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Strategies to Mitigate Supply Chain Disruptions During COVID-19: The Lived Experience of SC Professionals

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ABSTRACT

Drawing on Resource Dependence Theory (RDT), the objective of this study is to empirically explore supply chain disruptions of COVID-19, and suggest strategies to mitigate them. In-depth interviews were conducted with supply chain professionals working in the Electrical & Electronic (E&E) industry in Malaysia. Interviews were analysed by following seven steps of the van Kaam method. Findings suggest six strategies: global command centre with daily planning cycle to mitigate component shortages; collaboration with suppliers to mitigate glove shortages; assist local suppliers in obtaining permits to mitigate disrupted manufacturing; dual sourcing to mitigate single-sourcing disruptions; collaboration with freight carriers and government agencies to mitigate disrupted freight; and ERP-integrated EDI to mitigate disrupted data sharing. The findings offer strategies for managers to de-risk their supply chains in post-COVID-19 era, and it could be applied further in similar future supply chain disruptions.

Keywords: *COVID-19, Digital collaboration, Dual sourcing, Recovery strategies, Electrical & electronics industry, Malaysia, Supply chain disruption,*

1. INTRODUCTION

The coronavirus disease (COVID-19) outbreak forced lockdowns in many countries since January 2020. There were closures of airports, highways, factories, warehouses, and government agencies resulting in travel restrictions, flight suspension, and border control, which significantly disrupted the flow of goods and services. As the logistics network was distorted and supplier factories were shut down, the material flow and field support to manufacturing plants were affected. People were confined at home, which caused shortages of workers that affected the operations and deliveries of products (Sengupta, 2020). Thus, supply chains were disrupted heavily by COVID-19, a single event of low frequency but with a high impact (Hosseini, Ivanov, & Dolgui, 2019). These disruptions caused order lead time twice as long because many international suppliers operated only at 50% of their capacity. Buyer companies, therefore, faced inventory shortages to support their operations (Berman, 2020). Global supply chains were seriously disrupted by shortages, long lead time, and higher prices of components, raw materials, shipping containers, trucks, and warehouse spaces. As lockdowns were eased in many countries in the third quarter of 2021, demand rocketed but global supply chains have had challenges and struggling to bounce back. Supply chain disruptions may get worse before they get better, especially with bottlenecks in every supply chain (Ellyatt, 2021).

COVID-19 forced companies to work collaboratively with Small and Medium Enterprise (SME) suppliers to ensure their survival and support (PYMNTS, 2020). Many companies started multi-sourcing to reduce dependence on a single supplier (Galea-Pace, 2020a). Other companies focus on multi-tier suppliers, activate alternate suppliers, and enhance inbound materials visibility (Kilpatrick, 2020). Betti and Ni (2020) argue for government support to eliminate artificial tariffs. Queiroz, Ivanov, Dolgui, and Wamba (2020) suggest resource allocation to build resilience. However, these studies remain rhetorical in the face of an unprecedented, far-reaching disruptive COVID-19 outbreak (Boccaletti, Ditto, Mindlin, & Atangana, 2020; Sarkis, Dewick, Hofstetter, & Schröder, 2020). COVID-19 posed a threat to humanitarian logistics and product logistics (Ivanov, 2020a). Managers turned around their business with new normal strategies. But their lived experiences are rarely explored and documented. Thus, this research fills the research gap in studying the lived experience of supply chain professionals amidst COVID-19 disruption.

Digital technologies are prominent in building a more resilient supply chain during and post-COVID-19 (Sengupta, 2020). While people were asked to stay home, online selling and home delivery became a new normal for SMEs. Thus, information and communication technologies (ICT) are supposed to help SMEs achieve better planning, scheduling, and transparency of goods movement. However, most SMEs are unprepared for such disruptions due to inadequate ICT systems and support staff (Paul & Chowdhury, 2020). for example, 3D printing could be useful for respirators, shields, nasal swabs, adaptors, and valves but it comes with

challenges in cost and speed of adoption (Attaran, 2020). Queiroz *et al.* (2020) proposed digital twins, data analytics, AI, digital manufacturing, and Blockchain. However, the adoption of these emerging technologies was far from reality during the crisis because companies focused overly on COVID-19 related technology for the safety and well-being of employees and customers. Also, studies remained mostly conceptual or opinion-based papers, and lack a practical understanding of how technologies at the ground level could support the recovery strategies.

With this backdrop, while COVID-19 forced companies to revise their operating strategies as they approached the new normal, studies so far remained quite an oratory on the pandemic per se, and its impacts in general (Queiroz *et al.*, 2020; Sharma, Adhikary, & Borah, 2020; Singh, Kumar, Panchal, & Tiwari, 2020). The supply chain impact of COVID-19 and ground-level challenges facing the companies remained unexplored. With an exception, van Hoek (2020), using interviews and publicly available data, offered examples of supply chain professionals who identified and managed demand and supply, controlled risk across industries. But a clear understanding of the severity of impacts and how the companies managed to cope with a new set of strategies in a new normal environment is still limited.

This study selected Malaysia's E&E industry for its population due to global chip shortages, and many semiconductor factories of chip cutting, chip packaging, and chip testing are stationed in Malaysia. Covid-19 impacted computer chip shortages which would last for at least two years. Taiwan produces 50% of the chips for the global market followed by China, the United States, and then Malaysia. Malaysia supplies more than 13 per cent of global trade in the chip industry, which is worth over $20 billion. One of the companies is Unisem which supplies Apple's contract manufacturers. In addition, Malaysia is home to other factories serving chipmakers, namely STMicroelectronics, infineon, Intel and Renesas (Lee, 2021; Ngui, 2021). The worldwide chip shortages affected the production of international car manufacturers, namely Toyota and Ford (Debby Wu, Yoolim Lee, & Ngui, 2021). Ford was forced to half production of 60000-70000 F-150 pickups. General Motors removed features from some new models and shut down many plants for weeks and months (Leslie, 2022). The chip shortages also affected electronic supplies and smartphone companies (Ben-Meir, LeMay, & McMahon, 2022). Malaysia is a key player in the semiconductor trade and any disruption that happened would affect the global supply chain (Ben-Meir *et al.*, 2022; Debby Wu *et al.*, 2021; Gupta, 2022; Leslie, 2022). However, many of the abovementioned articles were not empirical research and they were not focused on Malaysia specifically. Hence, this research fills in the research gap of "What are the COVID-19 disruptions, and new normal strategies adopted to mitigate them in Malaysia context?" This study, therefore, aims to explore the ground realities of COVID-19 disruption and related strategies that emerge out of the crisis, which includes supply chain strategies to mitigate global computer chip shortages.

The remainder of this paper is organized as follows. Section 2 reviews the background literature on resource dependency theory, the impact of COVID-19, and supply chain recovery strategies. Section 3 outlines the qualitative research methods and respondent details. Section 4 presents interview findings, and Section 5 undertakes a discussion and implications. Finally, Section 6 concludes the study with limitations.

