

Assessing the Impact of Black Swan and linked Supply Chain Disruptions on Supply Chain Design

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Abstract

The aim of this study is to assess the impact of Black Swan and linked Supply Chain Disruptions on Supply Chain Design. The motivation of this paper is to understand how firms can manage supply chain disruption risks related to the COVID-19 pandemic and how has the COVID-19 pandemic change the supply chain design for multinational enterprises. Content analysis is used to investigate the objectives of research. For this study recent literature from 2004 to 2020 is reviewed. Focus of this research is on supply risk, demand risk, and environmental risk. Findings show that catastrophic disruptions like COVID-19 might cause some suppliers or a cluster of suppliers to fail to deliver supplies. So, focus on efficiency alone is inadequate, and companies must consider other factors in supply chain network design like adaptability, agility, and alignment. Companies can manage risk related to Black Swan events (e.g Covid-19) by effective SCRM and by building in redundancy or flexibility that can enhance supply chain resiliency.

Keywords: Supply Chain Risk Management; Supply Chain Design; Outsourcing; Reshoring.

Reference to this paper should be made as follows: Alazzaz, A. (2021) 'Assessing the Impact of Black Swan and linked Supply Chain Disruptions on Supply Chain Design', *Asia Pacific Journal of Emerging Markets*, Vol. 5, No. 1, pp. 1–12.

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1. Introduction

The concept of supply chain management (SCM) emerged when companies shifted their operations overseas in the 1980s (Gunasekaran, Patel, & McGaughey, 2004). The movement of operations abroad and outsourcing trends allowed firms to reduce operational costs, improved access to raw materials, provided a wider range of suppliers, increased manufacturing flexibility, and enhanced competitive advantages (Chu, Park, & Kremer, 2020). At the same time, supply chains became more complex, more concentrated in a few areas in the world, and more sensitive to disruption (Lund et al., 2020). The global spanning nature of today's supply chains means they are increasingly susceptible to black swan, or one off, events that disrupt the flow of materials and products (Xu, Zhang, Feng, & Yang, 2020). Examples of black swan events include the 2008 financial crisis, the 2011 Asian Tsunami, and the Covid-19 pandemic of 2020 and 2021. These disruptions not only cause negative financial and operational performance for supply chains members but can also lead to loss of reputation and even worse bankruptcy (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Sodhi, Son, & Tang, 2012). Therefore, firms have turned their attention to enhancing their supply chain risk management (SCRM) capabilities to mitigate disruptions, and the associated hidden costs (Chopra & Sodhi, 2014; Pournader, Kach, & Talluri, 2020).

COVID-19 pandemic has affected almost every country and all industries on this planet. 95% of the Fortune 1000 companies have been disrupted by the COVID-19 pandemic (Ivanov, 2020). COVID-19, which was first reported in Wuhan, China, in December 2019, caused 80,773,033 confirmed cases and 1,783,619 deaths globally as of 30 December 2020 (WHO, 2020). COVID-19 pandemic can be considered a black swan event for several reasons. First, the pandemic has been affected all countries and industries around the world simultaneously. Whereas, previous disruptions had much limited geographic scope (Stecke & Kumar, 2009). The pandemic has affected both supply and demand simultaneously and also affected the logistics infrastructure (Craighead, Ketchen

Jr, & Darby, 2020; Ivanov, 2020). Third, the disruption has lasted for over a year and the length of the pandemic is still unknown (Ivanov, 2020).

COVID-19 not only caused businesses and policymakers to make decisions under high uncertainty (Mishra, 2020), but also forced managers to rethink their supply chains' operational capabilities (Choi, 2020). COVID-19 showed us that due to this unprecedented, black swan event few companies were adequately prepared. This shows that conventional models, strategies, and designs have vulnerabilities. There is therefore a need to rethink current supply chain designs to build more resilient supply chain model.

