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**THE INFLUENCE OF RISK MITIGATION
STRATEGIES TOWARD SUPPLY CHAIN
RESILIENCE: A CASE STUDY OF THE ELECTRONICS
MANUFACTURING SERVICE INDUSTRY IN PENANG**



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UUM
Universiti Utara Malaysia

**MASTER OF SCIENCE (SUPPLY CHAIN
MANAGEMENT)
WITH HONOURS**

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**THE INFLUENCE OF RISK MITIGATION STRATEGIES TOWARD
SUPPLY CHAIN RESILIENCE: A CASE STUDY OF THE ELECTRONICS
MANUFACTURING SERVICE INDUSTRY IN PENANG**

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**This Research Paper is Submitted to
School of Technology Management and Logistics,
Universiti Utara Malaysia,
in Fulfilment of the Requirement for the Mater Of Science (Supply Chain
Management) with Honours**



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(College of Business)
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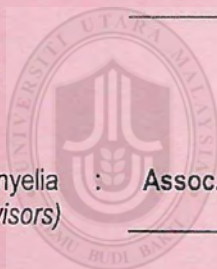
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ABSTRACT

This study presents a comprehensive investigation into the influence of risk mitigation strategies on supply chain resilience within the Electronics Manufacturing Service (EMS) industry in Penang. With the growing complexity of global supply chains, disruptions have become unavoidable, so an organization must implement effective risk management practices to maintain operational continuity. Through a detailed case study approach, this research examines the various risk mitigation strategies employed by EMS companies operating in Penang to enhance their supply chain resilience capability. In this study, we employ qualitative interview methodologies to investigate and explore how various risk mitigation strategies enhance supply chain resilience while facing various challenges. By adopting a qualitative approach, we aim to capture the rich insights and contextual factors that shape decision-making processes within a dynamic Electronics Manufacturer Services industry in Penang. Our findings reveal the multifaceted nature of risk mitigation strategies, encompassing proactive measures such as diversification of suppliers and geographic location, inventory management, and collaborative partnerships, as well as the deployment of innovative supply chain technology to navigate unforeseen disruptions. In conclusion, this research underscores the importance of proactive risk management practices in building resilient supply chains, particularly in the high-tech electronic manufacturing industry. By understanding the dynamics of risk mitigation strategies and their implications for supply chain resilience, organizations can better prepare for and adapt to disruptions, thereby enhancing their competitiveness and sustainability in an increasingly turbulent global marketplace while providing global material solutions that offer the company's customers an optimal level of value-added services and flexibility at the acceptable total cost.

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Keywords: *Supply Chain Disruption Risk, Supply Chain Risk Mitigation, Supply Chain Resilience, Electronics Manufacturing Service, Qualitative Research*

ABSTRAK

Kajian ini membentangkan penyiasatan menyeluruh tentang pengaruh strategi pengurangan risiko terhadap daya tahan rantai bekalan dalam industri Perkhidmatan Pembuatan Elektronik (EMS) di Pulau Pinang. Dengan kerumitan rantai bekalan global yang semakin meningkat, gangguan adalah tidak dapat dielakkan, jadi sesebuah organisasi mesti melaksanakan amalan pengurusan risiko yang berkesan untuk mengekalkan kesinambungan operasi. Melalui pendekatan kajian kes terperinci, penyelidikan ini mengkaji pelbagai strategi pengurangan risiko yang digunakan oleh syarikat EMS yang beroperasi di Pulau Pinang untuk meningkatkan keupayaan daya tahan rantai bekalan mereka. Dalam kajian ini, kami menggunakan metodologi temu bual kualitatif untuk menyiasat dan meneroka bagaimana pelbagai strategi pengurangan risiko menyumbang kepada meningkatkan daya tahan rantai bekalan sambil menghadapi pelbagai cabaran. Dengan menggunakan pendekatan kualitatif, kami menyasarkan untuk mengetahui wawasan yang kaya dan faktor kontekstual yang membentuk proses membuat keputusan dalam industri Perkhidmatan Pengilang Elektronik yang dinamik di Pulau Pinang. Penemuan kami mendedahkan sifat pelbagai rupa strategi pengurangan risiko, merangkumi langkah proaktif seperti kepelbagaian pembekal dan lokasi geografi, pengurusan inventori, dan perkongsian kolaboratif, serta penggunaan teknologi rantai bekalan yang inovatif untuk menavigasi gangguan yang tidak dijangka. Kesimpulannya, penyelidikan ini menekankan kepentingan amalan pengurusan risiko proaktif dalam membina rantai bekalan yang berdaya tahan, terutamanya dalam industri pembuatan elektronik berteknologi tinggi. Dengan memahami dinamik strategi pengurangan risiko dan implikasinya terhadap daya tahan rantai bekalan, organisasi boleh lebih bersedia dan menyesuaikan diri dengan gangguan, dengan itu meningkatkan daya saing dan kemampuan mereka dalam pasaran global yang semakin bergelora sambil menyediakan penyelesaian material global yang menawarkan pelanggan secara optimum. tahap perkhidmatan nilai tambah dan fleksibiliti pada jumlah kos yang boleh diterima

Katakunci : *Risiko Gangguan Rantai Bekalan, Pengurangan Risiko Rantai Bekalan, Ketahanan Rantai Bekalan, Perkhidmatan Pengilangan Elektronik , Penyelidikan Kualitatif*

DECLARATION

I declare that this report is my work and effort. It is my original work, and all the references were cited adequately as required by the university requirements. This report was carried out according to the rules and regulations of Universiti Utara Malaysia.



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Date: APRIL 2024

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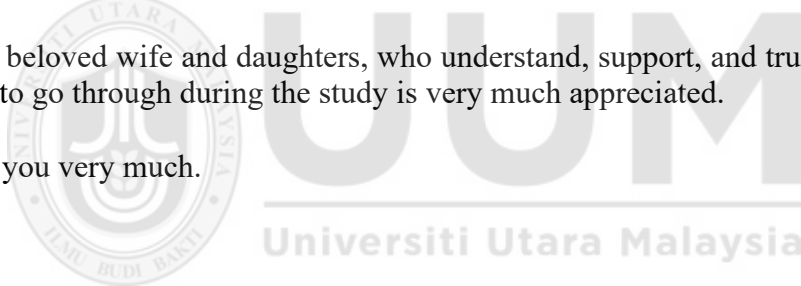


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LIST OF ABBREVIATIONS

EMS	Electronics Manufacturing Service
CM	Contract Manufacturer
OEM	Original Equipment Manufacturers
E&E	Electronics & Electrical
MIDA	Malaysia Investment Development Authority
ESG	Environmental Social Governance
WHO	World Health Organization
MNC	Multi National Company
SRM	Suppliers Relationship Management
SC	Supply Chain
VMI	Vendor Manage Inventory
SCT	Supply Chain Technology
IoT	Internet of Things
AI	Artificial intelligence
RFID	Radio Frequency Interference Device
EOL	End of life
GDP	Gross Domestic Product
JIT	Just In Time



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CHAPTER ONE - INTRODUCTION

1.1 Background

The global landscape of supply chain management has become increasingly complex and challenging due to various factors such as globalization, demand fluctuation, pandemics, natural disasters, and intricate supply chain networks (Patel, K. R. 2023).

Globalization has transformed supply chains, enabling businesses to access resources, markets, and labor across borders as illustrated in Figure 1.1.

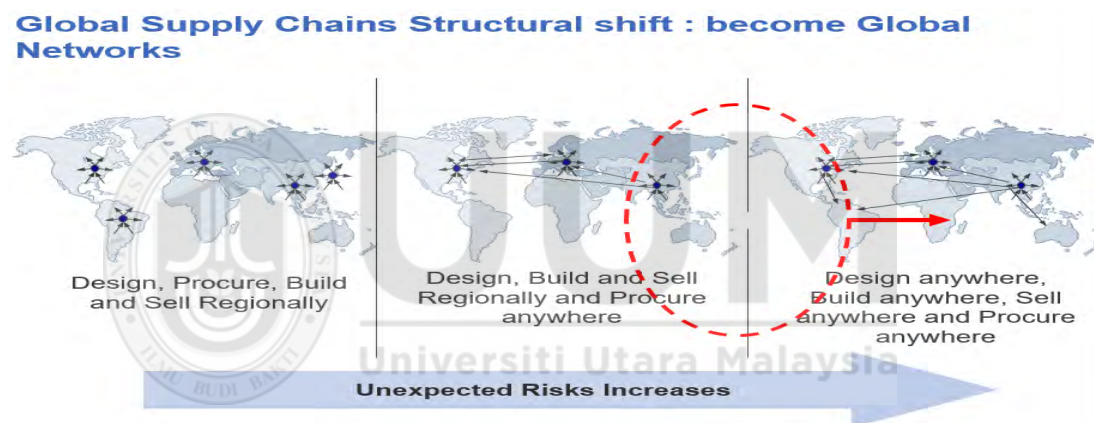


Figure 1.1: The globalization process shift

However, this has exposed the industry to many vulnerabilities factors, and risks, including natural disasters, geopolitical tensions, supply shortages, quality issues, and unforeseen disruptions like the COVID-19 pandemic (Cardosa et al, 2023).

Demand fluctuations, influenced by consumer preferences, economic cycles, and geopolitical factors, further exacerbate the challenges faced by supply chain stakeholders. The rapid change in demand can stress the resources and capacity,

leading to inefficiencies and potential disruptions in the supply chain (Kanike, U. K.,2023). Pandemics, such as the COVID-19 crisis, have created the unplanned vulnerability of global supply chains to unforeseen disruptions. Lockdowns, travel restrictions, and workforce shortages have disrupted production, transportation, and logistics, highlighting the need for resilient supply chain strategies (Ozili,2323). Natural disasters, including earthquakes, tsunamis, and hurricanes, pose additional risks, disrupting critical infrastructure and supply routes. Such events can have far-reaching consequences, affecting the availability of raw materials, components, and finished products.

According to Wahyuni,2012 and Khalid,2023, Penang known as “The Silicon Valley of the East” is renowned for its robust electronics manufacturing sector. In addition, it offers a unique environment characterized by a mature and well-established supply chain ecosystem, comprising not only EMS companies but also suppliers, logistics providers, and others. Based on www.pcba-manufacturer.com,2022, there are seven (7) EMS companies ranked among the global top 14 having their manufacturing set-up in Penang as shared in Table 1.1.

Table 1.1: Top rank EMS companies in the World

World EMS Ranking	Company Name	Headquarter	Manufacturing plant in Penang?	Estimate annual revenue (US\$ b)
1	Foxconn	Taiwan	No	193
2	Pegatron	Taiwan	No	45
3	Wistron	Taiwan	No	31
4	Jabil	U.S	Yes	27
5	Flex	Singapore	Yes	24
6	BYD	China	No	10
7	USI	China	No	8
8	Sanmina	U.S	Yes	7.8
9	Celestica	Canada	Yes	7.2
10	Kingpo	Taiwan	No	4.5
11	Plexus	U.S	Yes	3.8
12	CEC	China	No	3
13	Venture	Singapore	Yes	2.9
14	Benchmark	U.S	Yes	2.8

The comprehensive ecosystem and concentration of global EMS firms in Penang present an ideal setting for qualitative research investigating the influence of risk mitigation strategies in enhancing supply chain resilience, as it offers an in-depth view of the interdependencies and dynamics inherent in the EMS industry.

1.2 Problem Statement

While there is extensive research on disruption risk and supply chain resilience, there is a need for a focused comprehensive study on risk mitigation practices in the context of manufacturing, particularly identifying the existing research gaps and trying to close the gaps between the research finding and industry practice (Remko, 2020). The existing literature often discusses specific 1 or 2 strategies of risk mitigation strategies only (e.g., inventory management, supplier diversification, and geography diversification), but lacks a comprehensive framework that integrates various practices. Manufacturers often struggle with identifying the most effective combination of strategies which may include supplier collaboration and the deployment of supply chain technology, and lastly and most importantly there was a very limited or lack of articles study and published about the Penang EMS company.

This research seeks to contribute to the existing body of knowledge by offering a comprehensive of risk mitigation practices in the Penang EMS industry's supply chain. The findings will provide valuable insights for manufacturing executives, supply chain managers, and policymakers looking to improve the resilience of EMS manufacturing supply chains and ensure the continued stability and competitiveness of this vital sector. Understanding and effectively implementing these practices is essential for ensuring the resilience of manufacturing supply chains in an increasingly complex and uncertain global environment.

1.3 Research Questions

- a) What are the types of supply chain disruption risks faced by the Penang EMS industry?
- b) What are the current risk mitigation strategies adopted by leading EMS companies & and how do these strategies influence the mitigation of the disruption risk and improve supply chain resilience?

1.4 Objectives of the Research

This research paper aims to explore and analyse the influence of various risk mitigation practices adopted by EMS companies toward supply chain resilience enhancement. By examining case studies, industry best practices, and empirical data, we seek to achieve the following objectives:

- a. To identify Common types of risks in the EMS supply chain.
- b. To investigate the strategies employed by EMS in Penang to mitigate the potential risks to enhance supply chain resilience

By shedding light on these aspects, this research targets to contribute to a more detailed understanding of the evolving landscape of supply chain resilience in EMS and share valuable insights for industry practitioners, policymakers, and scholars

1.5 Significance of the Study

The significance of a study on "Risk Mitigation Strategies to Improve Supply Chain Resilience in Penang EMS Industry" is profound regarding modern business and global economic dynamics (Khalid, N. A.,2023). This research topic addresses critical

issues related to Penang EMS supply chain management and has several key implications which include (a) Effective risk mitigation strategies can reduce supply chain disruptions and associated costs, including production delays, increased inventory holding, and customer dissatisfaction (b) Improve supply chain resilience and ensure Business Continuity: Enhancing supply chain resilience helps businesses ensure continuous operations even in the face of disruptions (c) Companies with robust supply chain resilience are better positioned to respond quickly to market changes and outperform competitors in terms of product availability and customer satisfaction. (d) Reliable and resilient supply chains lead to improved customer satisfaction as customers can trust that their orders will be fulfilled on time and with high-quality products, resilience strategies can also incorporate sustainability initiatives, reducing environmental impact and ensuring that organizations practice ESG (Environmental, Social, Governance) policy and also enrich the body of knowledge.

