part of a company, and it typically begins from an unexpected source (Rolfes, 2016). Therefore, firms could reduce supplier risk by enhancing supplier product quality and reducing uncertainties (Quigley et al., 2018). In addition, the financial stability and ability of a supplier will maintain a strong market position. Technically and financially are the significant determinants to manage supply risk (Wagner & Johnson, 2004).

Table 1 shows the supply side challenges during disruption. There are numerous challenges on supply side which indicated by previous research.

Table 1: Supply side challenges during disruption

NO	Supply side challenges during disruption:	Sarker et al. (2016)	Okorie et al. (2020)	Agrawal et al. (2020)	Razdan & Kumar (2020)	Deloitte, (2020)
1	Supplier's operational inefficiencies	√				
2	Product quality and quantity discrepancies	√				
3	Resorting suboptimal replacements				√	√
4	Supply inconsistency		√		√	
5	Logistics and transportation delays	√				
6	Weak coordination between a supplier and the firm	√				
7	Material shortage		√	√	√	√
8	Lack of worker		√	√		

Therefore, in this research, the researcher focuses on several challenges such as supply inconsistency, material shortage and lack of worker.

*i. Supply Inconsistency*

According to Okorie et al. (2020) stated that supply inconsistency occurs due to the limitation and unpredictability situation at the merchant's side which linked with the place fluctuations and the number of important commodities may lead to an inconsistent supply boundary. For example, during the pandemic, supply-side capacity constraints and price and quantity volatility are significant disruptors, and these challenges have serious impact on Micro, Small and Medium Enterprises (Razdan & Kumar, 2020). Furthermore, the supply chain is a network of several entities. Usually, focal enterprises have dependent on immediate suppliers. Mapping is essential for maintaining visibility throughout a supply chain network (Sodhi et al., 2021). However, most supply chain networks still lack of supply chain network mapping. While, lack of visibility across the supply chain will influence the consistency of supply in supply chain.

*ii. Material Shortage*

Usually, material shortage in the market will occur due to increase in demand caused by stockpiling and panic purchasing and coupled with unclear operational continuity at the supplier's end (Raj et al., 2022). For instance, the global market has become uncertain since the outbreak of the pandemic and the subsequent lockdown of several nations. The rise in demand for certain essentials as a result of panic buying, combined with the uncertainty of supply-side operations. It is regarded as a significant risk to the access of critical materials and services during and the wake of lockdown. (Razdan & Kumar, 2020). Next, scarcity of material brings a ripple effect to some of firm. Thus, firm decide to resorting suboptimal replacements (Deloitte, 2020). It is important that poor selections and substitutes may result in suboptimal product quality and may have huge effects on the supply chain, including rework, extra costs and increase the risk of losing consumers (Raj et al., 2022).

*iii. Lack of Worker*

According to Agarwal (2022), a shortage of production labour might cause shipping to distribution hubs to be

delayed, laying the stage for large delays later on. Each uncomplete position has the potential to raise prices and create uncertainty in the supply chain, potentially causing disruptions that would not have happened if the workers had been properly staffed and operational.

Therefore, manufacturers and businesses may find it very hard to operate without incurring significant financial losses as a result of these costly disruptions, since supply chain are very complicated systems that rely on several parties working together efficiently. When one part of the supply chain fails, the results can be disastrous for businesses all over the world. For instance, delays in transporting goods from manufacturers to distributors centers have caused a block in the logistics sector, such as warehouses, causing some shops to run out of inventory (Doyle, 2021).

#### (b) Demand Side Challenges During Disruption

Demand disruption can define as an occurrence that produces a significant and rapid change in consumer need patterns that surpasses the supply chain's ability to adapt (Smith, 2021). As a results, when demand exceeds the maximum of the supply chain, part of the demand will not be supplied, or will not be met in a timely manner. For instance, disruptions in product delivery to customers due to transportation delays or other logistical inefficiencies, as well as inconsistent and unpredictable client demand, can call as demand disruption (Katsaliaki et al., 2022).

##### i. Demand Variation

One of the challenges of demand disruption is demand variations, such as changes in the number of orders, a shorter life cycle of product, and the launch of new items (Ho et al., 2015). From the supply chain perspective, demand fluctuation at the final goods level causes the well-known "Bullwhip" impact upstream. This impact grows in proportion to the number of echelons between the end consumer and the supplier base. Whiles demand variation occurs due to irregularity and inconsistency in consumer orders as a result of fluctuations in purchasing behaviour. For instance, for the recent research show that during Covid-19 outbreak the attitude of panic buying cause volatility in supply chain demand (Gunesseea&Subramanianb, 2020). The demand and supply are an essential function in a supply chain. If a firms fail to balance the supply and demand, the demand disruption will occur. As a results, it will cause prediction error and ineffectiveness coordination in supply chain (Chen et al., 2013).

#### (c) Logistics Side Challenges During Disruption

According to the Council of Supply Chain Management Professionals (CSCMP), stated logistics management as "that section of supply chain management that prepares, implements and manage the efficient, effective forward and reverse flow and storage of products, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements".

Table 2 shows the logistic side challenges during disruption. There are numerous challenges on logistic side which indicated by previous research.

Table 2: Logistics side challenges during disruption

NO	Logistics side challenges during disruption:	Razdan & Kumar (2020)	Okorie et al. (2020)	Biswas & Das (2020)	Hippold (2020)	Gupta et al. (2020)	Campbell (2022)
1	Delay in the delivery			√	√		
2	Lack of warehouse space	√			√	√	
3	Labour scarcity		√	√			
4	Last-Mile Delivery Challenges	√				√	
5	Delays and vehicle unavailability			√	√		
6	Scarcity of trucker						√

Therefore, in this research, the researcher focuses on several challenges such as delay in the delivery, scarcity of trucker and last-mile delivery challenges.

##### i. Delay in The Delivery

Delay in the delivery means import and local transportation restrictions, coupled with certain routes requiring diversions owing to barred zones (Butt, 2021). According to the Raj et al. (2022) state that majority main issues of an organization is striking a balance between the time it takes to acquire, manufacture, and distribute goods to customer and the willingness of customers to wait. In addition, more of the customer are rarely willing to wait for lengthy periods of time, especially when replacement items are available in the market. Besides, the time takes for

purchase raw materials is in determination, due to it being dependent on external suppliers and hence beyond the organization's control. For instance, based on the current research, Hippold (2020) reported Covid-19 endemic has resulted in limitations on transportation and movement of commodities and supplies, particularly in restricted or containment zones. As a result, lead times have increased and affecting the delivery timelines of crucial raw materials and semi-finished items.

### *ii. Scarcity of Trucker*

The recent challenges in supply chain logistics is scarcity of trucker (Campbell, 2022). Freight companies play an important role in the delivery of products. When only few drivers on the road means only few items moving at any one period, and without consistent flows to and from warehouses, the entire chain suffers. The duration for the buyers to place an order and receive the order will become longer. At the same time, products may not arrive on schedule at retailer's warehouse, so it causes fewer stock able to sell.

### *iii. Last-Mile Delivery Challenges*

After the pandemic, majority companies have responded to consumer demands to reduce physical contact points and are observed revamping their supply chain. In order to attract more customers, brands are either changing to fully captive in-house delivery services or collaborating with partners for last-mile delivery (Razdan & Kumar, 2020). However, by using last-mile delivery it means that customers need to pay for expedited deliveries, but most companies find it difficult to execute in a lossless manner. Besides, the uncertainty in demand makes it increasingly challenging to make decisions on how much inventory to store, managing temporary workers, and other issues that contribute to overhead (Ross, 2021). Therefore, inadequate visibility is another challenge of last-mile delivery. Buyers would like to know exactly where their shipment is (they want to see every step of the last-mile process) and when it will arrive, all of the aforementioned variables have increased the difficulty of last-mile delivery.

## 2.3 Strategies to Minimize Supply Chain Disruption

Supply chain disruptions and strategies to mitigation are an urgent concern for today's supply managers (Vanpoucke & Ellis, 2020). According to the Ivanov et al., (2017), found there are two main strategies can used to deal with the risk of supply chain disruption, which are proactive and reactive. In addition, flexible supply chain is other strategies to minimize supply chain disruption (Tang, 2018).