2. LITERATURE REVIEW

2.1 Resource Dependency Theory

Resource Dependence Theory (RDT), as proposed by Pfeffer and Salancik (1978), appears appropriately in this study to explain the resource dependence among supply chain partners during COVID-19. RDT, which is well-established in supply chain research (Shook, Adams, Ketchen, & Craighead, 2009), is yet to be leveraged in COVID-19 pandemic-related challenges (Craighead, Ketchen Jr, & Darby, 2020). Resources, either common or rare, are always limited in any organization (Laksmana, Shee, & Thai, 2020), and that were worsened further during lockdowns.

Resources determine an organizations' dependence on others (Pfeffer & Salancik, 1978). In view of this, Nandi, Sarkis, Hervani, and Helms (2020) claim RDT is a better option than resource-based theory for evaluating supply chain resilience during a crisis. They propose that organizations with higher resource dependency and lesser control of external agents encounter more difficulties. This results in difficulties to develop localization, agility, and digitalization to achieve resiliency (Nandi *et al.*, 2020). As interdependence varies with the availability of resources relative to the demand, organizations face uncertainties due to a lack of coordination (Pfeffer & Salancik, 1978). COVID-19 related disruptions disconnected supply chain partners.

Resource exchange depends on the relative magnitude of the exchange and the criticality of the resources. The former is the requirement of input and the degree of its dependence on the source of its supply. The latter may vary from time to time as the environment around the organization changes (Pfeffer & Salancik, 1978). This research seeks to understand the rules and regulations which limit resource access in the event of the COVID-19 pandemic.

Past research on COVID-19 found that consumers preferred to stockpile merchandise, which created a temporary demand spike that shifted the balance of power to suppliers' favour. The retailer-supplier relationship turned into a new arrangement where supply lead time and payment terms were changed in the suppliers' favour (Craighead *et al.*, 2020). This study switches the focus to the manufacturer-supplier relationship, where power could be shifted to suppliers due to relational asymmetry. Further, customer shipments were found to be shifted from drivers to brokers who took the opportunity to capture more supply chain revenue during COVID-19 (Giunipero, Denslow, & Rynarzewska, 2021). This study refocuses on the asymmetric dependence of shippers on freight carriers.

2.2 Supply Chain Disruptions Caused by COVID-19

COVID-19 has had an unprecedented impact on 89 of the NASDAQ-100 listed companies. These companies encountered supply and demand mismatches and technology challenges (Sharma *et al.*, 2020). India faced a similar mismatch of food supply and demand due to increased

infected cases (Singh *et al.*, 2020). Shipping and freight resources revealed that 59% of respondents' operations had been seriously affected in the form of late or non-payment from clients, cancelled credit lines, inconsistent demand, and increased costs (Moore, 2020). COVID-19 disruption affected supply chain robustness with negative effects (El Baz & Ruel, 2020).

COVID-19 weakened demand for certain products (e.g., textile, automotive, and public transport) but skyrocketed for other products (e.g., toilet paper, pasta, personal protective equipment (PPE), masks, and ventilators). The transportation industry faced a shortage of drivers and vehicle connectivity (Kumar, Luthra, Mangla, & Kazançoğlu, 2020). The fashion industry faced output seasonality and demand disruption due to lower consumption (McMaster *et al.*, 2020). The pandemic surfaced labor violations due to unauthorised manufacturing subcontracting and hiring of contract labors (Majumdar, Shaw, & Sinha, 2020).

Further, supply chain disruption caused a 20% decrease in food deliveries in India (Mahajan & Tomar, 2021). Food shortages in India were due to labor shortages and COVID-19 infected drivers (Singh *et al.*, 2020). COVID-19 impacted the food supply chain in the UK with the closure of food service outlets but an increase in retail purchasing (Mitchell, Maull, Pearson, Brewer, & Collison, 2020). Sourcing related issues were most disruptive in the food supply chain (Sharma, Joshi, Luthra, & Kumar, 2022). The supply of pharmaceutical ingredients was disrupted from China, and India stopped exporting 26 active pharmaceutical ingredients amid fears of shortages within the country. COVID-19 exposed the drawbacks of JIT in lean manufacturing with no inventory buffer (Iyengar, Vaishya, Bahl, & Vaish, 2020). Biswas and Das (2020) revealed manpower shortages, transport restrictions, and raw material scarcity. Due to inefficiency as proven by the supply chain efficiency ratio, the COVID-19 outbreak in China caused inventory shortages and cost increases to discount stores such as Walmart, Costco and Dollar General (Forehand, Roman, & Schaefer, 2021).

The supply chain obscurity of upstream bottlenecks had limited the ability to respond to the pandemic (Sarkis *et al.*, 2020). COVID-19 revealed the supply chain inability to deploy resources, and difficulties in capturing and sharing data (van Hoek & Lacity, 2020). Van Hoek (2020) finds a lack of preparedness and inadequate response plans, thus calling for greater supply chain resilience for faster recovery. There was a switch of demand in transport channels which stimulated digitalisation for visibility (van Hoek, 2020). Also, initiating collaborations with suppliers and the development of new suppliers was time-consuming.

In conclusion, COVID-19 disruption caused a mismatch of supply and demand; shortages of material, food, and labor; challenges in technology and data sharing; cost increase and payment issues. The previous studies were mostly focused on COVID-19 effect on food, fashion, and healthcare. There is more to explore and understand the supply chain disruptions in other sectors including the electrical and electronics (E&E) industry. Hence, this study fills the gap in exploring the E&E industry in Malaysia, a major centre for global chip testing and packaging, with infineon, NXP, and STMicroelectronics among the key manufacturers (Debby Wu *et al.*, 2021).

2.3 Recovery Strategies

Recovery strategies are dynamic responses to detect, assess and process the signals, and systems and then integrate resources to close loopholes that occurred in COVID-19 (Sharma *et al.*, 2020). Alicke, Azcue, and Barriball (2020) suggest recovery actions, namely, transparency in the multitier supply chain, optimizing production and distribution capacity, assessing end-customer demand, estimating available inventory, identifying and securing logistics capacity, and managing cash and networking capital. Queiroz *et al.* (2020) suggest recovery of the workforce, capacities, logistics infrastructures, forecasting of pandemic propagation, and ramp-up of decisions. Paul and Chowdhury (2020) and Mollenkopf, Ozanne, and Stolze (2020) propose to increase production hours, enhance suppliers' capacity, and look for alternate/backup/new suppliers. Galea-Pace (2020a) proposes a partnership with logistics providers to secure shipping capacity and explore different routes. Furthermore, Gunessee and Subramanian (2020) and Wilding, Dohrmann, and Wheatley (2020) suggest supply chain innovation and value chain collaboration; reconfiguration for the flexible and cost-effective supply chain; re-assessment of the current supply chain with a new set of priorities; and reformation of supply with multiple sources. Forehand *et al.* (2021) discovered that supply chain efficiency was the reason for discount store retailers, namely Dollar Tree and Target to outperform other retailers during Covid-19. Orlando, Tortora, Pezzi, and Bitbol-Saba (2022) suggest knowledge preparedness to mitigate the supply chain disruptions during COVID-19. The study added more important supply chain innovations, including timely sourcing of shipment to customers, e-procurement, identification of products and reverse logistics. Malsinghe *et al.* (2022) suggested that sustainable operations could contribute to better outcomes.