In conclusion, the study seeks to improve supply chain resilience and operation efficiency by addressing the current gaps and investigating the impact of proposed strategies (Remko, 2020) . In addition, interrelationships among various concepts are determined. Furthermore, the findings from this research paper on risk mitigation strategies to improve supply chain resilience are significant as they address critical aspects of modern business operations, offering opportunities for cost reduction, improved competitiveness, and enhanced stakeholder confidence in an increasingly complex and uncertain global marketplace (UM.,2021). This definitely will benefit all the supply chain stakeholders and also EMS industry expects to face future challenges.

1.6 Scope of the Study

This study is based on a qualitative interview case study to investigate the risk mitigation strategies practiced by 6 EMS companies in Penang and how these practices enhance their supply chain resilience.

1.7 Definition of the Key Term

Risk Mitigation: Risk mitigation is defined as a structured process of identifying, assessing, and implementing the strategy to minimize the impact of potential risks in the supply chain. It aims to reduce the negative impact of disruptions on the supply chain's performance (Chance,2021).

Supply Chain Resilience: Supply chain resilience is defined as the capability of a supply chain system to withstand and make a quick comeback from disruptions while maintaining its crucial functions. It involves the capacity to adapt to unexpected challenges and continue delivering products or services to customers (Pettit, T. J., Croxton, K. L., & Fiksel, J.,2019)

Risk Management: Risk management is a systematic approach to identifying, assessing, and controlling risks within a supply chain. It encompasses strategies and practices to minimize the negative consequences of risks on the supply chain's operations (Chance,2021).

Supply Chain: A supply chain consists of the network of organizations, processes, and information flow that is involved in the supplier, manufacturing, distribution, and delivery of goods or services to end customers (Hugos,2024).

Resilience Strategies: Resilience strategies are proactive measures and plans put in place to enhance the ability of a supply chain to recover quickly from disruptions. These strategies may include diversifying suppliers, stockpiling critical inventory, and developing alternative transportation routes (Pettit, T. J., Croxton, K. L., & Fiksel, J., 2019).

Disruption: A disruption is an event or circumstance that interrupts or negatively affects the normal operation of a supply chain. Disruptions can be caused by various factors, such as natural disasters, economic crises, or geopolitical issues (Sawik, T., 2020).

Supplier Relationship Management (SRM): Supplier relationship management involves the management of relationships with suppliers to ensure the availability of materials, quality control, and collaboration in risk mitigation efforts (Hazen, 2021).

Just-in-Time (JIT) Inventory: Just-in-Time inventory is an inventory management approach where materials or products are ordered and received only as needed, reducing inventory holding costs but increasing vulnerability to disruptions (Alvarado, 2022).

Supply Chain Technology (SCT): Supply chain technology refers to the application of various technological solutions and tools to optimize and manage the entire process of sourcing, manufacturing, distributing, and managing goods and services as they move from the supplier to the end consumer (MacCarthy, B. L., & Ivanov, D., 2022). Supply chain technology encompasses a wide range of tools and systems designed to improve efficiency, visibility, coordination, and decision-making within the supply chain. Some key components of supply chain technology include Big Data, Internet

of Things (IoT), Enterprise Resource Planning (ERP) Systems, Blockchain Technology, Artificial Intelligence (AI), and Machine Learning.

1.8 Organization of the Research Paper

Chapter 1 Shares the background of the study, the problem statement, research questions, and objectives, the significance, scope, and the definition of key terms.

Chapter 2 Discusses the concept and literature review of the various risk mitigation strategies practiced by Electronics Manufacturing Services (EMS) companies in Penang to enhance supply chain resilience

Chapter 3 Describes the related underpinning theories that lead to the understanding of the overall picture of the study. Besides, the evolving conceptual framework and methodology of this study. The research technique was described at the beginning of the third chapter, followed by sections on the study's design, methodology, data collection, analysis, and respondents' profiles.

Chapter 4 Studies the feedback and findings from the interviews, then analyzes and discusses the finding

Chapter 5 Review and summarize the study's findings and the likely potential implications for practitioners and researchers, it will also share the study's limitations and explore the direction for future research

CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

This Chapter consists of a literature review of the type of supply chain disruption risk, the definition and concept of various types of supply chain disruption risk, and the literature review of various risk mitigation strategies.

2.2 Type of Supply Chain Disruption Risk

2.2.1 Customer Demand Forecast Fluctuation Risk

Fluctuations in customer demand have been a key challenge, due to changing consumer behaviors and market dynamics. Forecasting accuracy became even more critical as demand patterns shifted unpredictably, it created raw material shortage which happens when the raw materials or products used in industry are unavailable or not enough quantity to meet overall market demand, this may be due to a shortage of lower lever raw material, example shortage of nickel which of lower lever raw material to produce semiconductor chip, the shortage may also due to sudden demand surge (Lucker.F., 2021).

2.2.2 Geopolitical Risk

It refers to the potential political, economic, military, and social risk that emerges from a nation's involvement in international affairs, this has increased volatility and uncertainties (Yu, 2023). Examples of Geopolitical Risks are (a)Trade war between the U.S and China which creates supply disruption and also unpredict price increases. The trade war between the US and China intensified uncertainties in the overall supply chain. Tariffs, trade restrictions, and political instability affected sourcing strategies

and led to increased costs and operational complexities (Zhang, 2021). (b) Russia's invasion of Ukraine resulted in global, especially European energy shortages and significant price increases of energy-related products, this caused a global mini-economic recession due to the depreciation of most country currency value vs U.S\$, fuel and & agriculture-related commodity shortages & price increases, it also causes of a huge surge of logistics cost. As Russia is the world's largest palladium and third largest supplier of nickel & these two raw materials will impact the supply of semiconductor chips and electrical vehicle (EV) batteries, this will cause a supply gap & longer lead of semiconductor chips and batteries (Ozili P. K., 2022). (c) The most recent, Piratical attacks on international shipping by Yemen-based Houthi rebels have created a significant security crisis in the Red Sea (<https://unherd.com/2024/02/china-is-winning-the-battle-for-the-red-sea/>), this creates a huge impact on the transit lead time as the ship cargo are not able to pass through the Red Sea (Ofozoba, 2023).

2.2.3 Single Source Supplier and Single Geographic Location

Dependency on a single source supplier or geographic location poses inherent risks, particularly in times of crisis (McMaster, 2020). The pandemic highlighted vulnerabilities in our supply chain, prompting a reassessment of the supply chain sourcing strategy to mitigate such risks

2.2.4 Pandemic Risk

A pandemic refers to the worldwide spread of new diseases caused by the new influenza virus (Huang Y., 2020), It has created big supply disruption across all the segments which include manufacturing, finance, health, education, and security. COVID-19 has been a significant disruptor, causing unprecedented challenges such as

workforce shortages, disruptions in transportation and logistics, and shifts in consumer behavior.

2.2.5 Supplier's Quality Disruption Risk

There is a risk of suppliers failing to comply with purchase order terms such as failing to meet agreed product quality standards or late delivery (George A.Zsidisin, 2016). Maintaining supplier quality is crucial for ensuring product integrity and customer satisfaction

2.2.6 Climate Change or Natural Disaster Risk

It is a risk caused by natural or climate hazards that disrupt the functioning of the community & it exceeds human capacity to cope with it. Climate change and natural disasters remain substantial risks with potentially severe consequences for our operations (Paul, 2020).

2.3 Definition and Concept of Risk Mitigation Strategies

For this research paper, the conceptual risk mitigation strategies consist of supplier diversification, Supplier Geography or location diversification, Building Buffer Inventory, Enhanced collaboration & supplier relationships, and Deployment of Supply Chain Technology and resilient improvement.

2.3.1 Supplier Diversification

Supplier diversification refers to the deliberate and systematic practice that involves multiple suppliers to source and purchase materials, components, or services necessary for the EMS industry's operations. It aimed to reduce dependency on a single source by engaging with multiple suppliers to improve supply flexibility and mitigate risks

associated with a single-source dependency by distributing procurement across different suppliers (Azadegan, A., Modi, S., & Lucianetti, L.,2021).

Supplier diversification is a proactive risk mitigation strategy. It aims to reduce vulnerability to disruptions caused by external risk which is due to a single supplier that caused issues such as delivery delays, quality issues, demand changes, or unexpected events based on the concept of (a) Sourcing raw materials or services from various suppliers, the risk of a single supplier's failure or shortcomings affecting the entire supply chain decreases. If one supplier faces issues, an alternative second or third supplier can help prevent severe disruptions and distribute the potential risk. (b) Working with multiple suppliers provides the EMS industry with increased leverage during negotiations. This competitive dynamic can lead to enhanced negotiation power for better delivery flexibility, improved service levels, and innovation to improve suppliers' resilient capability (Kalkanci, B.,2017). (c) Diversification enables a faster reaction to market changes, such as sudden increases in demand, supplier capacity limitations, or shifts in pricing. Having multiple suppliers ensures the industry's ability to respond swiftly to such changes. (d) In cases of unforeseen events like natural disasters, geopolitical issues, or financial troubles affecting one supplier, having alternate sources ensures continuity in the supply chain, thereby minimizing disruption and potential losses (Kalkanci, B.,2017). (e) The supply of semiconductor chips was disrupted during the 2021 COVID-19 period if any of the EMS in Penang purchased their semiconductor chips or any other raw material from a single source supplier base in China as there were total operation shutdowns in China's manufacturing plant and also major ports (Guan et al.,2020).

2.3.2 Supplier Geography or Location Diversification

Supplier geography or location diversification refers to the intentional and strategic sourcing of components, materials, or services from suppliers situated in various geographic locations. This strategic approach aims to reduce the vulnerabilities associated with supply chain disruptions by spreading sourcing activities across different regions, countries, or continents. The concept revolves around the idea that the concentration of suppliers in a single geographic area increases the susceptibility of the supply chain to various risks, such as Geopolitical Instability, natural disasters, and pandemics (Islam et al.,2020)

The strategy of supplier geography diversification, therefore, involves sourcing components or services from multiple suppliers situated in different geographical areas to mitigate these risks. It promotes resilience by minimizing the impact of localized disruptions on the entire supply chain network (Sytych, M., Kim, Y., & Page, S.,2020). Implementation of supplier geography diversification involves a systematic assessment and selection of suppliers from diverse locations. It is important and involved in the following steps:(a) Identifying and evaluating potential suppliers across various regions based on their capabilities, reliability, and capacity to meet the demand requirements. (b)Assessing the potential risks associated with each geographical location and developing strategies to mitigate these risks. (c)Distributing sourcing contracts across multiple suppliers in different locations to create a balanced and diversified supplier network. (d) Managing inventory levels and logistics to effectively handle sourcing from different geographic areas.

2.3.3 Building Buffer Inventory

Building up buffer inventory is a strategy plan for maintaining surplus stock or safety stock beyond actual material planning requirements (Macdonald, 2018). This buffer inventory acts as a safety cushion to absorb shocks and uncertainties within the supply chain, it will affect the ability to absorb shocks and disruptions based on the following concept: (a) Buffer inventory is a proactive measure aimed at mitigating the impact of disruptions. It acts as a safety net against unforeseen events such as supplier delays, sudden spikes in demand, production interruptions, or transportation issues. By having surplus inventory, the company is better equipped to navigate and absorb these disruptions without significant adverse effects on operations (Raj, 2022). (b) It introduces a layer of flexibility within the supply chain. When disruptions occur, having a buffer inventory allows companies to meet customer demands even when faced with short-term challenges, thereby maintaining a certain level of service and reliability. (c) Buffer inventory helps stabilize production schedules and fulfillment processes. It ensures a consistent flow of goods even in the face of unpredictable circumstances, reducing the risk of stockouts and associated negative impacts on customer satisfaction (De, 2022). (d) Through strategic inventory management, companies can effectively match supply with demand fluctuations. Buffer inventory allows for more adaptive and responsive approaches to varying market needs, serving as a tool to manage unexpected demand surges or drops (Obrenovic, 2020). (e) While maintaining buffer inventory incurs additional holding costs, it can potentially minimize overall costs related to disruptions. By preventing stockouts and preserving customer satisfaction, the costs associated with lost sales, rush orders, and customer dissatisfaction are mitigated.

2.3.4 Enhanced Supplier's Collaboration and Relationships

It means the strategic and proactive efforts made by companies to build stronger, more transparent, and interdependent relationships with their suppliers. It involves the development of a mutual alliance strategic partnership where communication, information sharing, joint problem-solving, and trust are at a high level of priority for both organizations. This strategic partnership aims to create a resilient supply chain ecosystem capable of effectively mitigating risks (Lavastre, O., Gunasekaran, A., & Spalanzani, A.,2014). In the context of the EMS industry in Penang, enhanced collaboration and supplier relationships function as an independent variable, affecting the overall resilience of the supply chain in various ways(Mckay, F.,2022) based on the following concept. (a) Both organizations are aligned with the company's future direction and shared vision & mission. (b) Establishing open, transparent, and efficient communication channels with suppliers is fundamental. This concept emphasizes the importance of regular dialogues, shared data, and information exchange to anticipate, address, and mitigate risks collectively. (c) Building a relationship based on mutual support and flexibility is crucial. This means being responsive to each other's needs, allowing for adjustments and adaptations during unforeseen circumstances, thereby creating a safety net against disruptions and building up long-term trust for both companies. (d) Risk Mitigation and Problem-Solving: Collaborative relationships with suppliers involve jointly identifying potential risks and devising effective risk mitigation strategies. The emphasis is on proactive problem-solving, preparedness for disruptions, and collectively working toward solutions to minimize the impact of any disturbances in the supply chain. (e) Building Resilience through Trust: Trust forms the core of enhanced collaboration and supplier relationships. Building trust involves

consistent performance, reliability, and a shared commitment to the success and resilience of the supply chain. Trust facilitates quicker decision-making during times of uncertainty. (f) Innovation and Continuous Improvement: A strong collaborative relationship fosters an environment conducive to innovation and continuous improvement. Suppliers and companies can work together to introduce new technologies, enhance processes, and streamline operations, thereby collectively enhancing the overall resilience of the supply chain.

2.3.5 Deployment of Supply Chain Technology (SCT)

According to (Braziotis, 2019), it involves the strategic implementation of various innovative tools and systems, such as but not limited to, IoT (Internet of Things), AI (Artificial Intelligence), blockchain, predictive analytics, RFID (Radio-Frequency Identification), and cloud-based solutions to improve transparency, visibility, efficiency, and adaptability within the EMS industry's supply chain.