### *(a) Proactive Strategy*

Proactive strategy means take action or preparation before a disruption happen. For instance, create a different strategy flow for risk management as well as proactive planning of catastrophic risk in the process of proactively planning. According of the Torabi et al. (2015), provided a bi-objective hybrid two-stage stochastic planning model to mitigate the impact of supply-side disruptions by using substitute suppliers or building a supplier continuity plan. An inventory model that improved the inventory plan was developed by considering some factors such as the inventory, supplier reliability, and the delivery capacity. (Islam et al., 2020). However, these proactive mitigation strategies are not suitable to solve those unexpected supply chain disruptions as well as develop redundancy or flexibility to a system can improve its resilience, doing so increases costs (Paul et al., 2019).

### *(b) Reactive Strategy*

Reactive strategy is more effective in enabling the supply chain to return to normal quickly after a system disruption (Kumar et al., 2016). According to Xia et al., (2004), a two-phase generic production and inventory disruption strategy was developed. It considered the cost of deviating from regular schedules after recovery and introduces the concept of an interrupt recovery time window. In order to minimise the expected total cost of ownership, Hishamuddin et al., (2012) extended the previous strategy and proposed an economic batch model based on disruption recovery method. The optimum size of manufacturing and the duration for recovery for a production line was determined. According to Ivanov & Rozhkov (2017), found that the risk of product shortages has been increase due to the disruption in production capacity. In the supply chain during and after disruption, coordinated policies were developed to solve this issue.

### *(c) Flexible Supply Chain*

Flexible supply chain can be defined as an organization can easily modify their production levels, raw-material acquisitions, and optimised their transport capacity. Generally, the common element that cause company fail flexible in their supply chain is using single-source supply. Although sourcing from a single supplier allows a company to save money, such as reduce the cost of supply management and reduce unit costs as a result of quantity discounts. However, it may cause difficulties in handling serious disruptions (Tang, 2018). While, flexible supply chain can be divided into two types, which are micro flexibility and macro flexibility. Micro flexibility means that how soon a supply chain can notice and deal to short-term problems. According to Sinha (2015), state that an organization with a high level of micro flexibility in its supply chain can solve spontaneous or unexpected challenges or opportunities soon and effectively. Therefore, macro flexibility is a vision of an organization's

strategies, programs, and policies. An organization with a macro-flexible supply chain system will be able to change current supply chains or create new supply networks to meet changed customer requirements.

### **3. Research Methodology**

This part explains about the research methodology used in the research by showing how the primary data and secondary data is obtained and analyzed by the researcher. Qualitative and interview method is being selected for this research. The topics covered in this section includes of the research design, population and sampling, data collection, research instrument and data analysis method.

#### **3.1 Research Design**

The qualitative method is selected to conduct in this research. Qualitative method can be determined as a capable of examining complicated situations and producing findings while recognizing the role of researcher in 'shaping' the research findings (Sutrisna, 2015). Besides, qualitative method focused on gathered and analyze words (spoken and written) and textual data. Therefore, a software such as Excel is used to code and let all analyst for automatically code transcripts. Once the analysis was completed, put them into a single document to compare the codes.

#### **3.2 Population and Sampling**

The population in this research was the managers who are familiar with the supply chain and working in manufacturing companies. The total respondent interviewed for this research was 10 people. Besides, snowball sampling method is used in this research. Snowball sampling was a non-probability method for acquiring a sample that uses participants to recruit additional participants.

#### **3.3 Data Collection**

A qualitative research methodology is used in this research for primary source of data collection from 10 different manufacturing companies. A face-to-face and online interview is conducted to discuss with the related respondents, and this interview is conducted with several open-ended questions related to this researcher. The respondents provided the data based on their experience and expertise.

#### **3.4 Research instrument**

In this research, the interview is conducted by using face to face method and digital technology (Google Meet). Before the interview, respondents received an email or WhatsApp regarding the interview questions and research purpose. During the interview, the researcher communicated with the respondents by using three languages, which are Malay, English or Mandarin. However, it is depended on the respondents. The duration of each interview is between 20-30 minutes. Besides, all interview is recorded and all the information is written down. The interview included three sections:

Section A: background or demography of respondent.

Section B: supply chain challenges faced by the companies during disruption.

Section C: strategies to minimize the supply chain challenges.

#### **3.5 Data Analysis**

The various technique of analyzed the qualitative data were performed such as transcribing the audio or video that recorded during the interview. The step involved data cleaning, categorizing data, recognizing the relationship and developing categories and lastly developing and propositions. Based on this research, a software "Excel" is used for coding and let all analyst to automatically code transcripts. Once the analysis was completed, put them into a single document to compare the codes.

### **4. Results and Discussion**

This research collected the data from 10 different types of manufacturing companies by using face-to-face interviews and online interviews method. All of the interview questions were answered by 10 respondents, and the response is analyzed by researcher in order to evaluate whether the objectives of this research have been achieved or not.

#### **4.1 Background of Respondent**

In this research, researcher has selected 10 respondents who are experts in supply chain management from different types of manufacturing industries. The background of 10 respondents has presented in table 3:

Table 3: Background characteristics of respondents

Company	Position	Number of years of experience	Types of manufacturing
C1	Director	10 years	Rubber Manufacturing
C2	Purchasing Executive	6 years	Furniture Manufacturing
C3	General Manager	5 years	Food Manufacturing
C4	Director	8 years	Glasses Manufacturing
C5	General Manager	15 years	Furniture Manufacturing
C6	General Manager	10 years	Mask Manufacturing
C7	General Manager	13 years	Aluminum Manufacturing
C8	Deputy General Manager	8 years	Furniture Manufacturing
C9	CEO	19 years	Furniture Manufacturing
C10	Senior Manager Supply Chain Planning	12 years	Glasses Manufacturing

Table 3 shows the background of the respondents who participated in the research which was conducted through the face-to-face interview and online interview method. Based on table 3 shows that the researcher collected the data from 5 types of manufacturing, which are rubber manufacturing (C1), furniture manufacturing (C2, C5, C8 and C9), food manufacturing (C3), glasses manufacturing (C4 and C10) and mask manufacturing (C6). In addition, every respondent is from a different job position and all respondents have at least 5 years of job experience in their current position.

#### 4.2 Analysis to Achieve the First Objective

##### **Research objective 1: To identify the challenges faced by the supply chain during disruption.**

In this part, the researcher aimed to identify the supply chain challenges that 10 companies confront during supply chain disruption. The data is collected and analyzed from 3 sides, which are supply side, demand side and logistics side.

##### *(a) Supply disruption*

Supply disruption is a divergence in incoming supply in terms of timing, quality, and quantity that may result in unfulfilled orders. Generally, supply disruption causes by different types of factors, including limits on the capacity of manufacturing in the supply market, delivery delays, shortage of supplier involvement or supplier bankruptcy (Hasan et al., 2022). In table 4 show that the themes are classified in connection to the first research question supported by evidence from the responses of 10 different manufacturing companies. *(Please refer appendix A)*

##### *(b) Demand Disruption*

Demand disruption occurs from failures emerging from downstream of the supply chain operation. While, demand disruption might be caused by disruptions in product distribution to customers since transportation restrictions, as well as the volatility and uncertainty of consumer needs (Hasan et al., 2022). In table 5 show that the themes are classified in connection to the first research question supported by evidence from the responses of 10 manufacturing companies. *(Please refer appendix B)*

##### *(c) Logistics Disruption*

Logistics disruption refers to the disruption or fully breakdown of supply chain operations and flows at one or more levels, such as physical, financial and cybernetic. In table 6 show that the themes are classified in connection to the first research question supported by evidence from the responses of 10 manufacturing companies. *(Please refer appendix C)*

#### 4.3 Analysis to Achieve the Second Objective

##### **Research objective 2: To determine suitable strategies to minimize the supply chain challenges.**

Supply chain disruption management is a significant set of procedures and methods that organizations use to reduce the impacts of supply chain disruption. Organizations will require more flexible and agile supply chains that can manage disturbance in the future, and what organization do to manage and prevent supply chain disruption is planning for disruption and ensuring that the company continues to provide and sell products (Lau, 2022). In table 7 show that the themes are classified in connection to the second research question supported by evidence from the responses of 10 manufacturing companies. *(Please refer appendix D)*

#### 4.4 Discussions

##### *(a) Supply Side Challenges*

###### *i. Increase in Price of Raw Material*

This research found that increasing the price of raw materials was the most prominent supply side challenge. Besides, researcher concluded that this challenge causes by several factors including many raw resources being in relatively short supply. Additionally, C3 unveiled stories about the price of material increase is due to the Russo-Ukrainian War. After Russia's Ukraine attack cause their cost of raw material (flour) continuously rising.