In the Supply Chain Risk Management literatures, scholars have studied a specific kind of risks such as political risk (e.g.(Roscoe, Skipworth, Aktas, & Habib, 2020)), financial risk (e.g. (Blome & Schoenherr, 2011)), product safety and security (e.g. (Marucheck, Greis, Mena, & Cai, 2011)), information risks (e.g. (Faisal, Banwet, & Shankar, 2007)); however, only a handful of studies have been conducted on supply chain disruption in the form of pandemics. In their review of the existing and emerging topics in SCRM, (Pournader et al., 2020) conclude that there is a shortage of research in the area of supply chain significant disruptions.

The motivation of this paper is to answer the following research questions: 1) How can firms manage supply chain disruption risks related to the COVID-19 pandemic? 2) How has the COVID-19 pandemic change the supply chain design for multinational enterprises?

2. Literature Review

SCM is defined by (M. I. CHRISTOPHER, 2017) as “the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.” (page13). Risk is quantifiable, but uncertainty is not because neither the impact and probabilities of occurrence is known (Norrman & Jansson, 2004). Supply chain risks can be either from uncertainty due to operational supply chain activities such as day-to-day demand fluctuation or from uncertainty resulting from disruptions to the operational activities like natural disasters (Tang, 2006). This research will only focus on the latter, supply chain disruption risks which is characterised by low probability and high impact on supply chain design (Ivanov, 2020; Zwißler & Hermann, 2012). Scholars (M. Christopher & Peck, 2004) categorised supply

chain risks into three categories that can be further subdivided to be five categories. The first category is risk that is internal to the firm include: control risk and process risk. The second category is risk that is external to the firm but internal to the supply chain network include: demand risk and supply risk. The third category is risk that is external to the network include: environmental risk. The focus of this research is on supply risk, demand risk, and environmental risk. According to (Chu et al., 2020) control, process, supply and demand risks have been widely discussed among both academics and practitioners for the ease of evaluating those risks via applying quantitative methods on local supply chain cases. However, from a global lens, environmental risk such as political stability is hard to evaluate and analyse because of the associated uncertainties affected by economic, social, and local political realities (Chu et al., 2020).

SCM scholars have not agreed on a definition of SCRM (Ho, Zheng, Yildiz, & Talluri, 2015), but this research will adopt a comprehensive definition of SCRM provided by scholars (Fan & Stevenson, 2018). They defined SCRM as: “The identification, assessment, treatment, and monitoring of supply chain risks, with the aid of the internal implementation of tools, techniques and strategies and of external coordination and collaboration with supply chain members so as to reduce vulnerability and ensure continuity coupled with profitability, leading to competitive advantage.” SCRM process comprises four stages: risk identification, risk assessment, risk mitigation, and risk monitoring respectively. In the first stage risks are identified and if an organisation fails to identify a risk, this risk cannot be treated and be part of SCRM process (Zwißler & Hermann, 2012). Therefore, risk identification is considered as the most important stage of SCRM process. The second stage of SCRM process is risk assessment, in which risks are assessed upon their likelihood of occurrence and the expected severity of impact. The third stage is risk mitigation where specific strategies (passive, reactive, or proactive) are deployed to manage risks (Zwißler & Hermann, 2012). The last stage is risk monitoring, which includes continues monitoring of changes in the previous three stages and the changes of risk levels (Zwißler & Hermann, 2012).

Effective SCRM rely on mitigation and/or contingency strategies to manage supply chain disruption risks (Tomlin, 2006). Mitigation strategies are actions taken in advance irrespective of a disruption occurrence (e.g. safety stock); whereas, contingency strategies are the plans that a company will use just in case if a disruption occurs (e.g. demand management tactic) (Tomlin, 2006). Other