The concept of deploying supply chain technology as an independent variable revolves around leveraging technological advancements to mitigate risks and enhance resilience in the EMS industry's supply chain in Penang involved on the following : (a) Advanced technology offers real-time visibility into the entire supply chain, allowing for proactive identification of potential disruptions or risks. This visibility enables stakeholders to react swiftly to any issues that may arise. (b) By utilizing predictive analytics, the supply chain can forecast potential disruptions and risks, enabling the development of proactive strategies to mitigate these issues before they significantly impact operations. (c) Implementing technology streamlines various supply chain processes, reducing manual errors and optimizing operational efficiency. Automated

systems can also enhance responsiveness and reduce lead times. (d) The deployment of technology allows for the collection and analysis of large volumes of data. This data-driven approach empowers decision-makers to make informed and agile choices, responding effectively to changes or disruptions. (e) The deployment of supply chain technology serves as a critical independent variable in fortifying the resilience of the EMS industry's supply chain in Penang. The agile application of the nature of technological solutions supports the industry in withstanding and quickly recovering from disruptions.

2.3.6 Resilient

Supply chain resilience is defined as the ability of a supply chain system to withstand and recover from disruptions while sustaining its critical functions. It involves the capacity to adapt to unexpected challenges and continue delivering products or services to customers (Pettit, T. J., Croxton, K. L., & Fiksel, J., 2019). Resilient improvement within the EMS encompasses several facets as below (Mckay, F., 2022): (a) Resilient improvement refers to the capability to adapt to unplanned disruptions, such as changes in demand, supply shortages, geopolitical conflicts, or natural disasters. It involves the capacity to adjust operations and strategies promptly to minimize the impact of these disruptions. (b) It involves the supply chain's capacity to recover efficiently after facing a disruption. This includes the ability to restore operations, recover lost ground, and return to optimal efficiency levels swiftly. (c) Resilient improvement necessitates building robustness into the supply chain by creating redundancies and alternative plans. This includes having backup suppliers, diversified sourcing locations, and buffer inventory to alleviate the effects of disruptions. (d) Resilient improvement involves proactively identifying potential risks

and deploying mitigation strategies in advance. This includes the use of technology, predictive analysis, and scenario planning to foresee and prepare for potential disruptions. (e) A key aspect of resilient improvement is the establishment of strong collaboration with suppliers, partners, and stakeholders. This involves the development of flexible and adaptive strategies in collaboration with these entities to navigate unforeseen challenges collectively.

2.4 Supply Chain Risks Mitigation Strategies

Based on Neshat and Stephan M. Wagner (2010), factors that make EMS supply chains vulnerable to disruption can be broadly classified as (a) Globalization and Multi-tier complex Supply Chains link, (b) Supplier and geographic location dependencies, (c) Geopolitical conflict, (d) Inventory and forecast management, (e) Information and cyber security, (f) Transportation and Infrastructure Issues, (g) Regulatory and Compliance Challenges, (h) Environmental and natural disaster, (i) Lack of Resilience Strategies, (j) Financial instability. All these vulnerable factors have created various types of potential supply risks which include Raw material shortage Risk (Lucker.F., 2021), Financial risk (Wang, R., Yu, C., & Wang, J., 2019), Transportation failure risk (Zhou et al., 2020), Geopolitical Risk (Sodhi, M. S., & Tang, C. S., 2021), Pandemic risk (Shahed et al., 2021). To reduce supply risk and weather manufacturing Supply Chain risk, global supply chain stakeholders have taken the following strategies:

2.4.1 Diversification of Suppliers' Base

Previous studies show the significance of diversification in coping with supply chain disruption risks (Hendricks, 2009). The theory follows the traditional wisdom of “don’t put all your eggs in one basket”. Diversification of suppliers' strategies has proved in the industry to protect against uncertainty. For example, according to a Nikkei survey conducted in March-April 2021, more than 80% of Japanese manufacturers had initiated diversification in their supply chains. Based on HSBC's (2020) finding, about 59% of corporate supply chain stakeholder diversified their businesses in the period from 2018 to 2020 to enhance their resilient capability. Diversification will improve a company's operational flexibility, which collaborates the supply and demand by using alternative suppliers when disruption risk happens (Lin et al., 2021). Application of Supplier-based diversification can improve the ability of firms to face supply chain disruptions and risks, it can help firms to minimize operation shutdowns due to supply disruption. Historical records and findings have demonstrated the effectiveness of supply chain diversification to ensure supply continuity assurance. A diversified supply chain base can enhance the operational effectiveness of firms to meet the needs of the market and customers. Furthermore, a diverse supplier base can help organizations achieve higher resilience by improving the capability to face potential supply chain disruption (Yin, W., & Ran, W., 2022)

2.4.2 Diversification of Suppliers' Geographic Location

EMS industries across the world are facing vulnerabilities in their supply chain network, factoring geographic diversification in supplier selection models is crucial for developing supply chains resilient against unpredicted disruption risk. The

comprehensive models for supplier qualification or partnership-level supply chain network design often include geographic diversity consideration (Islam, S., Hasan, M., & Fai, T. I.,2022).

Diversifying the supplier base has been a key target of the Japanese government to set up a robust and resilient capability since the impact of COVID-19. Recently, the domestic supply chains of Japanese firms started to be diversified as these companies rely on most of their raw material supply from Chinese vendors. In addition, the geographic diversification of supply chains of Japanese firms enables an organization to be more robust, resilient, and highly efficient after COVID-19 (Todo, Y., & Inoue, H.,2021). More than two-thirds of electronic chips manufacturing capacity and many vendors of key raw materials—such as silicon wafers, photoresists, and multi-layer PCB—are mainly concentrated in China, Taiwan, and other Asia Pacific. Furthermore, 8% of the world's high-technology electronics with capacities to produce below 10 nanometers of semiconductor chip wafers are located in South Korea, and 92 % are in Taiwan (Varas et al.,2021). Relying on a single geographic location for electronics suppliers can pose significant risks to the E&E supply chain. Natural disasters, geopolitical tensions, or pandemics in the country region can lead to raw material interruption and production productivity (Varas et al.,2021). By having suppliers in different countries or regions, supply chain stakeholders can mitigate the impact of trade barriers and avoid over-reliance on a single region's supply. Diversification will help spread the risk, making the supply chain more resilient. For example to reduce risks associated with overreliance on a single country in China. Apple has required Foxconn to move out its Apple iPhone 15 manufacturing plant from China to Tamil Nadu India (Iyer, C. G., 2021). To encourage the diversification of suppliers' geographic locations, the U.S. government has introduced various incentives and

policies which include financial support, and tax incentives to encourage innovative companies to set up their manufacturing facilities within the U.S. instead of focusing on a single country China or Taiwan facility (Varas et al.,2021).

2.4.3 Building Up Buffer Inventory

Risks and uncertainty factors have a direct impact on customer satisfaction and cause nonvalue costs. To manage some of these factors, keeping a buffer or safety stock is included as the strategy to meet supply and demand fluctuation to improve customer service and enhance supply chain responsiveness (Barros et al.,2021). After the pandemic, organizations have shifted their strategy to mitigate supply disruption risk to increase inventory and keep more buffer at the internal plant and sub-tier supplier & supplier site (Liberatore et al.,2012). Keeping a buffer stock strategy is a good approach to drive order flexibility especially when we manage a long lead time component, it also allows an organization to mitigate better during unexpected disruption and improve supply resilience & flexibility. Toyota Motor Corp., which is famous for being the pioneer developer of the just-in-time strategy, changed its rulebook as a result of the key semiconductor shortage. Toyota instructs its vendors to increase their semiconductor inventory levels from three months to five months. Although this policy change made the organization less efficient in terms of inventory management, Toyota continued to achieve profit and a record annual output level following the strategy shift (Mckay, F.,2022).

2.4.4 Enhance Supply Chain Relationships and Collaboration

Customer Relationship Management is a systematic approach to managing a company's connection and building up a customer-centric business system (Um,2021). Healthy relationships in business will help a company to be more agile and resilient to facing any uncertainty and also provide an edge over others' competitors, this will enhance operation effectiveness, streamline the supply chain, and allow flawless execution, in addition, it will provide better cost and improving supply relationships (Pohludka, M., & Štverková, H.,2019). Japanese Keiretsu means to build up an integrated system with suppliers and customers to ensure close communication and fast response for mutual benefits and ensure both parties are aligned in the company's direction, goal, and mission. Inter-company trust is central to Supply Chain Relationships to find a win-win solution. According to Lamsal, R. R., Devkota, A., & Bhusal, M. S. (2023), TSMC's strategy to build their manufacturing plant in the U.S. was motivated by long-term strategic partnerships with Apple and AMD, which are key customers of TSMC. Effective SCMR will help organizations to improve key competitive advantages. Collaboration with vendors covers more than just a normal coordinating relationship. Good supplier relationships have always been crucial, especially during times of supply-demand fluctuation, good relationships are important. During tough times, vendor will prioritize their deliveries to long-term strategic partners and these need to be established in good times for customers, not when we are in a bad situation (Mckay, F.,2022). The Supply Chain collaboration study proved that supply chain collaboration positively impacts & improves risk management capabilities which helps to enhance supply chain resilience and competitive advantage. The results also show the positive indirect effects of supply

chain collaboration on organization risk management capabilities (Um and Han,2021). Build up an integrated and collaborative system with suppliers and customers to ensure close communication and fast response on all open issues (Li et al.,2023), this will ensure both parties are aligned in the company's direction, goal, and mission. According to (Hao et al., 2022). Good supplier relationships have always been crucial but in times of supply disruption, strong collaborated relationships are highly important.

2.4.5 Embrace Supply Chain Technology

Supply Chain Technology is referred to as an innovation or technology that helps to facilitate the improvement in material management processes and information flow, it can be defined as the digital tool that supports and enhances the efficiency of the supply chain to enable “Everything at anywhere” (Taboada, I., & Shee, H., 2021). Supply Chain Technology is growing exponentially and can become an important source of information. The industry must start deploying digital technologies which include Artificial intelligence (AI), Internet of Things (IoT), Machine Learning (ML), Blockchain, and Big Data to improve supply chain visibility, agility, flexibility, and resiliency (Da Costa et al.,2022). The supply chain technology of manufacturing is a crucial way for a company to develop as the application of supply chain technology enables the firms through the in-depth deployment and configuration of digital capabilities, coordinating and predicting the potential risks, minimizing the uncertainties faced by the company, and enhancing company risk mitigation capability, and improving supply chain visibility and agility. Al-Banna (2023) disclosed that industries are moving towards the implementation of supply chain digital technologies to overcome unexpected, unplanned, and undesired conditions. It

explains the need for a company to prioritize risk mitigation strategies and improve supply chain resilience while facing disruptions and vulnerabilities at the same time highlighting the potential of digital technologies to improve organization resilience and ensure sustainable growth. Based on Kazancoglu et al., (2023) finding, the most critical and problematic areas faced in Strategic Supply Chain Management are transparency, traceability, demand & supply, and demand change. The purpose and the use of supply chain digitalization is to enhance the sustainability and resilience of supply chains during an uncertain environment. However, the deployment of an innovative supply chain will help supply chain stakeholders improve their resilient capability as illustrated in Figure 2.1 (Zhou et al., 2023).

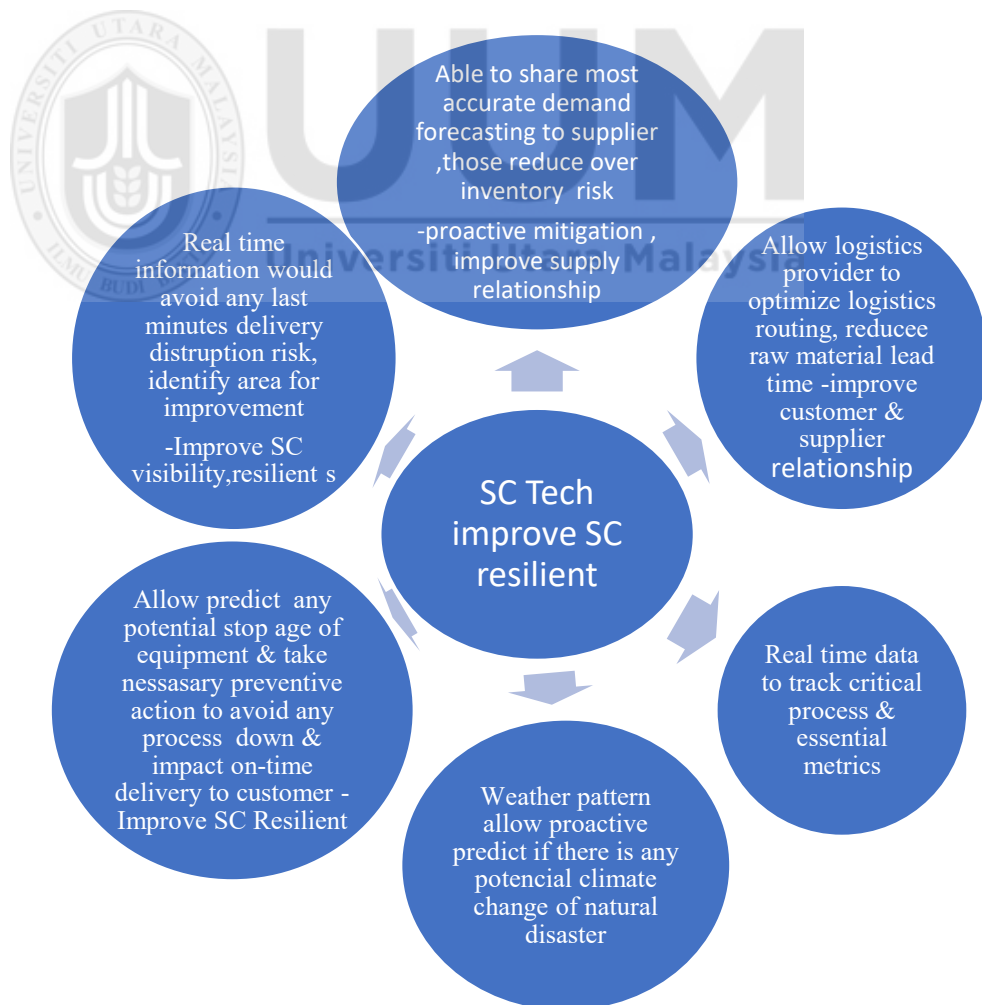


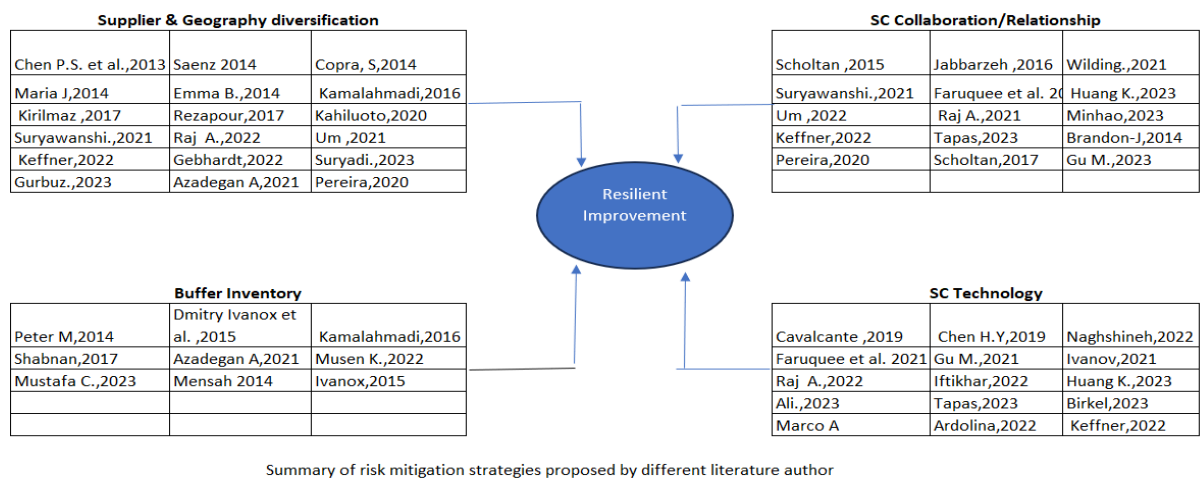
Figure 2.1: Benefits of data digitalization

In addition, a detailed study shows that the SCT has been widely deployed in different SC areas as shown in Table 2.1.