This is because, Russia and Ukraine typically provide one-third of the world's wheat supplies, but the continuous invasion has shut off their shipments (Terazono, 2022). However, according to Polski (2021), stated rising demand in Asia and Europe is the primary factor pushing higher raw material prices, since the output of China's industrial has reached full capacity, raw material consumption has risen dramatically.

###### *ii. Raw Material Delay*

In this research, raw material delay emerged as the second most prominent supply side challenge. Research found that delays in raw material flows are common when a supplier is unable to adapt to changes in demand due to excessive utilization or another element of inflexibility. For example, C6 state that sharply growing demand for mask during the pandemic causes high competition for raw material. The significant increase in demand for raw materials led to a shortage in the market, and the factories producing raw materials have also still not reached full capacity. As a result, the raw material will delay (Noyan, 2022). Moreover, discussion with 2 respondents highlighted that inclement weather or rainy season will cause the raw material delay, since ships unable to sail in the sea during heavy weather, as a consequence, during the monsoon season delays are usual (Rahman et al., 2017).

###### *iii. Material Shortage*

Material shortage was the third most prominent supply side challenge in this research. As is evident, the worldwide lack of physical resources (raw materials) has caused supply bottlenecks in all sectors. While, interview with 6 respondents of this research stated there are 2 reasons causes for this, which are growing demand due to the pandemic and continuing decrease the manufacturing capacities of raw material suppliers. According to Brunelli (2021), highlight that material shortages can result from internal and external issues. Internal issues occur within an organization, such as challenges with the manufacturing processes or faulty buyer-side planning. Besides, external issues occur with the supply chain partners, such as capacity issues or excessive wait times. Material shortages might also be caused by external reasons outside the control of the company and its partners, such as geopolitical unrest and unforeseen demand rises.

###### *iv. Quality of Raw Material Reduce*

The fourth most significant supply side challenge identified in this research was the quality of raw material reduction. Researcher concluded that the availability of raw materials is one of the most important production elements affected by supply chain disruption. Supply chain disruption has affected the continuity of operations for both suppliers and vendors. In this situation, suboptimal vendors and product replacements are often considered in order to reduce sourcing risks (Deloitte, 2020). This was confirmed by C1, C2 and C6, which stated that due to the limited supply from the original supplier caused them to change or find more suppliers to maintain their operation business. However, selecting unsatisfactory alternatives and replacements may result in poor product quality and have long-term negative effects on the supply chain, involving rework and extra expenses (Razdan & Kumar, 2020).

###### *v. Shortage of Labour*

According to this research, shortage of labour was the fifth most prominent supply side challenge. Besides, researcher realized most manufacturing fields may not appear to be directly linked to supply chain disruptions, but they have experienced significant changes. Further discussion with C7 said that continuity supply chain disruptions have resulted in rising demand in some sectors, and some companies rushed to satisfy their customers' demand, production restarted and working conditions grew extremely demanding. Hence, these additional pressures lead numerous employees to quit. Challenges of labour shortage are critical due to it being a cycle of challenges. For instance, more employees leave due to increased stress, the remaining employees must do more to compensate for decreased productivity. This added to the stress of workforce, and aggravating the labour situation (Agarwal, 2022).

##### *(b) Demand Side Challenges*

###### *i. Demand Variation*

Demand variation can be considered as the first greatest demand side challenge in this research. Therefore, researcher found that this challenge is the most difficult issues for successful supply chain management at all maturity levels. There are four key sources of demand variation, which are volatility, uncertainty, complexity, and



ambiguity (Henderson, 2021). For example, when there are large swings in inventory due to panic purchasing behaviour, the effect of the unexpected demand grows as it moves upstream in the supply chain. Empty shop shelves encourage even more panic purchasing, retailers lose potential revenue, distributors struggle to figure out who should get what of a given product, and manufacturers are overwhelmed by these abrupt, unexpected demand increases (Smith, 2021)

#### *ii. Sharp fall in demand*

While, amongst the 4 challenges, sharp fall in demand was this research's second greatest demand side challenge. Besides, this research discovered supply chain disruption causes fundamental changing customer behaviour, supply chains, and market access are throwing organizations off balance.

It means that limits the ability of customers or desire to buy products and services at predetermined prices (Brinca & Duarte, 2020). This was confirmed by C2, C5, C8 and C9, which argued that the pandemic causes a huge problem in the supply chain of the furniture industry, such as raw material prices rose due to shortages of transportation and manpower. Besides, pandemic has caused some ports to be closed for a period of time due to the epidemic policy, which will exacerbate the problem of supply chain disruption and thus affect the demand.

#### *iii. Demand Surges*

The third greatest demand side challenge for this research was demand surges. Based on this research, the researcher concluded that demand surge can be divided into 2 types: predicted or unpredicted. Generally, some predicted spikes in demand are due to season changes (Oliva, 2020). However, events such as the pandemic can cause demand surges on completely unpredictable in supply chains (Montgomery, 2020). Based on the C3 and C6 stated that organizations have begun to face unexpectedly high demand for essential products (food and medical mask) during the pandemic. This is because in the beginning phases of the outbreak, stockpiling behaviour increases direct demand in the retail sector. This causes a significant challenge for the supply chain sector and suppliers are finding it difficult to meet such high demand.

#### *iv. Cancel Order*

Out of these 4 challenges, cancel order was the last demand side challenge in this research. Discussions with C5, C7 and C10 unveiled that product is taking too long to produce and deliver to customers due to a shortage of material and strict restrictions during supply chain disruption. As a result, it causes some of the customers cancel orders. According to Turner (2021), highlights that in times of scarcity the majority of buyers are ready to agree on a sacrifice in product quality or kind. organizations should clarify the problem, such as providing a lower-quality or similar material to manufacturing clients while describing how to process these various goods. Besides, if supply is completely unavailable, establishing a short-term connection with a competitor is one alternative.

### *(c) Logistics Side Challenges*

#### *i. Fee Shipping Increase*

At the beginning of the supply chain disruption has increased shipping costs globally, hence fee shipping increase found to be most prominent logistics side challenge in this research. According to several respondents mention that another reason affecting the shipping cost increase is the Suez Canal Accident. In March 2021, the shipping a vessel "Ever Given" got stuck in the Suez Canal and blocked the whole river for around a week, and this accident let the freight rate to shoot up even more. Although this accident has been solved, but this accident caused delays for ships that were on their way to their destinations, and further delays caused by this accident such as these put additional pressure on freight costs (Markuse, 2022).

#### *ii. Container Shortage*

Container shortage consider as second prominent logistics side challenge in this research. According to the finding of this research, researcher concluded there are a lot of reasons why the supply chain experiencing a container shortage. As highlighted by C7, C8 and C9, this situation is due to numerous existing containers are stranded at ports, storage facilities, and vessels across the world. Besides, the other 3 respondents argued that the scarcity of shipping containers is caused by Port congestion and increased demand. This is because, many containers usually used to export manufactured products stopped moving shortly after the WHO designated COVID-19 as a pandemic and manufacturers shut down factories in response. Simultaneously, in reaction to decreased demand and the manufacturing slow-down, ocean freight carriers cut the number of boats at sea and this action empty containers held at ports were no longer picked up (Newton, 2022).

#### *iii. Extend Delivery Time*

Extend delivery time was the third prominent logistics side challenge of this research. Moreover, researcher found that majority of buyers are rarely willing to wait for a long time, especially when alternative items are accessible on the market. During the pandemic has resulted in limitations on the transportation and movement of products and materials, particularly in restricted or containment regions. As a result, lead times have increased, affecting the delivery schedules of essential raw materials and semi-finished products (Hippold, 2020). For example, C1 stated

that their shipment has grown an average of 14 days. Extending the delivery of raw materials and semi-finished products will have a cascading impact on the processing and shipment of products to the final customers, and it causes barriers to the supply chain's regular operation.