There were mixed findings for research on resilience building. Melnyk, Closs, Griffis, Zobel, and Macdonald (2014) suggest supply chain resilience delays a disruption, reduces its impact, and recovers from disruption. Golan, Jernegan, and Linkov (2020) propose resilience building, which included plan, absorb, recover, and adapt. Hobbs (2020) suggests flexibility, collaboration, reliability, and robust relationships. Galea-Pace (2020b) suggests building resilience through supply chain risk assessment; diversifying supplier networks; digital and automated manufacturing capabilities; evaluating and adjusting procurement; agile planning and fulfilment capabilities. Queiroz *et al.* (2020) explain resilience as systems, process, control, and recovery. Ivanov (2020) introduced a viable supply chain, a dynamic and behaviour-driven approach that reacted adaptively to both positive and negative pandemic impacts (Ivanov & Dolgui, 2020). Relational capital might facilitate supply chain resilience and act as a strong mediator between ambidextrous innovation and resilience. However, ambidexterity has less influence on supply chain resilience (Robb, Kang, & Stephens, 2022). The more resilient the supply chain, it will experience the less impact of COVID-19. And the level of resiliency depends on proactive strategies in product diversification, information sharing with stakeholders, alternative solutions, and good supplier relationships (Lopes, Gomes, & Mané, 2022). Although many different views about supply chain resilience already

exist, we believe in more empirical research required to provide a better understanding of supply chain disruptions and new normal strategies. While most of these are quite generic in approach to resilience building, the literature is still limited and needs further investigation to identify the right choice of strategies appropriate for COVID-19. This study fills the research gap by exploring more strategies to mitigate supply chain disruptions.

Gunessee and Subramanian (2020) suggest advanced digital solutions to assess the supply risks of multiple tiers of suppliers. Van Hoek (2020) suggests global sourcing to mix with nearshore/local sourcing. Sharma *et al.* (2020) suggests a diversified portfolio of suppliers. Diversification of supplier source and backup suppliers were proposed for the readymade garment industry in Bangladesh (Taqi *et al.*, 2020). This is similar to risk management to handle sourcing risks (Sumarliah, Usmanova, Fauziyah, & Mousa, 2021). Furthermore, companies had to re-evaluate sourcing strategies by balancing risk, flexibility, disruption, and agility (Sharma *et al.*, 2020). In relation to this, Ambrogio, Filice, Longo, and Padovano (2022) suggest sourcing mix across geographical regions to diversify risk. The food industry in India was urged to focus on local producers and growers (Mahajan & Tomar, 2021). Mitchell *et al.* (2020) argues for local production and market support in the UK. Moosavi, Fathollahi-Fard, and Dulebenets (2022), Pujawan and Bah (2022), and Ivanov and Das (2020) suggest switching to local suppliers to avoid supply disruptions. Other articles suggested strong relationships with key suppliers and visibility across the extended supply network (Deloitte, 2020). Sumarliah *et al.* (2021) suggest helping suppliers to cope with bankruptcy and social distancing rules.

Traditionally, Supply Chain Risk Management (SCRM) comprises four processes namely identification, assessment, mitigation, and control (Fan & Stevenson, 2018). In relation to SCRM, de Vries, van der Vegt, Scholten, and van Donk (2022) propose cross functional teams to manage supply chain disruptions warnings with centralised decision making orchestrated by one or two members. However, Gunessee and Subramanian (2020) find risk identification and assessments to be less reliable in coping with COVID-19 ambiguity and do not conclude the use of mitigation and control. This prompts new strategies which are yet to be explored. Agility, as a measure of resilience, helps to respond and to predict supply chain issues effectively (Deloitte, 2020). For the fashion supply chain, McMaster *et al.* (2020) propose a buffer to increase agility. They suggest online sales control demand disruption and increase revenue. Flexibility was suggested for readymade garment manufacturing in Bangladesh (Taqi *et al.*, 2020). For the food supply chain in the UK, ordering algorithms for the production schedule successfully reduced the COVID-19 impact. Betti and Ni (2020) suggest predictive models in proactive scheduling and dynamic planning to manage uncertainties and risks. But this empirical study aims to reveal the ground realities of companies' recovery strategies.

Digitalisation during COVID-19 was the top priority (Papadopoulos, Baltas, & Balta, 2020; Pujawan & Bah, 2022). Integration of advanced technologies (Sharma *et al.*, 2020); robotics and automated production and distribution (Ivanov & Das, 2020); 3D printing, blockchain, industry 4.0 (Paul & Chowdhury, 2020; Sarkis *et al.*, 2020); big data, cloud computing, and artificial intelligence for visibility and rapid response (Kilpatrick, 2020; Suhaimi, 2020) are believed to improve logistics processes. Research in textile firms in Pakistan showed that supply chain data analytics contributed significantly to the strategies of adaptability, alignment, and agility to sustain performance during COVID-19 (Khan, Piprani, & Yu, 2022). Block chain technology was useful for flexibility in resilient strategy in the food supply chain to manage supply and demand shock, real time monitoring and information sharing (Sharma *et al.*, 2022). Government incentives, tax relief, and loans could drive blockchain adoption to ensure contactless transactions with better security (Karmaker *et al.*, 2020). Moore (2020) found that 67% of participants agreed to invest in technology. The UK food supply chain identified robotics to relieve labor shortages. Similarly, Ambrogio *et al.* (2022) mentioned that the pandemic posed an opportunity to replace conventional manufacturing technologies with new and flexible technologies such as 3D printing. For the healthcare supply chain, rapid flow of information and analytics are perceived as paramount (Iyengar *et al.*, 2020). Truck synchronised systems were used to supply food and essential medical services to high-rise buildings in infected areas in India (Singh *et al.*, 2020). Better warehousing infrastructure and minimum transportation bottlenecks build resilience for the food supply chain during pandemics (Mahajan & Tomar, 2021).

In conclusion, the strategies suggested by previous research are partnership, resilience, increased capacity, optimise production, agility, viability, multi-sourcing, proactive scheduling, dynamic planning, digitalisation, and emerging technologies. However, the literature is silent about how companies can optimise their legacy ICT systems during a pandemic. Furthermore, many previous research were conducted for the food and fashion industry but research lacks new normal strategies in E&E industry context. The E&E industry contributes to chip production, which encounters serious global shortages during COVID-19 (Debby Wu *et al.*, 2021).