Table 2.1: Supply chain technology in various supply chain areas

SC Area	Supporting Technologies	Benefits
Demand forecast	Big Data Analytic	Develop a Data-Driven network, shorter total throughput time
Purchasing	Big Data, IoT	Improve supplier resiliency and relationship (accurate data integration)
Procurement	Blockchain, Big Data, IoT	Global sourcing, enhance supplier collaboration, prevent counterfeit
Capacity planning	Big Data	Accurate historical data, better decision and improve planning efficiency
Inventory Management	Big Data, Automation	Avoid human key in error, better historical traceability, improve inv accuracy and inv turn
Warehousing	Automation (RFID sensor), robotics	Reduce human dependency, reduce material picking time
Transport routing	Big Data, blockchain	Routing traceability, optimizing shortest transport routing, shipment visibility

Furthermore, more scholars have published their article reviews regarding risk management, a list of risk mitigation strategies proposed by the authors of 40 articles is shown in Figure 2.2.



Summary of risk mitigation strategies proposed by different literature author

Figure 2.2: Summary of risk mitigation strategies proposed by literature authors

2.4.6 Resilience Improvement

There is a lot of literature that tries to find out what is global supply chains function and the way they create a positive impact on productivity and financial outcomes. Nevertheless, the geographically concentration supply links will create greater disruption risks. In a highly link supply chain system, the disruption of a single organization may create a large impact on the entire chain. For example, the shutdown of a factory during COVID-19 may create huge economic exposures to the world (Yang, C., Tian, K., & Gao, X.,2023).

While encountering the same disruption, some organizations can handle it and back to normal in a shorter time. This outstanding performance is due to their supply chain's resilient capability while the manufacturing industry is facing more potential risk (Yang, C., Tian, K., & Gao, X.,2023). Supply chain resilience is the capability of a supply chain system to face and make a quick recovery from disruptions and at the same sustain its important functions. It involves the capacity to adapt to unexpected challenges and continue delivering products or services to customers (Pettit et al,2019

2.5 Chapter Summary

A detailed assessment of the literature has been conducted to investigate the type of supply chain disruption risk. Most earlier investigations have demonstrated the various types of mitigation strategies applied by global and local stakeholders in the Penang EMS Industry. This study will Investigate the influence of Risk Mitigation Strategies Toward Supply Chain Resilience: A case study of the Electronics Manufacturing Service (EMS) Industry in Penang.

CHAPTER THREE – RESEARCH METHODOLOGY

3.1 Introduction

Various underpinning theories are used in discussing risk mitigation strategies to enhance supply chain resilience in the EMS Industry. This study utilized five theories namely Risk Pooling Theory, Portfolio Theory, Theory of Constraints (TOC), Relational Exchange Theory, and Information Processing Theory. In addition, this chapter will also share the research conceptual framework and methodology.

3.2 The Related Underpinning Theories

Underpinning theory refers to the fundamental principles, concepts, or ideas that form the basis or foundation of a particular field of study, discipline, or practice. This study would like to share various underpinning theories that are applied based on each of the variances in this topic.

3.2.1 Supplier Diversification Underpinning Theory

(a)Risk Pooling Theory: This suggests that diversification, in this case diversifying suppliers, can help spread risk and reduce the impact of disruptions across a broader base (Cronk, L., & Aktipis, A.,2021). (b)Portfolio Theory suggests that diversification can reduce overall risk in a portfolio (in this context, the portfolio of suppliers). It's about spreading risk by having multiple sources, according to (Hamdi, 2018) it can be applied to review the value of individual supply chain risk management portfolio components and also compare alternate portfolios of risk management strategies.

3.2.2 Supplier Geography Diversification Underpinning Theory

According to Fan, D., & Xiao, C. (2023) review the Portfolio Theory is a key theory for navigating the potential risk created by vulnerable factors and it emphasizes the importance of supplier geography diversification strategy while Network Theory emphasizes the structure and connections within networks. Applying this to supply chains, it involves understanding the implications of diversification within the network of suppliers. Geographical diversification contributes to a more robust and interconnected supply chain network

3.2.3 Buffer Inventory Build-up Underpinning Theory

Theory of Constraints (TOC) suggests identifying constraints and having buffers to ensure smooth operations despite disruptions. Based on Watson, K. J., & Patti, A. (2008) analysis shows that the TOC technique which refers to buffer-rope, achieves higher levels which optimize protection of the constraint from variation. Buffer Stock Theory emphasizes the role of buffer stocks or safety stocks in absorbing sudden shocks or disturbances in the supply chain. Buffer stocks act as a cushion against variability, allowing the supply chain to remain operational even during unexpected disruptions. According to (Patel, 2023), buffer stock protects against various uncertainties and disruptions, enables some decoupling across multiple production stages, and achieves customer expectations as stated in The Service Level Theory

3.2.4 Enhance Supplier Collaboration and Relationship Underpinning Theory

Relational Exchange theory emphasizes long-term relationships and mutual trust between parties, the findings of the author show that a mechanistic management

control system and a collaborated relational buyer-supplier relationships have a positive effect on proactively managing supplier insolvency risks (Huang, Y.,2020).

3.2.5. Deployment of Supply Chain Technology Underpinning Theory

Information Processing Theory suggests that effective information processing (facilitated by technology) enhances decision-making and problem-solving. Reviewing a Supply Chain Risk information processing system comprising risk information sharing, risk analysis and assessment, and risk sharing mechanism, to manage SC Risk (Fan et al. 2017).

3.2.6 Summary of the Underpinning Theory

Due to the complexities of the discussed underpinning theories, many facets need to be detailed before they can materialize into the desired result, furthermore, due to complex processes, a multidisciplinary approach should be taken in selecting the models in a dynamic supply chain. No one theory fits all. If one works well before, it does not mean that it will work again in other situations. Thus, the theories above provide only the basic guidelines

3.3 Research Conceptual Framework

In qualitative research, a conceptual framework serves as a guide for constructing the study's instruments and providing explanations for the study's findings of this study. The key element of the conceptual framework is that it is primarily a conception of what to study and a tentative theory of the phenomena that we are exploring. The

function of this conceptual framework is to find the goals, develop related research questions, select appropriate methods, and identify potential validity conclusions (Johnson, 2020). Example of research conceptual framework for risk mitigation strategy toward resilience improvement as illustrated in Figure 3.1

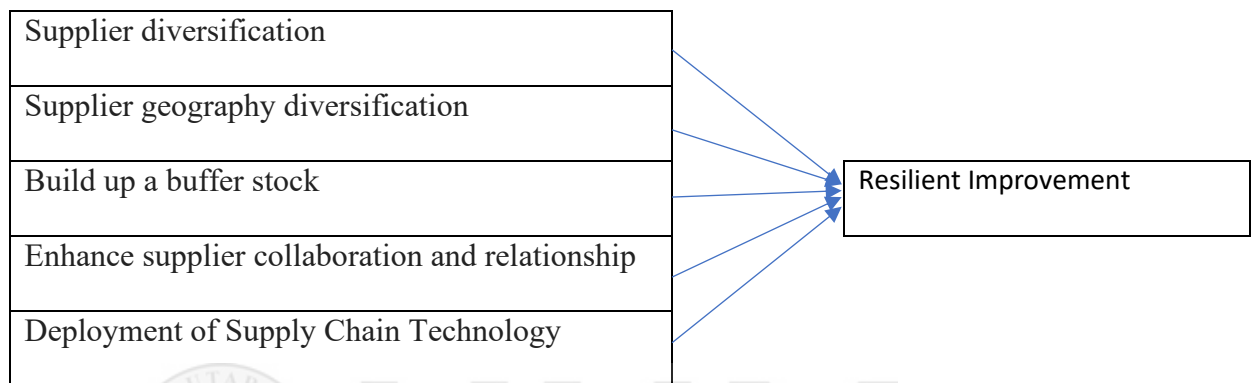


Figure 3.1: Conceptual framework on risk mitigation strategies

3.4 Research Methodology

3.4.1 Type of Research

Research is an investigation of anything that can be in any form to discover new things or new concepts. However, mostly the investigation will come out with results even though no new knowledge is discovered but will discover more information on the current research topic. The research questions, patterns, techniques, and analysis techniques affect the discovered results (Swedberg, 2020).

The quantitative approach adopts the 'scientific method' where the initial study of the theory, the objective is to test the hypothesis, it is focused on finding broad patterns and generating predictions. For qualitative research, the study is an 'exploration' to gain knowledge and overcome the problems on the discussed topics. A case study

methodology was needed to explore in depth what, why, and how questions associated with organization strategies and performance outcomes (Schoch,2020). Table 3.1 show summarizes the key differences between quantitative and qualitative research.

Table 3.1 The key differences between quantitative and qualitative research

Aspect	Qualitative Research	Quantitative Research
Research Approach	Inductive: Emerges from the data, no predefined theory.	Deductive: Starts with a theory or hypothesis.
Purpose	Exploring, understanding, and generating theories.	Testing hypotheses, identifying patterns, and predicting outcomes.
Data Collection	Relies on open-ended methods (structured/semistructure/unstructured interviews, observations).	Structured: Uses standardized instruments (surveys)
Sample Size	Small sample sizes to gain in-depth insights.	Large sample sizes for statistical significance.
Data Analysis	Interpretive analysis, thematic coding, narrative analysis.	Statistical analysis using numerical data.
Objective vs subjective	Acknowledges subjectivity; seeks to understand context and meaning.	Emphasizes objectivity; aims for unbiased results.

Quantifiability	Data is often descriptive and non-numeric.	Data can be quantified and analyzed statistically.
Generalization	Emphasizes detailed understanding, not generalizability	Seeks to generalize findings to a larger population
Examples of Methods	Interviews, focus groups, case studies, observations.	Surveys, experiments, content analysis.

3.4.2 Justification of the Methodology

The business environment in supply chain subject areas was increasingly complex and less agreeable by using just one type of research approach. To accurately describe, truly understand, and explain these complex subject areas, many researchers include more studies using qualitative approaches. A few examples can be found where real supply chains capturing at least three stages are described and analyzed in empirical research. Case studies allowed direct observation of the field, which would be particularly suitable for approaching several stages of a supply chain.

An exploratory study was undertaken to understand the nature of the problem as it is only a very limited study was conducted related to risk mitigation strategies in the EMS industry in Penang, which encourages the qualitative approach to be undertaken (Islam, M. A., & Aldaihani, F. M. F. (2022).

The inductive case study approach was suitable to explore how EMS companies in Penang plan and implement their risk mitigation strategies to improve supply chain resilience.

In the case study, complete information can be obtained about the subject of study. It also leads to new and creative insights while the researcher can explore relationships.

However, there are some disadvantages to the case study as the researcher was not able to generalize the results because of the small sample size. The case study Acknowledges subjectivity; and seeks to understand context and meaning, but it needs to take a longer time to conduct the dept interviews.

A case study methodology was needed to explore, understand, and generate theories by going through the complex what, why, and how questions associated with organization capabilities and performance outcomes, after the preliminary stages of the data collection, there was a need for “a more balanced approach to research using inductive research methods in addition to deductive methods in supply chain management . In this situation, a qualitative approach was preferred to build an understanding grounded in a detailed description of the subject area generated by collecting field data. It provided researchers with access to a deeper level of understanding of new or complex subjects by yielding a high level of detail (Islam, M. A., & Aldaihani, F. M. F. (2022).

3.4.3 Research Design

Based on Newman (2020) the overall background and basic logic of a research design's component is what determines how good it is. The planned research process is shown in Figure 3.2 below. The research technique will essentially operate as a process guideline to explore the supply chain risk mitigation strategies to improve resilience in the Penang EMS industry.



Figure 3.2: Planned Research Process

This research paper is an exploratory case study since not much is known regarding the Risk Mitigation Strategies Toward Supply Chain Resilience of the Electronics Manufacturing Service (EMS) Industry In Penang.

An inductive case study approach was selected to explore how EMS companies in Penang implement their supply chain risk to improve their resilient capability. This approach appeared to be well fit for several reasons as it worked well for investigating complex phenomena, which cannot be illuminated by surveys alone as it allows the researcher to communicate with the informant and to draw on multiple sources of information, leading to information-rich cases .

In this research study, the research method involved is qualitative. This method which needs to conduct several fields works to collect data. The data collection and analysis techniques stages include coding of data, case studies, data transcript, and thematic analysis for more details on the data analysis(Sukmawati,2023). (Islam M. A., 2022)

Following the preliminary stages of the interview data collection, a series of detailed interviews were conducted to complement and contextualize the interview findings .