#### *iv. Lead Time Uncertainty*

According to this research, lead time uncertainty was emerged as the fourth most prominent logistics side challenge. As highlight by Li et al. (2019), lead time uncertainty can cause an increase in inventory costs and inconsistent service levels, which have a direct impact on the supply chain's overall operating performance. Interview with 4 respondents revealed that supply chain disruption has affected lead time to a great extent.

For example, shortage and delay of raw material is one of the most important factors that lead the lead time uncertainty (indicated by C2). This is because, shortage and delay in raw material will limiting the fulfilment of a customer's purchase or the assembling of a product. While, based on C3 and C8 said that insufficient pallets on which to load and ship their products will be the other big challenge for manufacturers to ship products on schedules and meet demands of their customers.

#### *v. Shortage of Pallet*

Shortage of pallet was the last prominent logistics challenge identified in this research. Based on the research researcher found that one of the benefits of palletization is more efficient loading and unloading of items. Further, Leblang (2022) indicated pallets allow operators (or automated loading docks) to enter and remove the freight from vehicles more quickly, since it the handling equipment may stack the items, and minimizing the number of moves. After the pandemic outbreak, supply chain concerns reduced pallet availability, especially a rapid rebound in freight volume caused various sizes of pallets hard to find. Besides, a detailed discuss with C3 and C10 revealed that pallet shortages are worsening the supply chain issue, and this issue has seen limited improvement until 2022(Phillips, 2022).

#### *(d) Mitigation Strategies*

##### *i. Diversified Supplier*

Many respondents narrated that during the supply chain disruption, they found it challenging to secure raw materials from overseas partners, resulting in major supply chain delays, and it is critical to a manufacturer. The suggestion strategy provided by those respondents is to diversify suppliers (indicated by all respondents, except C5 and C10). According to Powell (2021) said supplier diversity programs are an excellent approach to improving a community's economy. Encouraging an organization to bring in additional suppliers increases the variety of products and services that may be supplied (Montilla, 2022). Researcher found this strategy causes a chain reaction in which market competitiveness grows, raising the quality of these products and services while keeping costs low.

##### *ii. Find a New Logistics Partner*

Based on the finding of this research, researcher found that it is important to find a professional logistics partner, since they can assist an organization when a supply chain disruption occurs. For example, third-party logistics (3PL) partners can help organizations in mitigating certain areas of the supply chain and maintain track of different components of the organization as needed (Chase, 2022). Manufacturers may use 3PL providers' experience, equipment, and industry knowledge to solve business challenges with novel strategies. This is because 3PL have a variety of consumer experiences, and they have prior knowledge of useful tactics that can be implemented during a disruption (Welling, 2021).

##### *iii. Diversified Customer Base*

Based on this research, researcher concluded when an organization depends on a single large customer for the majority of its revenue, its future is inherently linked to the customer. Depending on a single large customer cause the organization to limit control over the future of the firm and limits ability to prepare defensive business operations (mentioned by C1, C8 and C9). If the customer suffers a delay, disaster, or bankruptcy, the businesses that rely on the client would suffer similarly since they will not have been given the opportunity to take remedial steps (Stabler, 2018). According to Neha (2020) said diversified customer base reduces risk and provides stability, as well as enhanced financial security. It also allows organizations to work on a variety of projects with a diverse group of people.

##### *iv. Inventory Management*

According to the finding of this research, researcher discovered that keeping additional quantities of items, whether completed goods, parts and components, or raw materials, will help an organization survive during supply chain disruptions. According to Lau (2022) mention that planning what raw materials need to stockpile and how much you need to stock is a helpful contingency plan, since the organization can plan out what is needed when any part of the supply chain flow is disrupted. Discussion with several respondents argued that in order to avoid supply chain disruptions, majority organization decide to change from "just-in-time" to a "just-in-case" (JIC) inventory strategy.

It means that storage facilities are reconsidering the safety stock levels and stocking up on more products than usual. Keeping extra inventory in strategic locations reduces the risk to supply chain (Dube, 2022).

#### v. *Supply Chain Visibility*

Supply chain visibility can be defined as the capacity to follow distinct product transit, providing a clear perspective of inventory and operations (Robinson, 2017). A control tower with end-to-end visibility allows organizations to keep expenses under control while also planning for emergencies. Besides, partners can interact with one another to leverage combined resources in order to achieve the pursuit of common objectives with increased transparency between different level of the supply chain operation (Verwijmeren, 2022).

Supply chain visibility involve increasing the network through multi-sourcing, which lower the probability of supply scarcity. Improved cross-party communication can also help with exception management or replying to a customer's status question (indicated by C5 and C10).

### 5. *Conclusion*

In conclusion, this research was focused on identifying the challenges faced by the supply chain during disruption. Besides, to determine suitable strategies to minimize the supply chain challenges. At the end of this research, all data has been collected on time and meets both objectives of this research. In summary, the identification of supply chain challenges during disruption was important since supply chain disruption will cause a lot of negative ripple effects. Next, some respondents stated that supply chain disruption had a negative impact on their company's continuity planning. Researchers suggests that future studies should focus on determining how supply chain disruption affects business continuity.

### *Acknowledgement*

This research was supported by the Industrial Grant Scheme File No 100- TNCPI/PRI 16/6/2 (004/2023), Research Management Centre (RMC) of Universiti Teknologi MARA (UiTM), Kira Farm and RMC of Universiti Tun Hussein Onn Malaysia (UTHM).

### *References*

- Agrawal, S., Jamwal, A., & Gupta, S. (2020). Effect of COVID-19 on the Indian Economy and Supply Chain. May. <https://doi.org/10.20944/preprints202005.0148.v1>
- Ashley Brown. (2021). 6 Supply Chain Challenges & Tips To Overcome Supply Chain Issues in 2021. SKUBANA. <https://www.skubana.com/blog/future-of-supply-chain>
- Ben Lutkevich. (2020). Supply chain. TechTarget. <https://www.techtarget.com/whatis/definition/supply-chain>
- Berger, D. (2022). 5 Areas of Production Significantly Affected by Supply Chain Disruption. Global Trade. <https://www.globaltrademag.com/5-areas-of-production-significantly-affected-by-supply-chain-disruption/>
- Biswas, T. K., & Das, M. C. (2020). Selection of the barriers of supply chain management in Indian manufacturing sectors due to Covid-19 impacts. *Operational Research in Engineering Sciences: Theory and Applications*, 3(3), 1–12. <https://doi.org/10.31181/oresta2030301b>
- Bragagni, M. (2021). RAW MATERIAL PRICES INCREASE. March. <https://doi.org/10.13140/RG.2.2.10320.43526>
- Butt, A. S. (2021). Strategies to mitigate the impact of COVID-19 on supply chain disruptions: a multiple case analysis of buyers and distributors. *International Journal of Logistics Management*, February. <https://doi.org/10.1108/IJLM-11-2020-0455>
- Chase. (2022). 5 Ways to Minimize Supply Chain Disruptions. NewStream Enterprises. <https://www.newstreaming.com/5-ways-to-minimize-supply-chain-disruptions/>
- Chen, Jingze, & Wang, H. (2021). A Recovery Strategy in Manufacturing Supply Chains for Long-term Supply Disruption. Chinese Control Conference, CCC, 2021-July, 6487–6492. <https://doi.org/10.23919/CCC52363.2021.9550232>
- Chen, Jingzhe, Wang, H., & Zhong, R. Y. (2021). A supply chain disruption recovery strategy considering product change under COVID-19. *Journal of Manufacturing Systems*, 60(December 2020), 920–927. <https://doi.org/10.1016/j.jmsy.2021.04.004>
- Crane, K. (2022). 22 Insane Supply Chain Statistics [DATA]. Shipping Solution. <https://www.shippingsolutions.com/blog/22-insane-supply-chain-statistics>
- Creswell, J. (2013). Steps in Conducting a Scholarly Mixed Methods Research Abstract for DBER Group Discussion on 2013 - 11 - 14. Steps in Conducting a Scholarly Mixed Methods Research, 1–54. <https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1047&context=dberspeakers>
- Das, K. (2011). Integrating effective flexibility measures into a strategic supply chain planning model. *European Journal of Operational Research*, 211(1), 170–183. <https://doi.org/10.1016/j.ejor.2010.12.006>