3. methodolgy

This qualitative study used semi-structured, audio-recorded, and transcribed interviews to investigate the lived experience of COVID-19 for supply chain professionals in E&E companies in Malaysia. The E&E companies contributed up to 38% of the total export of Malaysia in 2018 and 2019 (MITI, 2019), and were hard hit during the pandemic due to global component shortages. The grounded interview approach is found suitable as it investigates lived experiences of supply chain professionals. The phenomenological method is suitable for research on COVID-19 as it helps the researcher to set aside the assumptions about the phenomenon (Creswell, Hanson, Clark Plano, & Morales, 2007; King, Horrocks, & Brooks, 2018).

3.1 Sampling & interviews

The sampling frame of more than 100 E&E companies was obtained from the directory of the Federation of Malaysian Manufacturers. Fifteen supply chain professionals were purposefully selected from fifteen different E&E companies as they deem fit. The spread of

companies, for example, automotive electronics, semiconductors, consumer electronics, component manufacturers, and their related logistics service providers, ensure variety and richness of data. All the fifteen participants have at least five years of supply chain working experience, and survived the disruptions caused by COVID-19. The data was collected over nine months from April to December 2020, the period in which Malaysia experienced its highest crisis. Regarding sample size, Guest, Bunce, and Johnson (2006) suggest data saturation with twelve interviews in any purposive sampling of homogenous participants. Hennink, Kaiser, and Marconi (2017) propose a sample size of nine which is sufficient for code saturation and helps to develop a comprehensive understanding of explicit issues in data. Therefore, fifteen interviews were deemed appropriate given the data collection difficulties during COVID-19 pandemic that forced social distancing and lockdown. The participants hold positions of Vice-President, General Manager, Senior Supply Chain Manager, and Logistics Manager. The respondents shared their hands-on experience within the companies in Malaysia and with their overseas suppliers during COVID-19. Approximately an hour-long semi-structured interview was carried out over Zoom or WhatsApp calls. Follow-up interviews for further clarification was also made. Interview question can be found in Appendix. Participants' demographics are listed in **Table 1.**

3.2 Interview Data analysis

Data analysis followed the seven steps of the van Kaam method (Moustakas, 1994, p. 120): 1) listing and preliminary grouping; 2) reduction and elimination to determine invariant constituents; 3) clustering and thematizing the invariant constituents; 4) final identification of the invariant constituents and themes; 5) constructing individual textual descriptions for each participant based on the validated themes; 6) constructing for each participant an individual structural description based on a textual description and imaginative variation; and, 7) constructing for every participant a textual-structural description of the meanings and essences of the experience. From the individual textual-structural description in step 7, a composite description of research findings was developed representing the group.

The first four steps of data analysis identified 32 invariant constituents and six themes of supply chain disruptions as shown in **Table 2**, and then 18 invariant constituents and 6 themes of strategies to mitigate supply chain disruptions as shown in **Table 3**.

Table 1 Demographic of Interview Participants

Company	Position	Company	Age	Qualific -tion	Experience (years)
#1	Procurement Head	Logistics solutions for E&E companies	43	Master	18
#2	SC Manager	Automotive Electronics	40	Bachelor	16
#3	Vice-President of Supply Chain	Consumer electronics	56	Master	31
#4	Logistics General Manager	Automotive electronics	53	Master	27
#5	Senior SC Manager	Electronic components	44	Bachelor	20
#6	Senior Logistics Manager	Semiconductor	50	PhD	26
#7	Procurement Manager	Consumer electronics	45	Bachelor	21
#8	SC Manager	Cable & wire	54	Bachelor	30
#9	Logistics Manager	Public Warehouse	48	Bachelor	24
#10	SC Manager	Office Machinery	40	Bachelor	16
#11	SC Director	Audio product	50	Master	36
#12	SC Director	Transformer	54	Bachelor	30
#13	Logistics General Manager	3rd party logistics provider	56	Diploma	35
#14	SC Manager	Consumer electronics	50	Bachelor	26
#15	Senior SC Manager	Automotive Electronics	45	Bachelor	21

Table 2 Data Analysis- Identification of invariant constituents and themes for SC disruptions by COVID-19

No.	32 invariant constituents of SC disruptions by COVID-19	Themes of SC Disruptions
1.	a) High demand for computers as people work from home. b) High demand for computers because of online classes for students c) Component shortages for computer production d) Component shortages for 3D printer production e) Component shortages for automotive manufacturing f) Price hike for components from overseas	Shortages and price decreases of components resulted from the demand surge for computers.
2.	a) Supply shifted to the manufacturing of medical gloves b) Glove manufacturers were allowed to operate at 50% of capacity c) Nitrile was in short supply from crude oil refineries, also affected by transport restriction d) Raw materials supply of glove manufacturing was not allowed to operate e) Glove factory shut down when workers were infected with COVID-19	Nitrile glove shortages due to supply shifted to the manufacturing of medical gloves and shortages of raw materials.

No.	32 invariant constituents of SC disruptions by COVID-19	Themes of SC Disruptions
3.	a) SME suppliers not aware of permit applications to resume manufacturing. b) Government agency websites/phone lines were overloaded. c) The non-entry of foreign labour disrupted factory operations. g) Technical staff from headquarters were not allowed to enter the country	Disrupted manufacturing resulted from unawareness of permit application and border closure.
4.	a) Material shortages due to single supplier from China, Europe, and Korea. b) Sourcing talent deficiency to select alternative suppliers. c) It took 2 years for suppliers to build high investment factories. d) Overseas supplier audits were not possible due to border closure. f) Not every item could be sourced locally	Material shortages are caused by single sourcing from overseas suppliers.
5.	a) Air cargo space was prioritized for PPE and medical supplies. b) Passenger aircraft were five times more expensive. c) Reduction of ocean cargo volume due to reduced manufacturing d) Road transport took longer transit time due to roadblocks. e) Reduction of customs headcounts and working hours disrupted truck deliveries. d) Truck drivers were attracted to work for e-commerce last-mile deliveries	Disrupted freight transportation due to cargo space constraints, customs headcounts and shifted transportation to e-commerce or medical supplies.
6.	a) Cloud solutions for supply chain transactions but EDI was not used. b) Supply chain transactions were manually performed offline internally and externally. c) Difficulties in digital collaboration with SME suppliers d) Real-time information was not available (RFID was not implemented) e) Visibility was available for those who adopted ERP-based SAP Hana f) Half of the local suppliers and 20% of overseas suppliers did not use the ERP system	Disrupted data sharing among supply chain partners if ERP-integrated EDI is not available.