In addition, when the subject topics are something new, progressive or complex, relevant variables were not easily identified and extant theories were not available to explain the subject area. In this situation, a qualitative approach was preferred to build

an understanding grounded in a detailed description of the subject area generated by collecting field data. It provided researchers with access to a deeper level of understanding of new or complex subjects by yielding a high level of detail (Creswell et al.,2007)

3.5 Research Process

In this research, the qualitative method is applied to obtain information and data from the respondents. The data collection will be through primary and secondary sources. The main direction of this stage is to Investigate the influence of Risk Mitigation Strategies Toward Supply Chain Resilience in Penang EMS Industry. During this stage, a literature review was conducted which discovered that the Penang EMS Industry needs to adopt various types of strategies to mitigate different types of potential disruption risk to improve their supply chain resilience. Structured interviews involve a formal interview session between the interviewer and the respondents. An interview protocol is developed before an interview, and it is conducted based on the protocol. The protocol covered a list of questions and topics related to the discussion topic in a particular order. However, any changes in questions or extras are allowed during the session. A structured interview helps the interviewer develop a deep understanding of the research topic to develop a relevant outcome. During the interview, the interviewer may ask more related questions to gain information and understand the topic. Structured interviews allow the interviewer to explore the topic and collect similar information from each respondent (Kallio,2016).

3.6 Data Collection

Data collection is one of the important activities contributing to the study's findings and results. This process will provide more precise information about the research title . The types of data used in this research are primary and secondary data. The method that will be used to analyze the raw data obtained from the interview is by using the thematic analysis method. For the interview, ten people from 4 different multinationals (MNC) and 2 local EMS companies (a total 6 EMS companies) located in Penang who have experience working as SCM directors, Managers, Commodity Managers, Sourcing Managers, and Senior Material Controllers will be asked the same questions during the interview. The recorded or written data will be compared between the answers and feedback by respondents. The data collection process execution follows the interview protocol to ensure the success of the interview session (Islam, M. A., & Aldaihani, F. M. F. (2022)).

3.6.1 Primary Data Collection

Interviews, meetings, and verbal and written feedback fall under primary data sources. An interview is a verbal information exchange conducted over the phone or in person in which the interviewer strives to obtain the respondent's experience, opinions, and information, interview method dominates what we have been described as living in an 'interview society'. An interview can be conducted over the phone, in person, or via online tools like Zoom or Webex. The interviewer controls the interview's format, subject matter, and question sequence. There are three types of interviews, that is Structured, semi-structured, and unstructured interview (Naoum, 2007). A structured interview focuses more on delivering present questions in the exact wording and order

as the interviewer is listed in the interview schedule. The advantage of structured data includes their uniformity, which enables data comparability. Semi-structured interviews do not follow a specific schedule or order of questions, it includes both closed and open-ended questions. However, there is no predefined order or schedule in an unstructured interview; instead, the interview is open, and respondents are free to answer. As the same and fixed questions are being asked with each participant, the Structured interview method is used for this research, During the interview, they are free to give their opinion when answering the question. The answer will be recorded in audio or written memo.

3.6.2 Secondary Data Collection

Secondary data acquisition was based on the researcher's information and various sources. The secondary data needs to support the original data. Most of the information was gathered through articles, journals, books, thesis papers, and websites on the internet.

Table 3.2 outlines primary and secondary sources for a qualitative interview research paper, we apply and use both the primary and secondary data sources.

Table 3.2: The outline of Primary and secondary data source

Type of Source	Primary Source	Secondary Source
Definition	Data directly collected from participants through interviews, observation, or survey	Interpretations, analyses
Example	Transcripts of an interview, field notes, audio/video recording of interview	Scholarly articles, books, literature review
Purpose	To gather first-hand information and insight from participants	To provide context, analysis, and additional perspective on primary data
Characteristics	Rich, detailed, and context-specific information	Synthesized, analyzed, and interpreted information from primary source

3.7 Ethical Considerations

The ethical considerations began right from the first contact with the participating respondent until the report preparation, ensuring the confidentiality and anonymity of the participants was paramount. The researcher has shared a Data Collection Letter to the respondent to participate in a planned interview. A follow-up call was made to the interviewee to highlight the purpose of the interview session and assure them of the confidentiality of the information gathered.

In the data collection process, the informants based on their convenience set the date and location of the interview. During the early stage of the interview, the researcher explained the study to the respondent. They were also encouraged to share their knowledge and experience openly and encouraged to ask questions if there were any doubts. The researcher informed the interviewee that all the record/written feedback information given would be kept confidential and be used for academic study purposes only. We took measures to anonymize data during analysis and reporting. Respondent

names and identities and the company's name and identity would not be disclosed by using generic identifiers instead of real names and informants, permission to tape-record the interview was also obtained.

3.8 Data Analysis

A qualitative research method is a scientific study that collects evidence through open-ended questions. To perform data interpretation, qualitative data analysis is necessary session (Islam, M. A., & Aldaihani, F. M. F. (2022)). In content analysis, emphasis is necessary to ascertain the data's meaning. Categories and themes of "respondents" from the data that fit these categories are assigned coded allocations in the data. The subsequent step is to compile a matrix of categorized data against groups. In this research, listen to each interview and write down audio or written feedback on what each participant said during the interview, the transcripts of the respondents' responses were manually analyzed in the context of the audiotaped interviews using qualitative analysis techniques such as thematic analysis, and content analysis.

3.9 Chapter Summary

This chapter shared the methodology of the study. It justified the methodology for the study. Then it describes the criteria for the case selection and the number of the cases. Then follow the data collection and analysis procedures.

Case study methodologies were selected as these exploration topics need to address the in-depth understanding of the various types of risk mitigation strategies to improve supply chain resilience for the EMS industry in Penang. The unit of analysis is the

organizational level for the focal company and the upstream and downstream companies. For case study, case study protocol and interview protocol are developed to ensure the reliability and validity of the data.



CHAPTER FOUR – FINDING AND DISCUSSION

4.1 Introduction

In this study, qualitative research methods based on a case study analysis were applied to investigate and explain the findings from the interviews by relying on the experiences and working knowledge of the respondents, the approaches allow researchers to explore the complexities and nuances of supply chain dynamics, including the implementation and effectiveness of risk mitigation strategies and their impacts on supply chain resilience from a broader organizational perspective.

Data is gathered through an in-depth interview session with 10 respondents who work as Supply chain Officials, Managers, and Directors from 6 EMS companies based in Penang. These managers have more than 15 years of working experience and they have been directly involved in the development and implementation of risk mitigation strategies within their respective supply chain functions.

The researcher adapted the research open-ended questionnaires for this research. The fact that the protocol was conducted before and during the research interview session indicates that the researchers made it one of their primary research topics to demonstrate the validity and

readability of the data. All of the mitigation strategies were determined based on the study's objective, which was to investigate the type of potential risk, and the risk mitigation strategies to improve supply chain resilience were selected to address issues.

4.2 Company Background and Respondent Profile

The respondents who took part in the interview consisted of Ten (10) respondents who hold a high-level position in supply chain management as Senior Officials, Managers, and Director from 6 EMS companies located in Penang, and they were contacted by phone to schedule an interview either face to face or by On-line call, these 6 companies include 4 multinational (MNC) companies who rank among top 14 in global EMS industry (refer FIGURE 1.1) and 2 locally based company who are among local top rank EMS in Penang. Due to concerns over confidentiality and anonymity, it was agreed during the interview session that the names of the company and people participating would not be made public. Instead, the identities of the companies will be replaced by codes (C1, C2, C3, C4, C5, and C6) and the respondents name represented by codes (N1, N2, N3, N4, N5, N6, N7, N8, N9, N10).

4.2.1 Background for These 6 Selected EMS :

C1 is among the global top 10 rank multinational electronics manufacturing services (EMS) companies, headquartered in the USA. The company offers a wide range of services, including design engineering, manufacturing, supply chain management, and aftermarket services, serving various industries such as healthcare, automotive, consumer electronics, aerospace, and injection molding. C1 operates in over 100 facilities across 30 countries, which include 3 to 5 manufacturing sites in Penang. C1 business model focuses on providing end-to-end solutions to its customers, from product design and prototyping to full-scale manufacturing and distribution. The company prides itself on its commitment to innovation, operational excellence, and customer satisfaction, leveraging advanced technologies and strategic partnerships to

deliver high-quality, cost-effective solutions tailored to meet the unique needs of each client.

C2 is among the top 10 multinational (MNC) electronics manufacturing services (EMS) companies headquartered in Singapore. It was founded 50 years ago in the U.S . C2 provides design, manufacturing, distribution, and aftermarket services to original equipment manufacturers (OEMs) in various industries, including automotive, healthcare, consumer electronics, industrial, communication, and semiconductors. With a global presence spanning over 30 countries and approximately 100 manufacturing sites which include 4 or 5 manufacturing facilities in Penang, C2 offers a wide range of services, including product design and engineering, supply chain management, prototyping, manufacturing, logistics, and after-sales services. The company's expertise in innovation, technology, and supply chain solutions has made it a key partner for many leading companies seeking to bring their products to market efficiently and effectively. C2 commitment to sustainability and corporate responsibility is evident through its efforts to minimize environmental impact, promote ethical business practices, and support local communities where it operates

C3 is among the top 10 leading global multinational EMS. It provided integrated manufacturing solutions, components, and services in various industries, including technology, healthcare, defense, aerospace, automotive, and more. Founded and headquartered in USA, C3 has grown into a multinational company with operations in over 25 countries which include 2 sites in Penang. The company's expertise lies in providing end-to-end manufacturing solutions, including design, engineering, prototyping, manufacturing, logistics, and aftermarket services. C3 specializes in producing high-quality, complex electronics and mechanical products, such as printed

circuit board assemblies, system-level assemblies, enclosures, cables, and precision machining components. Their manufacturing capabilities encompass a wide range of technologies, including surface mount technology (SMT), box build, machining, injection molding, and more. With a strong focus on innovation, quality, and customer satisfaction, C3 has established long-term partnerships with some of the world's leading companies across various industries. By leveraging their global footprint, advanced manufacturing facilities, and supply chain expertise.

C4 is among the top 15 global EMS companies. Headquartered in USA, C4 operates in various industries including healthcare and life sciences, aerospace and defense, communications industrial, and commercial. The company provides end-to-end solutions that include product conceptualization, design, development, prototyping, manufacturing, supply chain management, and aftermarket services such as repair, refurbishment, and sustaining engineering. With a focus on innovation, quality, and customer satisfaction, C4 collaborates closely with its clients to bring their products to market efficiently and effectively. It has a global footprint with manufacturing facilities and offices strategically located in North America, Europe, and Asia-Pacific which include 3 sites in Penang. C4 is known for its expertise and deployment of differentiation competitive strategy based on high mix and low volume in complex electronic and electromechanical systems, including printed circuit board assembly, box build assembly, and system integration. Its commitment to sustainability and corporate social responsibility is evident through its initiatives to minimize environmental impact, promote ethical business practices, and support the communities in which it operates.

C5 is a Penang-based Electronics Manufacturing Services (EMS) provider. C5 has been providing electronics manufacturing services and technical support to Networking, telecommunication, data computing, Instrumentation, Consumer Products, Medical Devices, Semiconductor, Automotive, and IoT sectors. C5 is the place for talented people to bring their creativity and technological skills to the highest potential, and place a high value on diversity of skill, experience and cultural. It offers various services such as surface mount technology (SMT), electro-mechanical module assembly, box-built assembly testing, inspection, semiconductor process, and molding process.

C6 is a Malaysia-based EMS company, headquartered in Penang, Malaysia with four manufacturing sites in Malaysia, China, Netherlands, and Czech Rep. It provides integrated manufacturing technology solutions for precision parts, assembly products, mechatronics modules, and equipment built for a wide range of industries. It also provides contract design manufacturing for robotic welded frames & structures, and electric motors & controllers for electric vehicles. C6 is equipped with diverse and specialized machines, facilities, and measurement equipment for precision machining, sheet metal fabrication, welding, painting, surface finishing and high-level assembly including cleanroom operations. C6 serves more than 30 OEM customers globally in computer peripherals, commercial & digital printing, semi-con front and backend equipment, E&E equipment, consumer electronics devices, imaging & display, medical equipment and devices, analytical instruments, data & telecommunication, electric vehicles, and oil & gas industry.

4.2.2 Respondent Profile

The selected respondents have worked as a Supply Chain Senior Officer, Manager, and Director as shared in Table 4.1. Each respondent has over fifteen (15) years of experience in supply chain management-related function

Table 4.1: Respondent Profile

Respondent	Gender	Position	Working Experience(Y)	Function	Company
N1	M	Senior Manager	20	SCM	C1
N2	F	Director	30	SCM	C2
N3	F	Manger	25	SCM	C2
N4	M	Manager	30	Commodity	C3
N5	M	Director	30	Sourcing	C4
N6	M	Director	30	SCM	C4
N7	M	Manager	30	SCM	C5
N8	F	Senior Official	15	SCM	C5
N9	M	Manager	30	SCM	C5
N10	M	Director	25	SCM & Business	C6

4.3 Interview Protocol

The interview protocol is designed with a specific theme for each answer. The answer will be categorized, followed by the theme. The interview protocol is prepared as a guideline for interviewing during this interview session. Based on (Islam, M. A., & Aldaihani, F. M. F. (2022), the interview includes a detailed description of the situations, individuals, interactions, observable behaviors, activities, views, ideas, and opinions, as well as precise declarations from those who have experience with to topics. It contains parts of or whole sections from correspondence, records/diaries, case histories, and other personal or organizational documentation.

Protocol will enhance the reliability of research guide the investigators in collecting data from cases systematically and help to reduce the potential biases of researchers (Yin R. K., 2014). The main guide is as follows:

4.3.1 Prior Interview Session: Get the “Data Collection Letter” from UUM administrative office, then share the letter with the respondent to get his agreement to attend the interview session (refer to appendix list)

4.3.2 Introduction: During the interview session, begin with a self-introduction and an explanation of the purpose of the interview. Provide information about confidentiality and how the data will be used.

4.3.3 Informed Consent: Obtain consent from the participant who took in the interview and record the conversation. Explain the purpose of the study and the voluntary nature of participation. Confidentiality was communicated and assured to all participating parties that no names (person name, company name, etc.) will be mentioned in the final report. All audio tapes, paperwork, and documentation were

strictly kept in a safe and will be deleted once the researcher completes the academic research paper

4.3.4 Opening Questions: Start with open-ended questions to establish rapport and encourage the participant to share their experiences, opinions, or perspectives.

4.3.5 Main Interview Questions: These are the core questions that address the research objectives. They should be open-ended and flexible to allow for in-depth exploration of the topic.

4.3.6 Probes and Follow-up Questions: Use probes to get more detailed responses or clarify ambiguous statements. Follow-up questions should drive deeper into specific aspects raised by the participant.