- De, N. (2020). The top reasons why you should diversify your client base. Escalon. <https://escalon.services/blog/why-you-should-diversify-your-client-base/>
- Derek Jansen and Kerry Warren. (2021). What Is Research Methodology and Why Is it Important? Indeed. <https://www.indeed.com/career-advice/career-development/research-methodology>
- DOYLE, A. (2021). What Is a Labor Shortage? The Balance Careers. <https://www.thebalancecareers.com/what-is-a-labor-shortage-5209862>
- Dube, C. (2022). Managing Inventory Amid Supply Chain Disruption. Kardex. <https://us.blog.kardex-remstar.com/inventory-management-amid-supply-chain-disruption>
- Dubey, R., Gunasekaran, A., Childe, S. J., Papadopoulos, T., Blome, C., & Luo, Z. (2019). Antecedents of Resilient Supply Chains : An Empirical Study. 1–12.
- Ellis, S. C., Henry, R. M., & Shockley, J. (2010). Buyer perceptions of supply disruption risk: A behavioral view and empirical assessment. *Journal of Operations Management*, 28(1), 34–46. <https://doi.org/10.1016/j.jom.2009.07.002>
- Emiko Terazono, J. E. and H. L. (2022). Russia attack on Ukraine set to hit global food supply chains. *Finances Times*. <https://www.ft.com/content/c0c9fe20-e219-45d4-b029-2cfbaf86a755>
- Fosso Wamba, S. (2020). Humanitarian supply chain: a bibliometric analysis and future research directions. *Annals of Operations Research*. <https://doi.org/10.1007/s10479-020-03594-9>
- Ghadge, A., Dani, S., & Kalawsky, R. (2011). Systems thinking for modeling risk propagation in supply networks. *IEEE International Conference on Industrial Engineering and Engineering Management*, 1685–1689. <https://doi.org/10.1109/IEEM.2011.6118203>
- Grace Lau. (2022). 5 Ways to Mitigate Supply Chain Disruption Effects on Your Business. Shift 4 Shop. <https://blog.shift4shop.com/mitigate-supply-chain-disruption>
- Gunesseea, S., & Subramanianb, N. (n.d.). Ambiguity and its Coping Mechanisms in Supply Chains Lessons from the COVID-19 Pandemic and Natural Disasters.
- Gupta, R., Madgavkar, A., & Yadav, H. (2020). Reopening India: Implications for economic activity and workers. 1–5.
- He, Y., Li, S., Xu, H., & Shi, C. (2020). An In-Depth Analysis of Contingent Sourcing Strategy for Handling Supply Disruptions. *IEEE Transactions on Engineering Management*, 67(1), 201–219. <https://doi.org/10.1109/TEM.2018.2868716>
- Henderson, C. (2021). How to Manage Demand Variability and Other Supply Chain Risks. ZIP Forecasting. <https://zipforecasting.com/en/demand-forecasting/demand-variability.html>
- Hippold, S. (2020). Coronavirus: How to Secure Your Supply Chain. Gartner. <https://www.gartner.com/smarterwithgartner/coronavirus-how-to-secure-your-supply-chain>
- Ho, C., Tai, Y., Tai, Y., & Chi, Y. (2015). A Structural Approach to Measuring Uncertainty in Supply Chains. 4415(October). <https://doi.org/10.1080/10864415.2005.11044334>
- Holly Ellyatt. (2021). There are millions of jobs, but a shortage of workers: Economists explain why that's worrying. CNBC. <https://www.cnbc.com/2021/10/20/global-shortage-of-workers-whats-going-on-experts-explain.html>
- Islam, M. T., Azeem, A., Jabir, M., Paul, A., & Paul, S. K. (2020). An inventory model for a three-stage supply chain with random capacities considering disruptions and supplier reliability. *Annals of Operations Research*. <https://doi.org/10.1007/s10479-020-03639-z>
- Ivanov, D., Dolgui, A., Sokolov, B., & Ivanova, M. (2017). Literature review on disruption recovery in the supply chain\*. *International Journal of Production Research*, 55(20), 6158–6174. <https://doi.org/10.1080/00207543.2017.1330572>
- Ivanov, D., & Rozhkov, M. (2020). Coordination of production and ordering policies under capacity disruption and product write-off risk: an analytical study with real-data based simulations of a fast moving consumer goods company. *Annals of Operations Research*, 291(1–2), 387–407. <https://doi.org/10.1007/s10479-017-2643-8>
- JASON FERNANDO. (2022). Supply Chain Management (SCM). Investopedia. <https://www.investopedia.com/terms/s/scm.asp>
- Jenkins, A. (2021). Just-in-Case (JIC) Inventory Defined. Netsuite. <https://www.netsuite.com/portal/resource/articles/inventory-management/just-in-case-inventory-jic.shtml>
- JJ Hox, H. B. (2005). Data collection, primary versus secondary.pdf.
- Katsaliaki, K., Galetsi, P., & Kumar, S. (2022). and future research agenda. In *Annals of Operations Research* (Vol. 319, Issue 1). Springer US. <https://doi.org/10.1007/s10479-020-03912-1>
- KENTON, W. (2022). Lead Time: Definition, How it Works, and Example. Investopedia. <https://www.investopedia.com/terms/l/leadtime.asp>
- Khan, S. (2016). Qualitative Research Method : Grounded Theory Qualitative Research Method : Grounded Theory. October 2014. <https://doi.org/10.5539/ijbm.v9n11p224>