Table 3 Data analysis – Final Identification of invariant Constituents and Themes for Strategies to Mitigate SC Disruptions

No.	18 invariant constituents of strategies to mitigate SC disruption	Strategies to mitigate SC disruptions
1.	a) Global command centre to optimize resources and capability in all locations b) Two hours of planning daily instead of weekly planning c) Scenario analysis via Advanced Planning Software to capture products with high margins d) Three levels (strategic, tactical, and operational) of forecasting shared across the supply chain	Global command centre with daily planning cycle for end-to-end supply chain
2.	a) Current supplier to offer one more production line before finding an alternative supplier b) Re-negotiation of contract because purchase status changed drastically c) Switch the materials from nitrile to natural rubber for gloves d) Work with glove manufacturers to resume production	Collaborate with suppliers to increase glove production and raw material shortages
3.	a) Organise operating permits for SME suppliers b) SME suppliers to follow social distancing procedures	Assist SME suppliers in getting permits to resume operations
4.	a) Multi-sourcing of suppliers from different regions b) Local sourcing/nearshore sourcing due to border closure	Local sourcing and multi-sourcing in different regions.
5.	a) Use alternate flights, which may be longer routes with more expenses b) Partnership with companies to secure cargo space c) Suppliers to collaborate with customs offices to get shipping permits	Collaboration with freight carriers and government agencies
6.	a) ERP-integrated EDI are more prioritised than emerging technologies b) Hybrid ERP and mobile apps are appropriate for internal/external communication c) Cloud ERP for SME suppliers to transmit electronic documents	ERP-integrated EDI is more prioritised than emerging technologies

This study ensured reliability by having all the interviews audio recorded for verbatim transcription. Subsequently, it was validated through member checking. The transcription was also sent to the participants for accuracy. The themes were confirmed as complete, realistic, accurate, and representative (Creswell & Guetterman, 2020).

4. FINDINGS: STRATEGIES TO MITIGATE SUPPLY CHAIN DISRUPTIONS

Subsequently, we followed steps 5 to 7 to identify and consolidate the themes (refer **Table 2** and **Table 3**) into six research findings and theoretical contributions as shown in **Table 4**.

Table 4 Data Analysis – Findings & Theoretical Contributions

No.	Themes for SC disruptions	Themes for recovery strategies	Findings/composite experience	Theoretical contributions to RDT
1.	Shortages and price increases of components resulted from the demand surge	Global command centre with daily planning cycle for an end-to-end supply chain	Global command centre with daily planning cycle to mitigate disruption of component shortages	Reduce resource dependence on critical components with the global command centre with a daily planning cycle
2.	Nitrile glove shortages as manufacturing shifted to medical gloves	Collaborate with suppliers to increase glove production and raw material supply	Supplier collaboration to mitigate industrial (glove) shortages	Collaborate with suppliers to improve resource dependence on gloves
3.	Disrupted manufacturing resulted from unawareness of permit application and border closure	Assist local SME suppliers to resume operations through a permit	Assist suppliers to mitigate disrupted manufacturing operations	Assist suppliers to improve resource dependence on manufacturing operations
4.	Material shortages due to single sourcing from overseas suppliers	Local sourcing and multi-sourcing as an alternative	Dual sourcing to mitigate single sourcing issues	Dual sourcing to improve resource (material) dependence on single suppliers
5.	Disrupted freight transportation due to cargo space constraints, customs headcounts and shifted transportation to e-commerce or medical supplies	Collaboration with freight carriers and government agencies	Collaborate with freight carriers and government agencies to mitigate freight disruption	Collaboration with freight carriers and government agencies to improve resource dependence on freight
6.	Disrupted data sharing among supply chain partners if ERP-integrated EDI is not available	ERP-integrated EDI is more prioritised than emerging technologies	ERP-integrated EDI to mitigate disrupted Data Sharing	Utilise ICT to improve resource dependence on data

It revealed six supply chain strategies that the participants implemented during the COVID-19 recovery. These are global command centre with daily planning cycles; supplier collaboration to mitigate industrial (glove) shortages; assist local manufacturers to mitigate disrupted manufacturing; dual sourcing to mitigate single sourcing issues; collaboration with freight carriers and government agencies to mitigate freight disruption, and ERP-integrated EDI to mitigate disrupted data sharing. The following section explains each disruption and its respective mitigation strategies.

4.1 Global Command Centre with Daily Planning Cycle to Mitigate Component Shortages

4.1.1 Disruption of Component Shortages and Computer Price increase Due to Demand Surge

We found that the order lead time of components became longer due to supplier factory shutdowns and disrupted transportation. In agreement with this, Berman (2020) revealed lead time at least twice more than pre-COVID-19 operations. As computer demand surged with the increased home office during the lockdown, the first impact of component shortage came from the first tier located within Malaysia followed by second-tier suppliers from China. Subsequently, it became severe when suppliers from Italy and France were hit with almost two months of lockdown. Delayed deliveries and frequent recommitment of deliveries from Korea and Europe caused price hikes. A Procurement Manager (#7) shared his experiences:

"We encounter component shortages from second-tier suppliers in China. Due to the serious impact of material shortages, the price increased by 20-25% for 80-85% of components."

"Suppliers terminate vendor managed inventory during the lockdown period and thus there is no delivery for us."

4.1.2 Strategy of the global command centre with the daily planning cycle

To mitigate the component shortage, participants performed a daily assessment of the end-to-end supply chain from the first-tier suppliers to the last customers. It comprised an assessment of every partner's physical, information, and financial flow where the focus was on transparency and risk management of critical and long lead time materials. The end-to-end supply chain assessments were like the suggestion made by Alicke *et al.* (2020).

Multinational companies set up a global command centre to mitigate real-time risks. The centre sets up a robust scenario planning to optimize resources and capabilities available at all locations. This included working with counterparts to build extra capacity. Companies were required to synchronize data with partners. The flexible and rapid planning cycles enhanced coordination and quick response between sales and operations that supported manufacturers for the right mix, high margin, short lead time, and optimum quantities. The alternate two-hour planning and daily planning cycle are unique in this research. A Supply Chain Manager (#14) shared her experience as:

"Take out no-margin products, improve life cycle, and

practice lean operations."

"Creating visibility on a weekly and daily basis helps optimize inventory and order fulfilment. Three levels of forecast (strategic, tactical, and operational) shared across the supply chain."

4.2 Supplier Collaboration to Mitigate Industrial Glove Shortages

4.2.1 Disruption of industrial Glove Shortages Due to The Shifted Supply of Medical Gloves

Industrial nitrile gloves are used for E&E production workers. But the focus was shifted to medical glove production during the crisis. Nitrile, a by-product ingredient of crude oil, was in short supply from crude oil refineries which were affected by transport restrictions. Latex gloves, as an alternative, were available but not all customers could accept the replacement. A Vice-President (#3) commented as:

"Only essential goods and healthcare products were allowed for production during the lockdown. However, industrial gloves were not categorized as essential goods initially."

Furthermore, glove supply was disrupted due to thousands of employees in Malaysia being infected by COVID-19. The factories were closed for several weeks which caused a severe shortage of industrial gloves.

4.2.2 Strategy to assist the Suppliers to Mitigate Glove Shortages

To mitigate industrial glove shortages, companies worked with existing suppliers for higher capacity. This was suggested in previous research (Mollenkopf *et al.*, 2020; Paul & Chowdhury, 2020). For inventory management, supply chain professionals negotiated with suppliers for flexible production and shipments according to demand. A supply chain manager (#8) said that *"for nitrile gloves, we look for a current supplier to offer one more production line before finding an alternate supplier."*

Re-negotiation of the contract was required as purchase volume, unit price and inventory status changed drastically. The lockdown resulted in order cancellation, order rescheduling, price reduction, and stock obsolescence. Renegotiation with SME suppliers on payment terms was initiated. The contract was reviewed to ensure business risks were shared openly and equally.