4.3.7 Closure: Thank the participant for their time and participation.

4.4 Transcribe the Interview Recording, Data Analysis, and Discussion of Findings

According to the research objective, the purpose of the interviews is to assist the literature evaluation that relates to supply chain disruption risk mitigation strategies that are implemented by the Penang EMS industry. In this research, listen to each interview and write down audio or written feedback on what each participant said during the interview, the transcripts of the respondents' responses were manually analyzed in the context of the audiotaped interviews using qualitative analysis techniques such as thematic analysis, content analysis, or narrative analysis.

For example, After transcribing the interviews, we will notice recurring themes or patterns in participants' responses. For instance, through thematic analysis, we might

find the themes that there are different types of supply chain disruption risk and mitigation strategies deployed by EMS industry stakeholders. We could then drive deeper into these themes by examining the findings behind these experiences, finally, you would interpret the analyzed data to draw conclusions and insights. By transcribing the interview recordings and applying qualitative analysis techniques, researchers can gain rich insights into participants' experiences, perceptions, and behaviors. To find out disruption risk mitigation strategies implemented by the Penang EMS industry, the results of the interview questionnaire questions are compared and analyzed.

4.4.1 Different Types of Potential Supply Disruption Risk

The following question was asked and the respondents were requested to share their experience of the different types of supply chain disruption risks faced by their company. “Could you share your experience regarding the different types of potential supply chain disruption risk faced by your company?”

Based on the interview feedback, all ten respondents (N1 to N10) from 6 EMS companies (C1 to C6) have hands-on experience in handling the following disruption risk

- a) Pandemic risk, for example COVID-19
- b) Geopolitical Risk, for example, US & China trade war
- c) Customer demand forecast fluctuation Risk
- d) Single source supplier and single geographic location
- e) Climate change or natural disaster Risk
- f) Supplier’s Quality disruption risk

According to respondents N1, N2, N3, and N8 feedback, the present top 4 rank disruption risk are (1) Geopolitical risk, (2) Single source supplier and single geographic location, (3) Customer demand forecast fluctuation/ inaccuracy, (4) Pandemic risk, while N4, N5, N6, N7, N9 and N10 rank (a) Geographic risk, (b) customer demand fluctuation, (c) quality risk and (d) natural disaster risk as their present top 4 risk. However, all of them agreed that the pandemic risk during COVID-19 in the years 2019 to 2022 was the most impacted risk that they faced. But based on the latest supply scenario, Geopolitical issues which include a trade war between U.S and China, and Red Sea tension are their present top risk.

Important statement or response from respondents :

Based on feedback from N1 *“Geopolitical issues, Dependency on a single source supplier or geographic location poses inherent risks, particularly in challenging times of crisis. Customer demand fluctuation and customer-dictated single-source suppliers also created a high disruption risk for us. The pandemic highlighted vulnerabilities in our supply chain, prompting a reassessment of our sourcing strategies and supplier relationships to mitigate such risks”*

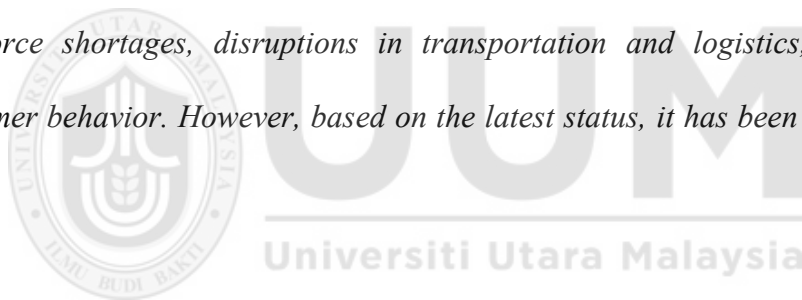
N3 mentioned that *“Geopolitics between U.S and U.S has created a lot supply uncertainties. Fluctuations in customer demand have been a key challenge, forecasting accuracy became even more critical as demand patterns shifted unpredictably especially those critical parts with single-source supplier”*

N6 shared that *“In addition to Geopolitical and demand fluctuation risk, quality risk may impact our operation continuity as has faced the line down situation due to incoming raw material rejection from a supplier, the impact of quality risk on product*

safety cannot be overstated. Mitigating quality risks is to ensure the continuity of quality incoming raw."

According to N7 *"We experienced demand fluctuation and natural disaster as our supply risk, while geopolitical tensions have always been a concern, the trade war between the US and China intensified uncertainties in our supply chain. Tariffs, trade restrictions, and political instability affected our sourcing strategies and led to increased costs and operational complexities. The latest tension in the Red Sea has created a lot of shipment delays."*

All the respondents shared that *"the pandemic COVID-19 risk has been a significant disruptor for us from 2019 to 2023, causing unprecedented challenges such as workforce shortages, disruptions in transportation and logistics, and shifts in consumer behavior. However, based on the latest status, it has been moved to lower risk."*



4.4.2 Risk Mitigation Strategies

The respondent was asked to share their experience of the supply chain risk mitigation strategies implemented by their company. The respondent was questioned about the different types of supply chain disruption risk mitigation strategies implemented by their company. "What are the current best practices in supply chain risk mitigation strategies adopted by your companies & and how do these strategies help to mitigate supply chain risk?

All ten respondents (N1 to N10) from 6 EMS companies (C1 to C6) feedback that they have experience in handling the following disruption risk strategies

- a) Supplier diversification

- b) Supplier geography diversification
- c) Build up buffer stock
- d) Supplier collaboration and strategic partner relationship
- e) Deployment of Supply Chain Technology (SCT)

The focus of each strategy depends on the contemporary issue which may be different from time to time. For example, the deployment of building up buffer stock was a key and top attention strategy during COVID time, however, based on N1, N3, N2, N4, N5 and N10 feedback, presently they consider buffer stock building as a low-priority strategy as the current market is softer and the current supply is more than demand, furthermore, buffer stock build-up will incur additional operation cost.

Important statement/feedback summary based on N1, N2, N3, N4, N5, and N10 mentioned: *“Based on our current practice and experience, it is part of our operation strategy to implement the current best practices in supply chain risk mitigation strategies including supplier diversification, supplier geography diversification, supplier collaboration, and strategic partner relationships, and deploying advanced Supply Chain Technology (SCT). These practices collectively enhance resilience and flexibility, enabling companies to effectively navigate disruptions and uncertainties in the supply chain landscape. Building up safety stock was also our key risk mitigation strategy, however, currently, we consider it as low priority strategy due to the overall softer demand market”*

According to N6, N7, N8, and N9:” *It is common in our company to implement supplier diversification, supplier geography diversification, supplier collaboration, and strategic partner relationships, and limited deploying advanced Supply Chain Technology, however, the focus of each strategy may be the difference from time to*

time. For example, we are currently involved in advance ERP implantation and simple bar code receiving/issuing”.

4.4.2 Supplier Diversification Strategy

To get the respondent to share their experience regarding their company implantation of supplier diversification strategy. “Does your organization implement supplier diversification as the strategy to mitigate potential disruption risk to improve supply chain resilience and how does the strategy help to mitigate supply chain risk?

Based on general feedback from MNC EMS supply chain stakeholders, supplier diversification was not their key strategy before COVID-19 they practiced a supply consolidation program to get better purchase prices based on global consolidated quantity, however, they have changed it to supplier diversification after COVID-19.

N1, N2, N3, and N4 feedback that : *“Before COVID-19, we did not focus much on supplier diversification, instead our sourcing teams are focusing more on supplier consolidation programs so that we can leverage our demand quantity from various sites and countries to consolidate different site volume to get a better discount price. However, this practice has changed after COVID-19, we changed our sourcing strategy to focus on supplier diversification. By engaging with multiple suppliers, we reduce our dependency on any single source. This mitigates the risk of disruptions caused by supplier pandemics, geopolitical issues, or other unforeseen events impacting a single supplier. Diversification provides greater flexibility and ensures supply continuity in responding to changes in the market. If one supplier encounters difficulties, we can quickly pivot to alternate sources to maintain continuity of supply,*

we need to ensure the supply continuity and improve the supply chain resilience to guarantee the healthy growth of the company business”.

Summary of experience sharing based on N5, N6, and N10 reply: *“Yes, we practiced supplier diversification as our risk mitigation strategy all the time, this will allow us to reduce our dependency on any single supplier, especially for those critical and long lead time components. By having supplier diversification, we have options to secure material with the other source when the first source is having an issue supplying. On top of that, we will have cost leverage when there is competition among the suppliers to win supply allocation”.*

N7 ,N8 ,N9 mentioned that *“For that component source that controlled by our company, we will practice supplier diversification program to mitigate potential single supply risk, for better deliver flexibility and also better price bargaining power, however for those components that supplier was dictated by our customer, then will follow customer approved vendor, For instance, restrictions imposed by customers on specific part numbers may limit the feasibility of qualifying second vendors”.*

4.4.3 Supplier Geography Diversification Strategy

To get the respondents to share their knowledge and experience regarding their company's implementation of the Supplier geography diversification strategy. The following question was asked *“Do you think supplier geography diversification is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk?”*

For MNC EMS (C1 to C4), their Global Commodity/Sourcing will coordinate with the manufacturing site team to work on the implementation of this strategy to navigate the potential risk and enhance supply chain resilience. However for those local EMS (C5 & C6), their procurement team will communicate with their customer to implement the details of the geography diversification strategy after they get customer approval.

N1 shared his practical experience that *“Supplier geographic diversification is a crucial strategy to navigate the supply risk. For example, recent attacks on Red Sea shipping, coupled with existing geopolitical and climate-related challenges, have given rise to a complex crisis affecting key global trade routes. United National Conference Trade and Development (UNCTAD) estimated that the weekly transits going through the Suez Canal decreased by 42% over the last two months. Logistic lead time and cost will impact*

N2, N3, N5, and N6 feedback that *“We have our global commodity or sourcing team who are located in difference countries to work on this strategy. Supplier geographic diversification is an important strategy in mitigating risks and enhancing supply chain resilience. By spreading sourcing across multiple suppliers from different regions or countries, we can reduce its dependency on any single geographic region supplier, thus minimizing the impact of potential disruptions risks. By diversifying suppliers across different regions or countries, companies can spread the risk associated with localized disruptions. For instance, if an earthquake or tsunami strikes one region, suppliers from other regions can still fulfill orders, reducing the overall impact on the supply chain, this will allow us to have better supply continuity and flexibility as*

dependency on a single source supplier or geographic location poses inherent risks, particularly in times of crisis”.

Conclusion of N7, N8, N9 feedback: *“Supplier geographical diversification can indeed be an effective strategy to mitigate risk and enhance supply chain resilience. By sourcing from suppliers located in different regions or countries, we can minimize its vulnerability to disruptions such as COVID-19, natural disasters, and geopolitical, or trade disputes in any one location. It will help in providing redundancy, spreading risk, enhancing flexibility, and optimizing the overall supply chain. For those components that supplier was dictated by our customer, then will buy from the country that is customer-approved, For instance, restrictions imposed by customers on specific part numbers may limit the feasibility of qualifying second vendors from different countries or regions”.*

N10 replied *“This strategy of supply chain helps to mitigate in the event of geographic crisis and disaster. diversification allows for greater flexibility in responding to changing market conditions. For example, if one region experiences a sudden increase in production costs or regulatory challenges, companies can quickly shift sourcing to alternative locations without significant disruption to operations. companies that strategically leverage supplier diversity will be better positioned to withstand disruptions and capitalize on growth opportunities.”*

4.4.4 Build-up Buffer Stock Strategy

To get the respondent to give feedback on their knowledge and experience regarding their company's implementation of the building-up buffer strategy. The following question was asked “Do you think that Building up a buffer is an effective strategy to

mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk?”.

Generally, they practiced buffer build-up as a key strategy to mitigate disruption risk and improve supply resilience and customer service, especially during the COVID-19 period. However before COVID-19, most of the companies deployed the Toyota Just In Time (JIT) and Vendor Manage Inventory (VMI) programs to improve operation efficiency and enhance inventory turn while minimizing the risk of excess and obsolete (E&O) inventory, furthermore they emphasized that it is important to get customer approval the amount of buffer stock to keep to avoid any inventory excess and obsolete (E&O) liability in case of any sudden demand drop or produce End Of Life (EOL).

N1 mentioned that *“Buffer Stock is important but depends on company finance health especially this impact day in inventory and cash flow. Our buffer stock strategy is dynamic and responsive to changes in market conditions and demand patterns. We regularly analyze demand forecasts, lead times, and supplier performance to adjust our buffer stock levels accordingly. It depends on customer strategy; the standard buffer stock plan is 30 days. But for some high-risk items, may plan for 90 days, we collaborate closely with our customers and suppliers to implement buffer stock strategies upstream in the supply chain. This includes sharing demand forecasts, coordinating production schedules, and establishing mutual agreements to hold buffer stock at strategic locations. By aligning our efforts with key partners, we can better manage risks and ensure continuity of supply*

Combination of N2, N3, N4, and N5 feedback as the following : *“Building up a buffer can indeed be an effective strategy to mitigate risks and enhance supply chain*

resilience. The buffer essentially acts as a safety net, providing a cushion against disruptions and uncertainties within the supply chain. We normally work with customers to keep about 10-20 % safety stock. By maintaining extra inventory or capacity, organizations can better absorb shocks caused by unexpected events such as natural disasters, geopolitical issues, or sudden changes in demand. Furthermore, Buffers will provide flexibility in responding to fluctuating demand or supply conditions. The urgency of keeping buffer stock got more attention from us during and after COVID-19, we focused on Just In Time and Vendor Manage inventory (VMI) program before COVID-19 to improve overall operation costs by improving inventory turn and avoid any obsolete inventory, we normally will get our customer approval before we keep additional safety stock to have clear liability”

N7 , N8 , N9 mentioned that “Yes, we applied this approach after getting approval from our customer. We will sign a mutual agreement with suppliers to buffer stock for certain periods based on customer forecasts. The buffer stock may be kept at the supplier side or our internal warehouse with a preference to keep it in our internal warehouse, maintaining buffers helps us to have visibility and understanding of inventory levels, production capacities, and demand patterns. This improved visibility enables better decision-making and proactive risk management strategies, leading to overall improvement of supply chain resiliency”.

N10 replied “Concerning buffer stocks, it is an important strategy to overcome sudden issues, we have an agreement with our customers that we hold buffer stocks for critical and long lead time parts but the risk and liability belong to them. we maintain a certain level of buffer stock for key raw materials and components that are critical to our production process. This ensures that we can continue production even if there are

unexpected delays or disruptions in the supply chain. By having this additional inventory on hand, we can minimize the impact of sudden changes in demand or supply constraints”.