- Kumar, S., Ruhul, P., & Daryl, S. (2016). A reactive mitigation approach for managing supply disruption in a three-tier supply chain. *Journal of Intelligent Manufacturing*. <https://doi.org/10.1007/s10845-016-1200-7>
- LEBLANC, R. (2022). Why Palletize? 8 Crucial Benefits of Pallet Usage. *Packing Revolution*. <https://packagingrevolution.net/why-palletize/>
- Li, Z., Fei, W., Zhou, E., Gajpal, Y., & Chen, X. (2019). The Impact of Lead Time Uncertainty on Supply Chain Performance Considering Carbon Cost. 1–20. <https://doi.org/10.3390/su11226457>
- Mark Brunelli. (2021). 18 Reasons for Material Shortages and Supply Chain Planning Exceptions: Are Your Planners Equipped to Face These Challenges? *Tracelink*. <https://www.tracelink.com/knowledge-base/18-reasons-supply-chain-planning-exceptions>
- Markuse, P. (2022). Why Shipping Is So Expensive in 2022 and How to Navigate It. *OptimoRoute*. <https://optimoroute.com/why-is-shipping-so-expensive/>
- Meyer, S. (2021). Combatting Ecommerce Supply Chain Disruptions and Steps You Can Take to Minimize Impact. *Bigcommerce*. <https://www.bigcommerce.com/blog/supply-chain-disruptions/>
- Mitroff, I. I. (2014). by Ian I . Mitroff and Murat C . Alpaslan. May 2003.
- Montgomery, O. (2020). 5 Types of Supply Chain Disruption with COVID-19 Examples. *Software Advice*. <https://www.softwareadvice.com/resources/supply-chain-disruption-types/>
- Montilla, A. (2022). 5 benefit of supplier diversity. *Atrium*. <https://www.atriumworks.com/resources/5-benefits-of-supplier-diversity-programs/#:~:text=It widens your pool of,are able to be supplied.>
- Newton, E. (2022). Why is There a Shipping Container Shortage? *SourceToday*. <https://www.sourcetoday.com/supply-chain/article/21236551/why-is-there-a-shipping-container-shortage>
- Noyan, O. (2022). Explosive demand growth could lead to supply shortages in raw materials. *Euractiv*. <https://www.euractiv.com/section/circular-economy/news/explosive-demand-growth-could-lead-to-supply-shortages-in-raw-materials/>
- Okorie, O., Subramoniam, R., Charnley, F., Patsavellas, J., Widdifield, D., & Saloni, K. (2020). Manufacturing in the Time of COVID-19: An Assessment of Barriers and Enablers. *IEEE Engineering Management Review*, 48(3), 167–175. <https://doi.org/10.1109/EMR.2020.3012112>
- Panday, P. N., & Biology, I. (2015). *FORE International Operations Conference 2015 ( FIOC-2015 )*. November.
- Parast, M. M. (2021). An examination of the effect of supply chain disruption risk drivers on organizational performance : evidence from Chinese supply chains. 4(December 2020), 548–562. <https://doi.org/10.1108/SCM-07-2020-0313>
- Parisa Kamali, A. (Shiyao) W. (2021). Longer Delivery Times Reflect Supply Chain Disruptions. *IMF Blog*. <https://www.imf.org/en/Blogs/Articles/2021/10/25/longer-delivery-times-reflect-supply-chain-disruptions>
- Paul, S. K., Moktadir, M. A., & Ahsan, K. (2021). Key supply chain strategies for the post-COVID-19 era: implications for resilience and sustainability. *International Journal of Logistics Management*. <https://doi.org/10.1108/IJLM-04-2021-0238>
- Paul, S. K., Sarker, R., Essam, D., & Lee, P. T. W. (2019). A mathematical modelling approach for managing sudden disturbances in a three-tier manufacturing supply chain. In *Annals of Operations Research* (Vol. 280, Issues 1–2). Springer US. <https://doi.org/10.1007/s10479-019-03251-w>
- Pavlov, A., Ivanov, D., Werner, F., Dolgui, A., & Sokolov, B. (2019). Integrated detection of disruption scenarios , the ripple effect dispersal and recovery paths in supply chains. *Annals of Operations Research*, 0123456789. <https://doi.org/10.1007/s10479-019-03454-1>
- Pedro Brinca, Joao B. Duarte, and M. F. e C. (2020). Is the COVID-19 Pandemic a Supply or a Demand Shock? *Crisis*, 6(20), 1.25. <https://files.stlouisfed.org/files/htdocs/publications/economic-synopses/2018/11/30/does-the-yield-curve-really-forecast-recession.pdf>
- Phillips, W. (2022). Supply Chains Seek Alternatives as Wood Pallet Shortages Remain. *Rm2*. <https://www.rm2.com/2022/08/25/supply-chains-seek-alternatives-as-wood-pallet-shortages-remain/>
- Polski. (2021). Pandemic causes shortage of raw materials – price rises on construction chemicals market. *Construction Market Experts*. <https://constructionmarketexperts.com/en/news/pandemic-causes-shortage-of-raw-materials-price-rises-on-construction-chemicals-market/>
- Powell, J. (2021). Supplier Diversity VS Supply Chain Diversification. *Scanmarket*. <https://scanmarket.com/en/blog/supplier-diversity-vs-supply-chain-diversification/>
- Priyabrata Chowdhury, K. H. L. and S. P. (2019). Operational supply risk mitigation of SME and its impact on operational performance. <https://doi.org/10.1108/IJOPM-09-2017-0561>
- Pujawan, I. N., & Bah, A. U. (2022). Supply chains under COVID-19 disruptions: literature review and research agenda. *Supply Chain Forum*, 23(1), 81–95. <https://doi.org/10.1080/16258312.2021.1932568>
- Quigley, J., Walls, L., Demirel, G., Maccarthy, B. L., & Parsa, M. (2018). Supplier quality improvement : The value of information under uncertainty. *European Journal of Operational Research*, 264(3), 932–947. <https://doi.org/10.1016/j.ejor.2017.05.044>

- Rahman, M. M., Yap, Y. H., Ramli, N. R., Dullah, M. A., & Shamsuddin, M. S. W. (2017). Causes of shortage and delay in material supply: A preliminary study. *IOP Conference Series: Materials Science and Engineering*, 271(1). <https://doi.org/10.1088/1757-899X/271/1/012037>
- Raj, A., Mukherjee, A. A., de Sousa Jabbour, A. B. L., & Srivastava, S. K. (2022). Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned. *Journal of Business Research*, 142(January), 1125–1139. <https://doi.org/10.1016/j.jbusres.2022.01.037>
- Rakesh Agarwal. (2022). Six key trends impacting global supply chains in 2022. KPMG. [https://home.kpmg/sg/en/home/insights/2022/03/six-key-trends-impacting-global-supply-chains-in-2022.html#:~:text=Driver shortages%2C logistics provider capacity,dominated discussions and required attention.](https://home.kpmg/sg/en/home/insights/2022/03/six-key-trends-impacting-global-supply-chains-in-2022.html#:~:text=Driver%20shortages%2C%20logistics%20provider%20capacity,dominated%20discussions%20and%20required%20attention.)
- Rebecca Rolfes. (2016). The Law of Supply Disruption and Demand Disruption. Insigniam. [https://insigniam.com/the-law-of-supply-disruption-and-demand-disruption/#:~:text=Supply-side disruption tends to,on what their customers want.](https://insigniam.com/the-law-of-supply-disruption-and-demand-disruption/#:~:text=Supply-side%20disruption%20tends%20to%20on%20what%20their%20customers%20want.)
- Robinson. (2017). Why is Supply Chain Visibility So Important? CHROBINSON. [https://www.chrobinson.com/en-us/resources/blog/why-is-supply-chain-visibility-so-important/#:~:text=Supply chain visibility is the,limiting disruptions and risk mitigation.](https://www.chrobinson.com/en-us/resources/blog/why-is-supply-chain-visibility-so-important/#:~:text=Supply%20chain%20visibility%20is%20the%20limiting%20factor%20in%20managing%20supply%20chain%20risks.)
- Ross, S. (2021). Seven Last-Mile Delivery Challenges, and How to Solve Them. Supply Chain Brain. <https://www.supplychainbrain.com/blogs/1-think-tank/post/32800-last-mile-delivery-challenges-and-how-to-solve-them>
- S, S. (2018). Difference Between Supply Chain and Value Chain. Key Differences. <https://keydifferences.com/difference-between-supply-chain-and-value-chain.html>
- Sarker, S., Engwall, M., Trucco, P., & Feldmann, A. (2016). Internal Visibility of External Supplier Risks and the Dynamics of Risk Management Silos. 63(4), 451–461.
- Scheibe, K. P., & Blackhurst, J. (2018). Supply chain disruption propagation: a systemic risk and normal accident theory perspective. *International Journal of Production Research*, 56(1–2), 43–59. <https://doi.org/10.1080/00207543.2017.1355123>
- Sinha, R. (2015). Why You Need to Have a Flexible Supply Chain System? LinkedIn. [https://www.linkedin.com/pulse/why-you-need-have-flexible-supply-chain-system-ranjan-sinha#:~:text=Flexible supply chains means that,low it can scale back.](https://www.linkedin.com/pulse/why-you-need-have-flexible-supply-chain-system-ranjan-sinha#:~:text=Flexible%20supply%20chains%20means%20that%20low%20it%20can%20scale%20back.)
- Smith, T. (2021). Have You Experienced a Demand Disruption? LinkedIn. [https://www.linkedin.com/pulse/have-you-experienced-demand-disruption-todd-smith#:~:text=A demand disruption is an,the supply chain to respond.](https://www.linkedin.com/pulse/have-you-experienced-demand-disruption-todd-smith#:~:text=A%20demand%20disruption%20is%20an%20event%20that%20disrupts%20the%20supply%20chain%20to%20respond.)
- Sodhi, M. M. S., Tang, C. S., & Willenson, E. T. (2021). Research opportunities in preparing supply chains of essential goods for future pandemics. *International Journal of Production Research*, 0(0), 1–16. <https://doi.org/10.1080/00207543.2021.1884310>
- Srinivas Talluri, Thomas J Kull, Hakan Yildiz, J. Y. (2013). Assessing the Efficiency of Risk Mitigation Strategies in Supply Chains - Talluri - 2013 - Journal of Business Logistics - Wiley Online Library. *Journal of Business Logistics*, 34(4), 253–269. <http://onlinelibrary.wiley.com.ez-aaa.statsbiblioteket.dk:2048/doi/10.1111/jbl.12025/pdf%5Cnhttp://onlinelibrary.wiley.com.ez-aaa.statsbiblioteket.dk:2048/store/10.1111/jbl.12025/asset/jbl12025.pdf?v=1&t=i3rblt8c&s=43668f3484e35d41342be5d496145c178a2ccbb5>
- Stabler, R. (2018). Increase Customer Diversity, Increase Business Value. Divestopedia. <https://www.divestopedia.com/2/1060/maximize-value/company-premium/increase-customer-diversity-increase-business-value>
- Sutrisna, M. (2015). Research Methodology in Doctoral Research : Understanding the Meaning of Research Methodology in Doctoral Research : Understanding the Meaning of Conducting Qualitative Director of PGR Training and Outreach. May 2009.
- Tang, C. S. (2018). Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics Research and Applications*, 9(1), 33–45. <https://doi.org/10.1080/13675560500405584>
- TARVER, E. (2020). Supply Shock. Investopedia. [https://www.investopedia.com/terms/s/supplyshock.asp#:~:text=A supply shock is an,%2C they're often negative.](https://www.investopedia.com/terms/s/supplyshock.asp#:~:text=A%20supply%20shock%20is%20an%20event%20that%20disrupts%20the%20supply%20chain%20to%20respond.)
- Todd Smith. (2021). Have You Experienced a Demand Disruption? LinkedIn. <https://www.linkedin.com/pulse/have-you-experienced-demand-disruption-todd-smith>
- Torabi, S. A., Baghersad, M., & Mansouri, S. A. (2015). Resilient supplier selection and order allocation under operational and disruption risks. *Transportation Research Part E: Logistics and Transportation Review*, 79, 22–48. <https://doi.org/10.1016/j.tre.2015.03.005>