4.3 Assist Suppliers to Mitigate Disrupted Manufacturing Operations

4.3.1 Disrupted Manufacturing Caused by Restricted Operations and Cross Border Traveling

Malaysia enforced a lockdown, known as a movement control order (MCO), from 18 March until 12 May 2020. Non-essential operations and cross-border traveling were stopped during the MCO period which disrupted many manufacturing operations. This is similar to the findings of Berman (2020). Many companies were not capable to apply for a permit from government agencies to resume either partial or full operations. Hence, supply chain professionals experienced delivery failures when SME suppliers gave up their operations. A Senior Logistics Manager (#6) said:

"SME suppliers do not know how to apply for a permit to resume manufacturing; government agency websites and phone lines were overloaded." The restriction on overseas travel further disrupted operations. The non-entry of foreign labour disrupted operations even after the lockdown was eased. Technical support, and research & development (R&D) teams from overseas headquarters could not come onsite for new product launching, which further disrupted deliveries of new products. A supply chain Vice-President (#3) stated that: *"R&D team from overseas could not arrive onsite for new product launching due to closure of country borders.". "Immigration department did not allow the entry of foreign labour. We had to hire temporary labour."* Disrupted operations reduced revenue leading to financial instability and payment issues for customers and suppliers. Customers requested longer payment terms of up to six months and suppliers requested shorter payment terms or advance payment terms. A Procurement Head of Logistics (#1) said that: *"Suppliers requested advance payment, but customers requested six months payment term".*

4.3.2 Assist Local SME Suppliers in Getting Permits to Resume Operations

Many SME suppliers in Malaysia, except essential products, were not allowed to operate during MCO. Supply chain professionals reportedly trained and helped the SME suppliers with social distancing in factories and warehouses. They assisted SME suppliers in getting permits to run at 50% of capacity. These are new findings unique to the Malaysian context. A Vice President (#3) said, *"I follow up with government agencies about the operating permits of SME suppliers."*

4.4 Dual Sourcing to Reduce Material Shortages from Single Sourcing

4.4.1 Single Sourcing from Overseas Suppliers Caused a Material Shortage

Material shortages were evidenced as supplier factories were shut down, particularly with single suppliers from China, Korea, and Europe. The pandemic uncovered the fragility of a single sourcing strategy. Sourcing professionals experienced talent deficiency to source, evaluate, select, and develop alternative suppliers. This became critical as the delivery backlog multiplied. This also puzzled suppliers to justify the investment in extra capacity because it takes at least two years for suppliers to build factories with a high capital outlay. The closure of country borders restricted the audits of overseas suppliers. Thus, it was hard to move from single sourcing to multi-sourcing. Although, single-sourcing vulnerability was agreed upon by Galea-Pace (2020a), the vulnerability of sourcing talents is new in this study. A senior Supply Chain Manager (#15) commented that: *"It takes time to select another supplier. The sourcing team must be competent in evaluating suppliers. They could not travel to evaluate overseas suppliers during the lockdown.". "It takes 3-4 years for a supplier to build a chemical plant, and a couple of years for another type of plant, and also requires high capital outlay."*

4.4.2 Strategy of Multi-Sourcing or Local Sourcing

Supply chain professionals started implementing various countermeasures of local sourcing, regional sourcing, or multi-country sourcing to secure material supply. Multi-sourcing of suppliers ensures continuous material supply. Due to border restrictions, it was crucial to move to local sourcing or nearshore sourcing. Nearshore sourcing was suggested for food production in India (Mahajan & Tomar, 2021). Taqi *et al.* (2020) suggest backup suppliers and sourcing diversification for the garment industry in Bangladesh.

4.5 Collaborate with Freight Carriers and Government Agencies to Mitigate Disrupted Freight

4.5.1 Disrupted Freight Transportation Due to Cargo Space Constraint

Minimal manufacturing resulted in less frequent cargo flights that operate on loads. PPE and medical supplies were prioritized in air cargo space. Hence, cargo space for E&E companies was limited. Urgent shipment caused air freight charges hiked by five folds in the first three months of lockdown. A Senior Logistics Manager (#6) commented that: *"Lack of aircraft space for imported and exported goods due to cancellation of cargo and passenger flights. Charter flights, as an alternative, were expensive. Airfreight charges increased by three folds."*

Initially, ocean cargo volume declined by 20-35% as urgent cargoes were switched to air shipment. Later, the reduction of passenger flights caused the cargo to move back through the sea route which caused vessel space shortages. However, some shipping lines reduced their operations for low volume caused by factory shutdowns. This caused problems for companies that needed to ship cargoes. Van Hoek (2020) states that demand surges initially but it slumps later as economic activities are reduced. A General Manager (#13) stated that: *"Sea freight volume went down 20%-35% because container shipping lines are concerned about 2nd and 3rd wave of COVID-19 that are likely to affect the ocean freight.". "Small factories use loose container load due to decrease in shipping volume. As many factories shut down, ocean freight could not operate as scheduled."*

Ocean freight increased the price of imported products from Europe to East Asia. As containers carried less than the full load, it caused the price increased by 150%. A logistics General Manager (#4) commented that: *"Export from East Asia to Europe is higher in volume than import. The container was loaded full to Europe, but the volume from Europe to East Asia was insufficient. Hence, ocean freight cost increased dramatically by 150%."*

Trucking transportations were less affected relatively. However, they operated under permits. There was a volume reduction of less than a truckload (LTL) because SMEs shut down their operations. As, warehouse workers and truck drivers stopped working, many cargoes were stuck in seaports. Further, the reduction of customs headcounts and working hours disrupted truck deliveries. A Logistics Manager (#9) commented that: *"Shipment backlog happened for exported cargoes because warehouse workers and truck drivers dare not go to the workplace. Imported cargoes stuck at the port due to MCO imposed during lockdown period, which restricted staff to clear cargoes."*

Also, many truck drivers were attracted to work for e-commerce last-mile deliveries that experienced high demand during the lockdown.