4.4.5 Supplier Collaboration and Strategic Partner Relationship Strategy

To get the respondent to share their knowledge and experience regarding their company's implementation of the supplier collaboration and strategic partner relationship strategy. The following question was asked “Do you think that Supplier collaboration and strategic partner relationship is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk?”

Generally the respondents feedback and shared that Supplier collaboration and strategic partner relationships are important components of an effective strategy to mitigate supply chain risks and enhance resilience. By fostering strong partnerships, organizations can enhance risk identification and management, improve communication and coordination, increase flexibility and agility, share risk management responsibilities, and drive innovation and continuous improvement throughout the supply chain. They also emphasized that strategic partners play a key role as they will enjoy raw material allocation priority from their strategic vendor during a supply-challenging time.

N2 said that “*Collaboration and partnership program is very important so that we can work closely to improve the supply chain resilience, example the close collaboration with supplier and customer will allow us to know the detail and real-time demand fluctuation and work closely act fast on the gap and swap of the supply, mitigate*

among the others of their customers and the best is mitigate the balancing of overall supply vs overall demand of our customers. No surplus elsewhere when we are having shortages “.

N3 shared that *“supplier collaboration and strategic partner relationships play a key role in mitigating supply chain risks and improving resilience. For Example, we will enjoy raw material allocation priority from our strategic vendor during a supply-challenging time. One example of collaboration's important role in ensuring supply chain resilience comes from a manufacturing company that weathered a significant disruption. During a sudden supplier shutdown due to a natural disaster in Taiwan, our company's collaborative relationships with alternate suppliers proved invaluable. Through proactive communication and established partnerships, they swiftly reallocated resources and production capabilities to maintain operations”.*

N4 mentioned that *“By having collaboration and strategic relationship with suppliers, more accurate market trends and news are available for strategic planning and decision making. Apart from benefiting from the information aspect, the most strategic partnership will have better supply chain terms & conditions (ie: payment terms, agility participation, and customer service support). Also by having a strategic relationship, we get better attention at the supplier end when it comes to issues escalation (getting allocation, quality issues, pull in, push out) “.*

Based on respondent N5's feedback *“Yes, the relationship will play an important role. Although under normal purchasing process, we have a Purchase Order (PO) or agreement link with the supplier, however, a relationship or collaboration will help the company to go through to challenging supply period as the strategic vendor will*

consider delivery allocation by putting priority and special attention or support to strategic customer. One example is that the purchase lead time in the agreement is 6 weeks, however, due to the strategic collaboration partnership, the supplier will deploy whatever available resource to reduce normal lead to 3 weeks to support us in case of any sudden demand increase by customers. The strong relationships foster a sense of commitment and accountability among suppliers, encouraging them to prioritize the success and resilience of the entire supply chain. In times of crisis or uncertainty, suppliers are more likely to go above and beyond to support each other and collectively address challenges, minimizing the impact of disruptions and improving resiliency on the supply chain's performance”.

Feedback summary from N6 ,N7 ,N8 ,and N9 : “Having a good relationship with a supplier tends to gain a higher level of trust between the 2 parties. This will enable more collaboration and flexibility to resolve supplier chain challenges like shortages and inventory management”.

N10 shared that” Joining Electronics trade associations and having partners within the manufacturing community, we can get help in situations of crisis. We contact some of these partners. If they have on hand stocks of any particular parts we loan from them a certain quantity. Once our supply has docked in, we will return the quantity to the partner. This collaborative effort not only minimized downtime but also enabled the company to meet customer demands without compromising quality or delivery timelines. Without such collaborative relationships in place, the impact of the disruption could have been far more severe”.

4.4.6 Deployment of Supply Chain Technology Strategy

To have the respondent share their knowledge and experience regarding their company's deployment of Supply Chain Technology strategy. The following question was asked “Do you think that the Deployment of Supply Chain Technology strategy is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk?”

Based on the respondent feedback The deployment of the Supply Chain Technology (SCT) strategy is indeed an effective approach to mitigate risks and enhance supply chain resilience. This strategy leverages advanced technological tools and solutions to streamline operations, enhance visibility, and enable predictive analytics and accurate demand forecasts, it will help to optimize decision-making processes throughout the supply chain system. By harnessing the power of technology, organizations can proactively identify, assess, and mitigate risks, thereby ensuring continuity of operations and maintaining customer satisfaction even during supply challenging times." For MNC EMS (C1, C2 , C4), they are working closely with headquarters to deploy to advance SCT such as the implementation of RFID sensor bar code in their warehouse and production area to have real-time traceability of their inventory status, the progress of their Work In Progress (WIP) and also help them to improve their sourcing risk mitigation activities. Robotics and automation implementation in their operation to enhance their supply chain resilience, they also focus on advanced Entrepreneur Resource Systems (ERP) and digitalized demand-driven systems to Streamlined their operations, and enhance traceability and supply chain inventory visibility. As for 2 local EMS, currently they more focus on advanced Entrepreneur Resource Systems (ERP) and some simple bar code RFID and automation systems

while they are exploring the implementation of the digitalized process which is in line with the Malaysian government's Industry Revolution (I.R 4.0) policy.

Based on N1's response *"Today's digital economy demands a new approach to manage the entire supply chain ecosystem, known as supply chain digital transformation. This involves "employing analytics, artificial intelligence, robotics, the Internet of Things, and other advanced technologies to collect and process information automatically and either support decision-making and other activities or automate them altogether." A fully integrated suite of sourcing, orchestration, and logistics platforms that uses big data analytics and artificial intelligence can deliver greater visibility, recommended actions, and predictive risk mitigation for supply chain resiliency"*.

N2 and N3 shared that *"SCT deployment will enhance and improve the speed of the information flow and will help to have more real-time data, this will ease and improve the overall End to End process. We deployed the RFID bar code during the raw material receiving and issuing process, this will reduce human key errors or missed keys in transactions, this improve inventory accuracy and traceability. The implementation of advanced software systems, such as supply chain management platforms and predictive analytics tools, has allowed us to gain real-time visibility into various aspects of our supply chain operations"*.

N4 feedback that he has very limited experience in SCT deployment.

Based on N5 and N6 feedback: *"SCT Faster turnaround time, higher level of accuracy & efficiency at a cheaper cost. The experience is a real-time link to supply to manage, trace, and improve visibility while managing the SCM system which involved more than 1000 raw material parts no, and also different expectations from different customers. An effective clean-to-build tool that can help to crunch material clean to*

build within seconds versus conventional 48 – 96 hours. The automated data is more reliable than the manual or semi-auto process. This will enable the next course of action to be taken immediately, especially in a disaster situation”.

N8 and N9 said that *“SCT will help to identify problems early and respond quickly to disruptions. Easy to track the material transactions and movement, the utilization of RFID technology has revolutionized our inventory management processes. By tagging each product with RFID chips, we were able to accurately track inventory levels at every stage of the supply chain*

According to N10 *“SCT devices and technology if used within the supply chain will enhance the capability of the manufacturer. It will improve the accuracy and speed to locate the parts and move them to the Production floor. With an integrated supply chain system, it will highlight and alert some problems before they get too serious. With the ability to collect and analyze vast amounts of data from multiple sources, including suppliers, transportation networks, and market trends, we can better identify potential vulnerabilities and anticipate disruptions before they occur. For example, by monitoring supplier performance metrics and tracking historical data on delivery times, we can proactively address any issues that may impact our supply chain continuity, this is in line with our company policy in implementing SC IR 4.0”.*

4.5 Summarizes the Main Findings

Table 4.2 shows the summary of the findings based on the questions that were distributed to the respondents. The purpose of this summary was to make it simpler to locate the key findings of this research.

Table 4.2: Summary of the main finding

Question	Respondent	Finding
Could you share your experience regarding the different types of potential supply chain disruption risks faced by your company?	N1, N2, N3, N4, N5, N6 N7, N8, N9, N10	a) Single source supplier and geographic location b) Geopolitical risk c) Customer demand fluctuation/forecast inaccuracy d) Pandemic, COVID-19 e) Supplier Quality f) Climate change/Natural disaster
What are the current best practices in supply chain risk mitigation strategies adopted by your companies & and how do these strategies help to mitigate supply chain risk?	N1, N2, N3, N4, N5, N6 N7, N8, N9, N10	a) Supplier diversification b) Supplier geography diversification c) Build up buffer stock d) Supplier collaboration and strategic partner relationship e) Deployment of Supply Chain Technology (SCT)
Does your organization implement supplier diversification as the strategy to mitigate	N1, N2, N3 ,N4	we changed our sourcing strategy to focus on supplier diversification. By engaging with multiple suppliers, we reduce our dependency on any single

potential disruption risk to improve supply chain resilience and how does the strategy help to mitigate supply chain risk	N5, N6, N10	source. Diversification provides greater flexibility and ensures supply continuity in responding to changes in the market. If one supplier encounters difficulties, we can quickly pivot to alternate sources to maintain continuity of supply, we need to ensure the supply continuity and improve the supply chain resilience to guarantee the healthy growth of the company business we practiced supplier diversification as our risk mitigation strategy all the time, this will allow us to reduce our dependency on any single supplier, especially for those critical and long lead time components. By having supplier diversification, we have options to secure material with the other source when the first source is having an issue supplying. On top of that, we will have cost leverage when there is competition among the suppliers to win supply allocation
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	N7, N8, N9	we will practice a supplier diversification program to mitigate potential single supply risk, for better delivery flexibility and also better price bargaining power, however for those components that the supplier was dictated by our customer, then will follow the customer-approved vendor
Do you think supplier geographic diversification is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk	N1 N2, N3, N5, N6	Supplier geographic diversification is a crucial strategy for navigating the supply risk Supplier geographic diversification is an important strategy in mitigating risks and enhancing supply chain resilience. By spreading sourcing across multiple suppliers from different regions or countries, we can reduce its dependency on any single geographic region supplier, thus minimizing the impact of potential disruption risks Supplier geographical diversification can indeed be an effective strategy to

	N7, N8, N9	mitigate risk and enhance supply chain resilience. By sourcing from suppliers located in different regions or countries, we can minimize its vulnerability to disruptions such as COVID-19, natural disasters, and geopolitical, or trade disputes in any one location. It will help in providing redundancy, spreading risk, enhancing flexibility, and optimizing the overall supply chain
Do you think that Building up a buffer is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk ?”.	N1 N2, N3, N4 ,N5	Buffer Stock is important but depends on company finance health especially this impact day in inventory and cash flow. Our buffer stock strategy is dynamic and responsive to changes in market conditions and demand patterns. The buffer essentially acts as a safety net, providing a cushion against disruptions and uncertainties within the supply chain. We normally work with customers to keep about 10-20 % safety stock. By maintaining extra inventory

	N7, N8, N9	or capacity, organizations can better absorb shocks caused by unexpected events such as natural disasters, geopolitical issues, or sudden changes in demand. Maintaining buffers helps us to have visibility and understanding of inventory levels, production capacities, and demand patterns. This improved visibility enables better decision-making and proactive risk management strategies, leading to overall improvement of supply chain resiliency
Do you think that Supplier collaboration and strategic partner relationship is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk ?”	N2	Collaboration and partnership program is very important so that we can work closely to improve the supply chain resilience, example close collaboration with suppliers and customers will allow us to know the details and real-time demand fluctuation and work closely to act fast on the gap and swap of the supply

	N3	supplier collaboration and strategic partner relationships play a key role in mitigating supply chain risks and improving resilience. For Example ,we will enjoy raw material allocation priority from our strategic vendor during a supply-challenging time
	N4	By having collaboration and strategic relationships with suppliers, more accurate market trends and news are available for strategic planning and decision-making. Apart from benefiting from the information aspect, most strategic partnerships will have better supply chain terms & conditions
	N7, N8, N9	Having a good relationship with a supplier tends to gain a higher level of trust between the 2 parties. This will enable more collaboration and flexibility to resolve supplier chain challenges like shortages and inventory management

Do you think that the Deployment of Supply Chain Technology strategy is an effective strategy to mitigate the risk and improve supply chain resilience, and how does the strategy help to mitigate supply chain risk ? 	N1	A fully integrated suite of sourcing, orchestration, and logistics platforms that uses big data analytics and artificial intelligence can deliver greater visibility, recommended actions , and predictive risk mitigation for supply chain resiliency”.
	N2, N3	SCT deployment will enhance and improve the speed of the information flow and will help to have more real-time data, this will ease and improve the overall End to End process. We are deployed RFID bar code during raw material receiving and issuing process,this will reduce human key in error or missed key in transaction ,this improve inventory accuracy and tracibility
	N5, N6	SCT Faster turnaround time, higher level of accuracy & efficiency at a cheaper cost. The experience is a real-

		time link to supply to manage, trace, and improve visibility
	N8, N9	SCT will help to identify problems early and respond quickly to disruptions. Easy to track the material transactions and movement, the utilization of RFID technology has revolutionized our inventory management processes
	N10	With the ability to collect and analyze vast amounts of data from multiple sources, including suppliers, transportation networks, and market trends, we can better identify potential vulnerabilities and anticipate disruptions before they occur. For example, by monitoring supplier performance metrics and tracking historical data on delivery times, we can proactively address any issues that may impact our supply chain continuity, this is in line with our

		company policy in participating SC IR 4.0
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4.6 Chapter Summary

In general, based on feedback from all the respondents (N1 to N10) from 6 EMS companies, they acknowledged that common supply chain risks faced by Penang EMS company are Customer Demand Forecast Fluctuation Risk, Geopolitical Risk, Single source supplier and Single geographic location, Pandemic Risk, Supplier's Quality Disruption Risk, Climate change or natural disaster Risk. They also agreed that effective supply chain disruption risk mitigation strategy included supplier diversification, geographic diversification, buffer stock management, supplier collaboration, and SCT deployment to build a resilient supply chain ecosystem, however, the focus of each strategy adopted by each company may differ from time to time pending on (1)Urgency of Current contemporary issue,(2) Overall market supply and demand scenario,(3)Company supply chain competitive strategy and policy,(4) Agreement with the customer and lastly company's and customer expectation. By embracing a comprehensive and integrated approach to risk management, EMS companies can better withstand disruptions and capitalize on emerging opportunities in the competitive landscape

Based on Table 4.3, shows the findings on the types of disruption risks, and the risk mitigation strategies are in line with the literature review which was mentioned in Chapter 2.