- Tse, Y. K., & Tan, K. H. (2012). Managing product quality risk and visibility in multi-layer supply chain. *International Journal of Production Economics*, 139(1), 49–57. <https://doi.org/10.1016/j.ijpe.2011.10.031>
- Tummala, R., & Schoenherr, T. (2011). Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP). *Supply Chain Management*, 16(6), 474–483. <https://doi.org/10.1108/13598541111171165>
- Turner, J. (2021). Your How-To on Leading Sellers Through Economic Disruption. Gartner. <https://www.gartner.com/en/articles/your-how-to-on-leading-sellers-through-economic-disruption>
- Usman Munir. (2017). RESEARCH INSTRUMENTS FOR DATA COLLECTION | Usman Munir - Academia.edu. Academium, 1–4. [https://www.academia.edu/34823600/RESEARCH\\_INSTRUMENTS\\_FOR\\_DATA\\_COLLECTION?pop\\_sutd=true](https://www.academia.edu/34823600/RESEARCH_INSTRUMENTS_FOR_DATA_COLLECTION?pop_sutd=true)
- Vanpoucke, E., & Ellis, S. C. (2020). Building supply-side resilience – a behavioural view. *International Journal of Operations and Production Management*, 40(1), 11–33. <https://doi.org/10.1108/IJOPM-09-2017-0562>
- Verwijmeren, M. (2022). What Is Supply Chain Visibility? MPO. <https://www.mpo.com/blog/what-is-supply-chain-visibility>
- Wagner, S. M., & Johnson, J. L. (2004). Configuring and managing strategic supplier portfolios. 33, 717–730. <https://doi.org/10.1016/j.indmarman.2004.01.005>
- Welling, A. (2021). Mitigating Disruptions in the Supply Chain: Benefits of a Lasting 3PL Provider Partnership. DC Velocity. <https://www.dcvelocity.com/blogs/2-one-off-sound-off/post/53199-mitigating-disruptions-in-the-supply-chain-benefits-of-a-lasting-3pl-provider-partnership#:~:text=Partnering with a 3PL provider,warehouse space for faster fulfillment.>
- WILL KENTON. (2021). Supply Chain. Investopedia. <https://www.investopedia.com/terms/s/supplychain.asp>
- Xia, Y., Yang, M. H., Golany, B., Gilbert, S. M., & Yu, G. (2004). Real-time disruption management in a two-stage production and inventory system. *IIE Transactions (Institute of Industrial Engineers)*, 36(2), 111–125. <https://doi.org/10.1080/07408170490245379>
- Yueh, H., Das, A., & Ivanov, D. (2019). International Journal of Information Management Building resilience and managing post-disruption supply chain recovery: Lessons from the information and communication technology industry. *International Journal of Information Management*, 49(June), 330–342. <https://doi.org/10.1016/j.ijinfomgt.2019.06.002>

**Appendix A (Summary of the theme of supply side challenges)**

Table 4: Summary of the theme of supply side challenges

<b>Supply side challenges</b>	<b>Theme</b>	<b>Evidence from Companies (C)</b>
1. Raw material delay	Season	C5: Inclement weather season will cause the raw material delay, due to ships unable to sail in the sea during heavy weather C9: Rainy season will cause the raw material delay, due to the labour of suppliers unable to carry out their daily work
	High competition of raw material	C6: Sharply growing demand for mask during the pandemic causes high competition for raw material. The significant increase in demand for raw materials led to a shortage in the market, and the factories producing raw materials have also still not reached full capacity. As a result, the raw material will delay.  C7: Insufficient raw materials will occur when increasing the competition for raw materials, and indirectly influence raw material delay.
	Tight restrictions	C1: Because of the lockdown, the majority of suppliers had to close their operations and were unable to deliver the necessary materials, especially to the China suppliers  C4: Because of the SOP of the pandemic, there has been a general lack of labour throughout the supply chain. This causes longer material unloading and distribution
2. Increase in price of raw material	Russo-Ukrainian war	C1: Fuel costs have increased due to unprovoked of Russia and unjustifiable aggression against Ukraine. Eventually lead to a substantial increase in the material  C3: Russia and Ukraine typically provide one-third of the world's flour supplies, but the continuous invasion has shut off their shipments, and causes rising in price of raw material.  C7: Uncertainty affected markets with respect to metals produced in Russia and essential to the supply chains of contemporary manufacturing companies.
	Unpredicted demand	C4: The economy recovered, there has been an increase in demand for products, and there is a mismatch in supply, leading to a supply bottleneck and pushing up prices, resulting in higher inflation.  C6: With high worldwide market demand, many raw materials are in limited supply.
	Increase in shipping price	C8: Lack of containers on the market, which have ended up in different regions and ports throughout the world due to the disruption of trade lines. Eventually transportation costs have risen dramatically.



		C10: The rising cost of transporting goods around the world might result in a price of raw materials
3. Quality of raw material reduce	Limited supply	<p>C1: Limited supply from the foreign suppliers caused them to change or find more local suppliers to maintain their business operation, but there will increase the risk of quality issues.</p> <p>C2: Limited supply forced them to adapt their supplier base, and one of the common challenges is the new suppliers are losing control over the quality of their products.</p> <p>C6: Limited supply on foreign and local suppliers cause companies should find the outsource but uncertain quality of raw material will increase the risk of rework and extra cost.</p>
4. Shortage of labour	Long period of supply chain disruptions	<p>C2: Some employees will transition to other sectors during a long period of supply chain disruption</p> <p>C4: Labour-market shifts are becoming more evident, with many employees willingly leaving jobs just as demand for employees grows as economies recover after long term of disruption.</p> <p>C7: Continuity supply chain disruptions have resulted in rising demand in some sectors, and some companies rushed to satisfy their customers' demand, production restarted and working conditions grew extremely demanding</p>
5. Material shortage	Limited availability	<p>C6: Because of the lockdown policy, suppliers have been forced to close manufacturing, resulting in a decrease in raw material availability.</p> <p>C3: One of the challenges faces by food industry is the limited in packing materials, and that may cause a delay in delivering the goods to store shelves.</p> <p>C5: Growing demand due to the pandemic and continuing decrease the manufacturing capacities of raw material suppliers. Eventually lead to limit availability of material.</p> <p>C7: A magnesium shortage might limit the availability of aluminium production.</p> <p>C8: The rising demand for wood during the pandemic causes limited availability of wood.</p> <p>C9: The pandemic caused a labour shortage in several industries, involve the forest products sector, resulting in a reduced availability of wood products.</p>

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**Appendix B (Summary theme of demand side challenges)**