4.5.2 Strategy to Collaborate with Freight Carriers and Government Agencies

To achieve smooth shipping, the support of local government agencies and freight carriers was critical. This is noticeably new in this study. Equally important was a partnership with airlines, ocean liners, and trucking companies to secure cargo space. Alicke *et al.* (2020) and Galea-Pace (2020a) had similar suggestions regarding cargo space permits through partnership. However, the current study discovers a new finding that companies assist their SME supplier to apply for shipping permits during the lockdown. A Senior Logistics Manager (#6) commented that *"I assist my suppliers to collaborate with a customs office to get shipping permits during the lockdown period."*

The participants shared their experiences of using alternate flight routes to deal with insufficient flight space that turned out to be expensive. Galea-Pace (2020a) also suggests a similar approach. A senior Logistics Manager (#6) said that *"we used alternate flights, and changed the routes even if it was the longer route and more expensive."*

4.6 ERP-Integrated EDI to Mitigate Disrupted Data Sharing

4.6.1 Disruptions Due to inadequate Data Sharing and Digital Collaboration

Literature shows that dolphin choir partners are not of similar readiness for digital collaboration (Sharma *et al.*, 2020). Many transactions are manually performed offline internally within departments and externally with supply chain partners. Unfortunately, not many companies adopt ERP with SAP Hana, a demand-driven software, which has an in-memory database and application development platform capable of processing high volume data in real-time to ensure data visibility.

A senior SC Manager (#15) said that *"our internal system is ERP-based SAP Hana which is demand-driven, and visibility is not an issue."* Also, another Manager (#5) commented that *"suppliers need to invest in IT if they like to do our business, but we accept customers who lack IT infrastructure."* A senior Logistics Manager (#6) mentioned that *"more than 50% of my local suppliers and 20% of overseas suppliers are not ready for SAP-ERP system. But my customers have more systematic IT systems."* Further, a manager (#2) said that *"my suppliers cannot remote control their supply chain functions, they need to go back to the office to operate from the system, or to print hard copies."*

This digital collaboration inadequacy was evidenced within SMEs in Southeast Asia and Europe. SMEs could not electronically transmit purchase orders and invoices to trading partners. Furthermore, many suppliers did not utilise RFID and thus real-time information was not collected. RFID tags are considered costly unless they are required by customers. A SC Director (#12) highlighted that "RFID tags are expensive and not required by customers." This is similar

to the findings of Loo and Seow (2018) and Loo (2019) in Malaysia context.

4.6.2 Strategy of ERP-Integrated EDI to Enable Data Sharing

The COVID-19 pandemic emphasized emerging technologies adoption in the supply chain (Shee, Miah, & De Vass, 2021) and industry 4.0 technologies in manufacturing (Taboada & Shee, 2020). This research found participants favouring Enterprise Resource Planning (ERP) systems over other emerging ones such as artificial intelligence, IoT, drone, and 3D printing (Shee *et al.*, 2021). A senior Logistics Manager (#6) commented that "with IoT, we don't see much advantage; ERP should be sufficient." Further, participants agreed that the ERP-integrated EDI system was relevant and supportive of supply chain processes internally within the company and externally with partners. The most common system used was hybrid-ERP which offers on-premises and cloud systems with lower costs. However, for SME suppliers with limited budgets, supply chain professionals recommended a cloud-based system which agreed with Shee, Miah, Fairfield, and Pujawan (2018). A SC Director (#11) said that "we experience the usage of Hybrid-ERP and mobile apps are more appropriate."

RFID and bar codes were not commonly used by SME suppliers. It remains expensive as RFID tags cost RM3 to RM5 per piece (or US$1) and barcode labels cost RM1 per piece. Even multinational companies cut costs by putting RFID tags into pallets rather than on items. A Senior Logistics Manager (#6) said that "currently we use RFID tags. Going forward, we are planning for AI, IoT, Big data analytics, and advance supplier communication." Participants, however, did not see the practical and financial benefits of rushing for emerging technologies. This finding aligns with Papadopoulos *et al.* (2020) who argue for the availability of an appropriate system for SMEs. A Procurement Manager (#7) commented that the "acceptance level is still low for 3D printing."

5. DISCUSSION AND IMPLICATIONS

5.1 Discussion

The COVID-19 pandemic caused long-term disruption, disruption propagations, and high uncertainty (Ivanov, 2020a). This study explored realistic strategies to mitigate the disruptions of COVID-19 through lived experiences of E&E industry professionals in Malaysia. Most of the previous research so far included either multiple industry (van Hoek, 2020) and manufacturing (Biswas & Das, 2020; Paul & Chowdhury, 2020) in general; food (Hobbs, 2020), healthcare (Iyengar *et al.*, 2020), and garment (Taqi *et al.*, 2020) in particular. Sector-specific study in the context of the E&E industry with the recovery strategies is new in this study. It fills the gap between supply chain resilience theory and industry practices during COVID-19.

This study revealed six strategies to mitigate disruptions from COVID-19 as stated in **Table 4**. While these strategies are derived around supply chain disruptions during COVID-19, we believe that they are relevant for any future supply chain disruptions. We suggest that the first strategy of the global command centre focusing on daily planning cycle could mitigate the component shortage through teamwork. Historically, the cross functional teams and centralised decision making have been orchestrated by one or two members (de Vries *et al.*, 2022). However, this study does more than that with a robust scenario of daily planning by a team of people to optimize resources and capabilities available at all locations. Further, the proposed strategy could not only mitigate any future material/component shortage for SMEs with a single factory, but it could possibly be applicable for multinational companies.

The second strategy suggested is to collaborate with suppliers to increase glove production. This is in line with previous research to increase production hours during COVID-19 (Mollenkopf *et al.*, 2020; Paul & Chowdhury, 2020). This research, however, found renegotiation of supplier contracts in relation to volume, price and payment term that were very helpful to increase supplier production. in the event that suppliers still cannot increase the production, then it is advisable to explore alternative suppliers. This strategy could be a good reference to mitigate any disrupted production at supplier factories.

The third strategy is to assist SME suppliers in getting government permits to resume operations, which provides a solution to RDT perspective of increase supplier dependence. This included helping suppliers in managing social distancing rules in production as found in previous research (Sumarliah *et al.*, 2021). However, assisting suppliers to apply for operation permit to resume partial production amid lockdown enforcement was a new insight. This strategy could be helpful for any future supply chain disruption caused by a lockdown in any pandemic or disaster.

The fourth strategy suggested in this study is dual sourcing to mitigate single sourcing issues. This is, of course, in line with the suggestions made in previous research (Deloitte, 2020; Galea-Pace, 2020b; Sharma *et al.*, 2020; van Hoek, 2020). Nevertheless, this research adds that local sourcing might not always be possible for high precision or technical items, and it might take 2-3 years to develop suppliers locally. For a long-term plan, foreign suppliers or foreign experts could be invited to open factories locally. In the event local sourcing is impractical, it is advisable to have dual sourcing from other regions or countries. This strategy could be applied to manage single sourcing issues beyond the COVID-19 pandemic.

The fifth strategy is to collaborate with freight carriers and government agencies which is similar and highlighted in past research by Alicke *et al.* (2020) and Galea-Pace (2020a). The current study also suggests working with freight carriers on alternative routes (Galea-Pace, 2020a). This collaborative approach is an element of resilience (Hobbs, 2020; Pettit, Fiksel, & Croxton, 2010), although the participants in this study did not specifically mention the resilience-building strategies. A unique finding of this study is that companies collaborated with SME suppliers to get shipping permits from customs officers.