Table 4.3: Discussion of the main finding

Theme	Finding	Literature Review
1	Type of supply chain disruption risk Customer Demand Forecast Fluctuation Risk Geopolitical risk Single source supplier and single geographic location Pandemic risk	Fluctuations in customer demand have been a key challenge, due to changing consumer behaviors and market dynamics. Forecasting accuracy became even more critical as demand patterns shifted unpredictably surge (Lucker.F., 2021) It refers to the potential political, economic, military, and social risk that emerges from a nation's involvement in international affairs, this has increased volatility and uncertainties (Yu, 2023) Dependency on a single source supplier or geographic location poses inherent risks, particularly in times of crisis (McMaster, 2020) A pandemic refers to the worldwide spread of new diseases caused by the new influenza virus (Huang Y., 2020)

	Suppliers quality risk Climate change or natural disaster Risk	It is a risk of the supplier fail to comply with purchase order terms such as failing to meet agreed product quality standards or late delivery(George A .,2016) It is a risk caused by natural or climate hazards that disrupt the functioning of the community & it exceeds human capacity to cope with it. Climate change and natural disasters remain substantial risks with potentially severe consequences for our operations (Paul, 2020).
2	Risk Mitigation Strategies Diversification of suppliers' base	A diversified supply chain base can enhance the operational effectiveness of firms to meet the needs of the market and customers. Furthermore, a diverse supplier base can help organizations to achieve higher resilience by improving the

		capability to face potential supply chain disruption(Yin, W., & Ran, W.,2022) Factoring geographic diversification in supplier selection models is crucial for developing supply chains resilient against unpredicted disruption risk. (Islam, S., Hasan, M., & Fai, T. I.,2022) . Keeping buffer or safety stock is included as the strategy to meet supply and demand fluctuation in order improve customer service and enhance supply chain responsiveness (Barros et al.,2021). Good supplier relationships have always been crucial but in times of supply disruption, strong collaborated relationships are highly important ((Hao, 2022) The industry must start deploying digital technologies which include Artificial intelligence (AI), Internet
	Diversification of Suppliers' geographic location	
	Building up buffer inventory	
	Enhance supplier relationships and collaboration	
	Embrace Supply Chain Technology	

		of Things (IoT), Machine Learning (ML), Blockchain, and Big Data to improve supply chain visibility, agility, flexibility, and resiliency (Da Costa et al.,2022)
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CHAPTER FIVE – CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter will discuss the influence of Risk Mitigation Strategies Toward Supply Chain Resilience. Based on the research objective in Chapter 1 and the literature review in Chapter 2, it will correlate with the findings by sharing the summary, implication, and limitations of the study. In addition, some suggestions and recommendations for future research improvement.

5.2 Discussion of Research Finding

Interview findings revealed that supplier diversification plays a critical role in enhancing supply chain resilience within the EMS industry in Penang, especially after COVID-19. Based on the latest development, respondents emphasized the importance of having multiple suppliers for key components to mitigate risks associated with supplier disruptions compared to suppliers' consolidation programs before COVID-19 for cost-saving purposes. They noticed that Diversifying suppliers not only provides alternative sourcing options but also fosters competition, which can lead to improved quality and cost-effectiveness. However, challenges such as maintaining consistent quality standards across diverse suppliers and managing relationships with multiple partners were highlighted as potential drawbacks of this strategy.

The findings disclosed the significance of supplier geography diversification as a means of mitigating geopolitical and natural disaster risks. Participants acknowledged that spreading suppliers across different geographical regions can reduce the vulnerability of the supply chain to localized disruptions. Moreover, having suppliers

in diverse locations enables companies to leverage regional strengths and access specialized capabilities. Nevertheless, concerns regarding increased transportation costs and coordination complexities were noted as key considerations when implementing this strategy. Some of the respondents shared that they may consider deglobalization or localization programs after going through a geopolitical trade war and the latest Red Sea tension.

Interview data indicated that building up buffer stock serves as a crucial risk mitigation strategy to enhance supply chain resilience. Most of the companies applied the concept of Just In Time (JIT) before COVID-19, however after COVID-19, supply chain stakeholders highlighted the importance of maintaining sufficient inventory levels to absorb demand fluctuations and unforeseen disruptions. Buffer stock provides a safety net during times of supply chain volatility, enabling companies to fulfill customer orders without delays. However, the trade-off between carrying costs and stockout risks necessitates careful inventory management to strike the right balance.

In addition, the interviews emphasized the significance of fostering collaborative relationships with suppliers and strategic partners to bolster supply chain resilience. Participants noted that close collaboration facilitates information sharing, joint problem-solving, priority allocation, and mutual support during crises. Strategic partnerships enable companies to align objectives, streamline processes, and co-create value across the supply chain ecosystem. Nonetheless, building trust and alignment of interests among partners were identified as fundamental challenges in establishing effective collaboration.

The findings also share the role of supply chain technology (SCT) in enhancing visibility, agility, and responsiveness within the EMS industry supply chain.

Participants emphasized the importance of investing in advanced technologies such as real-time tracking systems, and advanced ERP analytics systems to mitigate risks and improve decision-making capabilities.

Lastly, based on most of the respondent feedback, the current most critical SC risks are customer demand fluctuation and geopolitical risk which require advanced SCT to provide clear visibility & transparent information, accurate demand forecast to improve SC visibility, flexibility, and agility.

Overall, the interviews highlighted the interdependence and complementarity of the proposed risk mitigation strategies. The research shows the need for an integrated approach that combines supplier diversification, geographic diversification, buffer stock management, supplier collaboration, and SCT deployment to build a resilient supply chain ecosystem. By adopting a holistic strategy that addresses various dimensions of risk, EMS companies in Penang can better navigate uncertainties and sustain competitive advantage in the dynamic global market.

In conclusion, the qualitative interview findings discovered the critical role of risk mitigation strategies in improving supply chain resilience within the EMS industry in Penang. The suggested strategies of supplier diversification, supplier geography diversification, building up buffer stock, supplier collaboration, and SCT deployment emerged as key enablers of resilience. However, successful implementation may require careful consideration of trade-offs between responsive and efficient strategy, collaboration among stakeholders, and continuous adaptation to encounter market dynamics. By embracing a comprehensive and integrated approach to risk management, EMS companies can better prepare & respond to contemporary disruptions, ensuring continuity of operations and maintaining competitive advantage

in competitive market environments. For an example ,the strategies deployed before and after COVID-19 as shared in Table 5.1:

Table 5.1: Supply Chain deployment strategies before and after COVID-19

No	Activities	Before COVID-19	After COVID-19
1	Supplier selection	Focus on quality, cost and delivery	Risk Mitigation & Resiliency capability will be key criteria
2	Cost & Lead Time Reduction	Achieved through raw materials competitive cost, lower operation, and inventory cost, shorter lead time	Cost reduction by automation, total supply chain cost & lead time reduction via data analytics while improving supply chain resilience
3	Inventory management	Inventory optimization & implementation of JIT pull is the top KPI	Increase Supply Chain Resiliency by keeping buffer stock for the critical component is the norm
4	Supplier network connection	Most of the connections via simple electronic data interchange (EDI) and email	Integrated network system among manufacturer, suppliers, logistics provider & customers

			to improve information visibility and resiliency
5	Number of qualified suppliers	Try to reduce the number of suppliers through a consolidation program.	Diversified the number of suppliers and multi-geography location
6	Supplier collaboration and relationship	Not as a priority focus	Supplier relationship and collaboration strategic partnership
7	Deployment of Supply Chain Technology	More on daily & not advance application	Consider the deployment of Supply Chain Technology as key KPI

5.3 Implication of The Study

It is predicted that the results of this study will also be applied to other projects that facing similar issues and challenges. Additionally, this study can be seen as a contribution to the corpus of practical information regarding the practiced strategies in risk mitigation in the manufacturing industry. The following are some of the practical impacts that the industry expects to face:

i. Enhanced Risk Management Practices

The research may uncover specific risk mitigation strategies that are effective in enhancing supply chain resilience within the EMS industry. These findings could

inform EMS companies in Penang and beyond about best practices for managing risks in their supply chains.

ii. Improved Business Continuity Planning

Understanding how different risk mitigation strategies contribute to supply chain resilience can help EMS companies develop more robust business continuity plans. This could involve identifying vulnerabilities and implementing measures to mitigate disruptions proactively.

iii. Cost Reduction Opportunities

By identifying effective risk mitigation strategies, companies may discover opportunities to reduce costs associated with supply chain disruptions. For example, investing in certain technologies or diversifying suppliers may incur initial costs but lead to long-term savings by preventing or minimizing disruptions.

iv. Supplier Relationship Management

The research may shed light on the importance of strong relationships with suppliers in building resilient supply chains. Companies may learn how to foster better communication, collaboration, and trust with their suppliers to mitigate risks effectively.

v. Strategic Decision Making

Findings from the research could inform strategic decision-making processes within EMS companies, helping them prioritize investments in risk mitigation based on their potential impact on supply chain resilience and overall business performance.

vi. Competitive Advantage

Companies that effectively implement the lessons learned from the research may gain a competitive advantage in the EMS industry. By demonstrating resilience in the face of disruptions, they can build trust with customers and stakeholders and differentiate themselves from competitors.

vii. Long-Term Sustainability and contribute to long term country's GDP

Building resilient supply chains is not only about managing immediate risks but also about ensuring long-term sustainability. The research may uncover strategies that not only mitigate current risks but also help companies adapt to future challenges, such as technological advancements, regulatory changes, and market fluctuations and country GDP's growth.

In addition to the mentioned practical impact, this research contributes to the theoretical understanding of supply chain resilience by investigating the strategies employed by EMS companies to mitigate risks in their supply chains. By identifying common risks and analyzing mitigation strategies, the study also enriches the body of knowledge and academic literature on how organizations can enhance resilience in their supply chains, especially within the context of the EMS industry.

Overall, investigating the influence of risk mitigation strategies toward supply chain resilience in the EMS industry in Penang has the potential to generate valuable insights with practical implications for companies, policymakers, scholars, and other stakeholders involved in supply chain management ,risk mitigation efforts and contribute to long term country's GDP

5.4 Limitations of The Study

This study has certain limitations. The first is a result of how the respondents to this survey responded that this study has a limited number of companies or individuals participating in your study, and this could affect the generalizability of your findings to the broader EMS industry. Second, the respondents' bias in their opinion, may be inherent biases in the selection of participants or the data collection process. For instance, whether their opinion is original and true. As a qualitative study, the interpretation of data may be subjective and influenced by the researcher's own biases or preconceptions, researchers may unintentionally seek out evidence that confirms their preconceived notions about the relationship between risk mitigation strategies and supply chain resilience, potentially leading to biased conclusions. As a result if it is biased, it is unknown whether perspective should be accepted or whether the views of additional respondents should be accepted. In Addition, conducting a qualitative case study requires a significant investment of time and resources. There may be limitations in terms of the duration of the study or the availability of resources to thoroughly investigate the influence of risk mitigation strategies on supply chain resilience. Furthermore, Access to proprietary or sensitive information within companies may be restricted, limiting the depth of the analysis and the ability to fully understand the effectiveness of risk mitigation strategies.

5.5 Recommendation for Future Research

Studying the insights gained from the qualitative interviews conducted with 6 EMS companies in Penang regarding risk mitigation strategies and their influence on supply chain resilience, future research, proposes that it could explore the implementation and

effectiveness of specific risk mitigation strategies which may involve a quantitative analysis to measure based on numerical statistical data on the impact of different strategies on supply chain resilience metrics such as responsiveness, flexibility, agility and also measurement of time to restore operations, recover lost ground, and return to optimal efficiency levels swiftly.. Furthermore, it is suggested to widen the scope of the study to include different industries that could offer comparative perspectives which included the human training perspective, and talent development and enrich the understanding of effective risk mitigation strategies across diverse contexts. In addition, a proper publication plan should be studied and in place to disseminate the study findings in the International Journal of Supply Chain Management

5.6 Conclusion

The study identified several common risks faced by EMS companies in their supply chains. These risks include but are not limited to, the pandemic COVID-19, natural disasters, single-sourcing dependencies, quality supply disruptions, geopolitical issues, and market fluctuations. These risks were found to have significant impacts on the resilience of supply chains within the EMS industry in Penang. The research investigated the strategies employed by EMS companies in Penang to mitigate these identified risks and enhance supply chain resilience. Through interviews and analysis, the study found that EMS companies utilize various risk mitigation strategies to address these challenges effectively. These strategies include inventory management practices, supplier diversification efforts, building collaborative relationships within the supply chain network, and adopting relevant technologies to improve supply chain resilience. The findings from the interviews and analysis were consistent with existing literature on supply chain risk management and resilience. The strategies identified by

EMS companies in Penang are aligned with those recommended in academic research and industry best practices. This alignment suggests that EMS companies are well aware of the potential risks in their supply chains and are proactively implementing strategies to mitigate them, thereby enhancing their resilience to disruptions. The deployment of these risk mitigation strategies by EMS companies in Penang signifies a proactive approach toward building resilience in their supply chains. By effectively managing and mitigating risks, these companies can minimize the impact of disruptions and maintain continuity in their operations. Enhanced supply chain resilience not only ensures business continuity but also strengthens competitiveness in the dynamic marketplace.



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INTERVIEW QUESTIONS

Q1: Could you share your experience regarding the different types of the potential supply chain disruption risks faced by your company and please help to rank the top 4 risk

Q2: Does your company implement the following risk mitigation strategies to enhance supply chain resilience?

Q3: Does your organization implement supplier diversification as the strategy to mitigate potential disruption risk to improve supply chain resilience? If yes, why do you implement it? If No, why you do not implement it?

Q4: Do you think supplier diversification is an effective strategy to mitigate the risk and improve supply chain resilience? Why do you think so?

Q5: How do you perceive the role of supplier geography diversification in enhancing supply chain resilience?

Q6: Can you share specific instances or experiences where diversifying supplier locations positively impacted your organization's ability to mitigate risks and maintain operational continuity?

Q7: Can you describe the current risk mitigation strategies employed in your supply chain, particularly focusing on the use of buffer stock?

Q8: In your experience, how has your organization implemented buffer stock to mitigate supply chain disruption challenges?

Q9: How do you perceive the role of supplier collaboration and supplier strategic relationship enhancement in mitigating risks within the supply chain?

Q10: Can you provide specific examples or experiences where such collaboration has played a crucial role in ensuring supply chain resilience?

Q11: In your experience, how has the integration of supply chain technology influenced the identification and assessment of potential risks within your organization's supply chain?

Q12: Can you describe instances where the deployment of supply chain technology like IoT, RFID, Blockchain, integrated ERP, data digitalization played a significant role in enhancing supply chain resilience during challenging situations?

Q13: What is the key element that your organization factors in while measuring supply chain resiliency capability?