Table 5: Summary theme of demand side challenges

<b>Demand challenges</b>	<b>side</b>	<b>Theme</b>	<b>Evidence from Companies (C)</b>
1. Demand variations	Changing buying habits	in	<p>C1: Pandemic result in a shift in the buying behaviour of customers, causing large changes in demand.</p> <p>C3: The threat of stock outs and supply chain disruptions caused by the pandemic will further increase customers' impulsive purchases.</p> <p>C4: Due to financial loss, many people are changing their consumption habits, such as compare price.</p> <p>C6: Panic buying has led to demand fluctuation at the beginning of pandemic.</p> <p>C7: Many people are unemployed during pandemic leading to no extravagances and drop in non-essential product consumption.</p> <p>C9: Changing in purchase behaviour cause disruptions or uncertainty in demand.</p> <p>C10: As situation factors affect changes in purchasing behaviour, demand changes continuously.</p>
2. Sharp fall in demand	Economic shocks		<p>C2: The economic effect of the epidemic will reduce demand and disrupt supply.</p> <p>C4: An economic shock may lead to high unemployment during supply chain disruption, and it will cause a huge drop in demand for non-essential.</p> <p>C5: The impact of the pandemic has increased inflation in the United States, and indirectly reduce a large amount of furniture demand.</p> <p>C8: Majority of furniture manufacturers have 80%-90% export to the United States, while when occurred inflation in US caused demand has dropped sharply.</p> <p>C9: Price of material will increase during supply chain disruption, and it will lead the cost of product increase and reduce the demand of customers.</p>
3. Demand surges	Essential product		<p>C1: Sales peaked as baby products were an impending crisis.</p> <p>C3: In the beginning phases of the outbreak, stockpiling behaviour increases direct demand in the essential product (food).</p> <p>C6: Pandemic has resulted in a significant scarcity of face masks, which is mostly explained by an increase in demand.</p>
4. Cancel order	Behaviour change		<p>C5: During pandemic product cannot be export to overseas due to some of the restrictions, it causes cancelling order and switching to new vendors.</p> <p>C7: Product postpone export to overseas due strict restrictions; it impacts the relationship between vendors and customers and cause cancelling order.</p> <p>C10: Product is taking too long to be delivered and replaceable products in the market lead to customers cancelling their order.</p>

**Appendix C (Summary theme of logistics side challenges)**

Table 6: Summary theme of logistics side challenges

<b>Logistics challenges</b>	<b>side</b>	<b>Theme</b>	<b>Evidence from Companies (C)</b>
1. Extend delivery time	Large volume shipments		C1: Huge volume shipments during supply chain disruption cause their shipment has grown an average of 14 days.  C4: A sudden or unexpected surge in shipment delivery volumes during the pandemic will result in an increase in delivery time.
		Extreme weather	C2: When a ship waits at a port unable to function due to weather, the entire logistical chain suffers as a result, include delivery time.  C5: The common issue cause delay in delivery time is extreme weather, since ships unable to sail in the sea during heavy weather  C9: The rainy season will cause longer delivery time, due to longer unloading time.
2. Fee shipping increase	Insufficiency shipping capacity		C1: Every company rushed to move the goods, which poses a huge challenge to transportation capacity and affect to freight rate.  C6: The rise in demand for essential products was more than predicted and was not met by an adequate amount of shipping capacity, eventually effect on shipping cost.  C7: Congestion at the port and a shortage of container equipment affected the shipping cost and capacity
		Suez Canal Accident	C3: The shipping a vessel “Ever Given” got stuck in the Suez Canal and blocked the whole river for around a week, and this accident let the freight rate to shoot up even more.  C4: The Suez Canal accident caused delays for ships that were on their way to their destinations, and further delays caused by this accident such as these put additional pressure on freight costs.  C10: The Ever Given mega-ship halted traffic in the Suez Canal for over a week in March 2021, which caused a significant increase in container spot freight costs.
3. Container shortage	Quantity available containers decreased.	of	C3: When the outbreak struck, the routine movement of containers throughout the world was abruptly disrupted. Thus, reducing the number of containers available
		has	C6: Despite the fact that there are millions of containers globally, the disruption caused shortages in the available container at the port.  C10: The number of available containers is limited, since the supply of new containers is grossly low.

	Port congestion			<p>C7: The scarcity of shipping containers is caused by Port congestion and increased demand.</p> <p>C9: Port congestion causes the unloading of cargo on board will be delayed, which also indirectly affects the number of containers available.</p> <p>C8: This situation is due to numerous existing containers are stranded at ports, storage facilities, and vessels across the world.</p>
4. Shortage of pallet		Shifts in demand		<p>C3: The manufacturer's output is limited due to ongoing demand, as well as material and labour constraints, forcing the price of pallets to increase.</p> <p>C10: The issue of shortage of pallets has occurred as a result of timber scarcity, increased costs, combined with an increase in demand.</p>
5. Lead time uncertainty	time	Shortage of physical resources	of	<p>C2: Shortage and delay of raw material is one of the most important factors that causes the lead time uncertainty.</p> <p>C3: Insufficient pallets on which to load and ship their products will be a big challenge for manufacturers to ship products on schedules and meet the demands of their customers.</p> <p>C8: Shortage and delay in material supply are considered to be one of the most critical reasons contributing to worldwide delays in lead time.</p>

#### Appendix D (Summary theme of mitigation strategies)

Table 7: Summary theme of mitigation strategies

Strategies to minimize the supply chain challenges	Theme	Evidence from Companies (C)
1. Diversified supplier	Backup suppliers	<p>C1: Having a varied supply base and backup vendors is an important part to prevent of supply chain disruption.</p> <p>C2: Backup suppliers is a good strategy to have simple access to a number of vendors, when something goes wrong with your main vendor.</p> <p>C3: Standby more suppliers help companies establish more strategic partnerships with suppliers and gives benefits in numerous areas and cost reductions.</p> <p>C4: Organization should try to find and backup suppliers form local and foreign area.</p> <p>C6: Finding suppliers with supplies in several regions and a varied supply base can help to offset the impact of supply chain disruptions.</p> <p>C7: Backup alternative suppliers are the best business strategies to manage disturbance in the future, it same like don't put your eggs into one basket.</p> <p>C8: Supplier diversity and backup helps to increase competition, especially during supply chain disruption.</p>

2. Find a new logistics partner	Partnership	<p>C9: Diversified supply base and backup vendors is a key factors of supply chain resiliency</p> <p>C1: Proper logistics partner provide organization greater flexibility in product delivery.</p> <p>C2: Partnering with a reliable logistics partner can keep the organization supported throughout supply chain disruptions.</p> <p>C4: Partner with a third-party logistics services provider to discover alternate methods to have the product delivered as soon as possible.</p> <p>C7: Partnership with a third-party logistics (3PL) help decreases the risk of supply chain frustration and lowers the risk of customer loss since products can arrive faster.</p>
3. Diversified customer base	Marketing strategy	<p>C1: In order to minimize the challenges of supply chain disruption, organization have attempted to resolve demand uncertainty by using a marketing strategy, which are diversifying the consumer base.</p> <p>C8: A diverse consumer base defines as a market strategy that expands a company's opportunities for success and meets the demand of each customer</p> <p>C9: Using the strategy of diversified customer base help avoiding the threat of consumer concentration may raise the value of company.</p>
4. Inventory management	Build up inventory	<p>C2: Having additional parts or components and raw materials will help the organization reduce the challenges during supply chain disruptions.</p> <p>C4: Sufficient inventory is a contingency plan that helps to mitigate the impact of supply chain disruption.</p> <p>C6: To prevent supply chain disruptions, majority of organization have shifted from "just-in-time" (JIT) to "just-in-case" (JIC) inventory strategy.</p> <p>C9: Inventory forecasting assists in inventory management overall.</p> <p>C10: Organizations are reconsidering their safety stock levels and storing more inventory than usual in order to avoid or prevent future supply chain disruptions.</p>
5. Supply chain visibility	Transparency	<p>C5: Supply chain transparency is the capacity of the organization to view processes at every level of its supply chain.</p> <p>C6: Transparency may help a company's reputation as a trustworthy firm, attracting more consumers.</p> <p>C10: Transparency enables businesses to discover and capitalize on opportunities to boost supply chain efficiency and performance.</p>

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