The sixth strategies of ERP-integrated EDI, such as hybrid-ERP, cloud-ERP, and mobile-ERP are more prioritised than other emerging technologies during COVID-19 (van Hoek, 2020). In the event SME suppliers encounter financial issues to invest in ERP-integrated EDI, then cloud-ERP with software as a service (SaaS) is believed to be a cheaper solution. Nevertheless, this study finds emerging

technologies with higher investment are crucial in the long run to enhance visibility.

5.2 Theoretical Implications

First, it extends the RDT (Pfeffer & Salancik, 1978) to the COVID-19 context highlighting the resource criticality that resulted from disruptions. From the RDT perspective (Craighead *et al.*, 2020), resource criticality could cause resource price increase and longer order lead time which further disadvantages the parties that depend on it. This research contributes to RDT by suggesting a strategy for setting up a global centre & daily planning cycle to reduce resource dependence. Second, as glove manufacturers allocate more resources to medical equipment production, collaboration with parties with discretionary power to increase resources is a contribution to RTD. Third, restricted operations, and limited cross-border travel restricted access to resources (Pfeffer & Salancik, 1978). The strategies to assist local suppliers in getting permits for partial or full operations is a unique way to gain more resources.

Fourth, the finding revealed the issue with single-supply sourcing that ended up with disrupted material shortages (Pfeffer & Salancik, 1978). It contributes to RDT by suggesting that dual sourcing from local or nearby regions could eliminate the dependence on a single-supply source. Fifth, the lockdown and disruptions of scarce resource availability increase freight rates. From the RDT perspective, this study shows the power shift from shippers to freight carriers as compared to the finding of Giunipero *et al.* (2021) where power shifted from trucking drivers to brokers. This study further contributes to RDT with the strategy of collaborating with freight carriers to gain more cargo space allocation and change routing.

Sixth, the finding on disrupted data sharing among supply chain partners explains the need for the interdependence of resources as proposed in RDT. The top priority is to implement electronic data interchange (EDI), thus enabling ERP systems to reduce uncertainty due to a lack of coordination. Further, emerging technologies are found to be not the top priority, as also suggested by Nandi *et al.* (2020), that companies with high dependence face difficulty to adopt blockchain.

Seventh, this study also contributes to supply chain resilience-enhancing strategies and responds in particular to the call of many scholars for more empirical research, particularly during COVID-19 (Ivanov, 2020a; van Hoek, 2020). Further, it responds to the call for event-based research (van Hoek, 2020) by bridging the gap between theoretically oriented resilience-enhancing strategies and industry practices during the COVID-19 outbreak. Thus, it provides event-specific additional insights over earlier conventional SCRM and resilience (Chowdhury & Quaddus, 2016; Ivanov, 2020).

5.2 Practical Implications

The findings offer practical insights for E&E supply chain professionals who can apply the recovery strategies during and post-COVID-19 era. Although SCRM strategies are quite effective in facing high-frequency-low-impact events (El Baz & Ruel, 2020), these professionals need to understand that those strategies are relatively less effective for a low-frequency-high-impact event like the COVID-19 pandemic. The lived experience of supply chain professionals in this study helps others de-risk their operations as they emerge from COVID-19. While the impacts are severe, specific strategies like frequent planning against COVID-19 updates; dual local/regional sourcing as against single sourcing; assisting suppliers to mitigate disrupted manufacturing, and collaborating with transporters will help to get over the crisis. Moreover, findings suggest that supply chain professionals can use ERP-integrated EDI to monitor supply chain visibility. As inter-organizational data sharing is paramount during and post COVID-19 for daily planning and scheduling. E&E supply chain professionals need to focus on digital collaboration in a new normal business context.

6. CONCLUSION AND LIMITATIONS

The findings concluded with six strategies to mitigate disruptions. This is the first among few studies that used lived experiences of supply chain professionals to explore strategies through ground level experience. Particularly, it has addressed the call for research on a single event namely COVID-19 which has a low-frequency but high impact as compared to earlier disasters like SARS 2003, MERS 2013, and Ebola 2014 viruses.

Refer **Figure 1** for the summary of six disruptions and their associated strategies. A global command centre with daily planning cycle for the end-to-end supply chain to mitigate component shortages is a new finding. Collaborating with suppliers for industrial nitrile gloves is a new contribution to manage the supply in the event of the supply being switched to medical gloves. Assisting SME suppliers to obtain operations/manufacturing permits during the COVID-19 lockdown is ~~a~~ unique in this study. Collaboration with the government in getting shipping permits for SME suppliers is novice, although collaboration with freight forwarders was mentioned earlier by Alicke *et al.* (2020) and Galea-Pace (2020a). The existing ERP-integrated EDI to mitigate disrupted data sharing is a more relevant and preferable strategy than adopting other emerging technologies (van Hoek, 2020). But it was hardly mentioned by previous research.

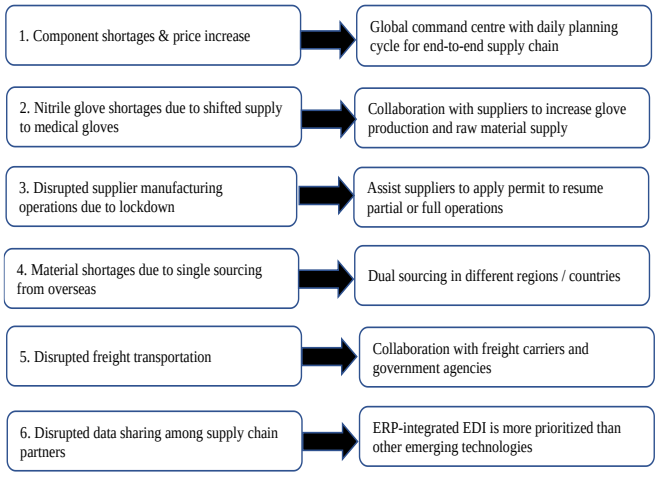

Figure 1 Disruption and associated Strategies

Although the impact of the pandemic and resilience-building strategies of supply chains remain more or less the same in Malaysia and beyond, the findings can be generalized to other industries and beyond the COVID-19 pandemic with caution. Future research could investigate the effectiveness of these strategies as time progresses in the post-COVID-19 era. A survey method can investigate the strategies to mitigate the disruption in a wider scope. Further, in-depth case studies with more sample sizes are recommended to test the wider validity of our findings in different contexts.

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APPENDIX

Semi-structured interview questionnaire

1. How does COVID-19 cause disruptions to your supply chain?
2. How does COVID-19 disrupt your component/material deliveries from suppliers?
3. What strategies have you followed to mitigate material/component shortages?
4. How does COVID-19 disrupt your domestic and international freight transportation?
5. What are your strategies to mitigate disrupted freight transportation?
6. What are the technologies you use to share data with your supply chain partners? Are they useful to mitigate the disruption caused by COVID -19?
7. To What extent the strategies were different during and after COVID-19?
8. What's your view on long-term supply chain strategies to sustain a future pandemic?
9. What's your view on long-term supply chain technologies to sustain future pandemics?

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