scholars categorised SCRM strategies as passive, reactive, or proactive (Grötsch, Blome, & Schleper, 2013; Norrman & Jansson, 2004; Roscoe et al., 2020; Sheffi & Rice Jr, 2005). Passiveness means not taking any actions until the disruption event manifests and then acting aimlessly and chaotically (Grötsch et al., 2013). Reactiveness is similar to the contingency strategies in which the aim is to reduce the event's severity (e.g. flexible manufacturing capacity) (Chopra & Sodhi, 2004; Roscoe et al., 2020). Scholars (Roscoe et al., 2020) defined reactive SCRM strategies as "Tactical and operational decisions that lead to tangible investments in variable assets aimed at reducing the severity of a risk event." Pro-activeness is similar to the concept of mitigation strategies in which the aim is to reduce the likelihood of a risk event (e.g. moving supply chain facilities to less risky locations) (Roscoe et al., 2020). Scholars (Roscoe et al., 2020) defined proactive SCRM strategies as "Strategic decisions that lead to tangible investments in fixed assets that change the supply chain network architecture and reduce or eliminate the probability of a risk event."

All firms are exposed to disruption risks, yet not all firms have an effective SCRM to mitigate or contain disruptions from rippling through the supply chain (Chopra & Sodhi, 2014). Supply chain disruption ripple effect occurs when disruption effects spread beyond the initial disruption node (Scheibe & Blackhurst, 2018). Researchers (Hassini, Cheng, & Kam, 2008) provided a three-level classification of risk impact. At the first level, risk impacts the whole network and the magnitude of effects creates substantial disruption to the entire network delivery of service. At the second level, risk just threatens a sub-network branch, and effective SCRM should contain the risk impact to that sub-network branch to eliminate the risk of ripple effect to other branches or the entire network. At the third level, risk just threatens an individual node and/or a link of the network, and here again an effective SCRM should contain the risk impact or otherwise the risk could ripple and as a result the risk impact level might be escalated to level 2 or even to level 1. The concept of not containing ripple effect is similar to what we have seen during COVID-19 pandemic, where it started in Wuhan with few cases and then COVID-19 spread all around the world (Scheibe & Blackhurst, 2018).

(Ivanov, Sokolov, & Dolgui, 2014) proposed four reasons for ripple effect namely complexity, IT-failures, leanness, geographical specialisation. (Scheibe & Blackhurst, 2018) study found that the nature of the supply chain disruption, supply chain dependence and structure, and decision that supply

chain managers make to deal with the disruption to be the factors affecting ripple effect (Scheibe & Blackhurst, 2018). The less complex a supply chain network design is, the less potential will be ripple effect. In other words, the fewer nodes in a supply chain network, the easier for a company to manage risks and have a better visibility, velocity, and control of the network (M. Christopher & Lee, 2001). A framework proposed by scholars (Dolgui, Ivanov, & Sokolov, 2018) revealed that ripple effect and disruption impact can be controlled through resiliency, redundancy, robustness, and flexibility.

The SCRM process, which its first step is risk identification, works with traditional events such as earthquake however with unprecedented events like COVID-19 such an approach might not be effective in the absence of historical data (Pettit, Croxton, & Fiksel, 2013). Resilient companies have fewer vulnerabilities, and are more capable to handle supply chain disruptions (Ambulkar, Blackhurst, & Grawe, 2015; Sheffi & Rice Jr, 2005). Supply chain resiliency is defined by scholars (Ponomarov & Holcomb, 2009) as the “adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.” Therefore, building resiliency is crucial for firms’ operation continuity during unprecedented supply chain disruptions (Sheffi & Rice Jr, 2005). Building supply chain operation resiliency improves operational performance not only in dramatic times but also in relatively stable times (Dreibelbis, Delich, & Kelly, 2008). Investment in building resilient infrastructure should be accompanied with ability to actively manage and reconfigure those resources to cope in severe disruptions (Ambulkar et al., 2015).

Building in redundancy or flexibility can enhance supply chain resiliency (M. Christopher & Peck, 2004; Sheffi & Rice Jr, 2005). Building in redundancy (e.g. stockpile) can help companies to mitigate disruption risks, yet the associated costs should be studied thoroughly (Sheffi & Rice Jr, 2005; Zsidisin & Wagner, 2010). Building in flexibility is more powerful than adding redundancy, as flexibility enables firms to acquire the right capabilities that sense threats and respond to them rapidly (Sheffi & Rice Jr, 2005). (Sheffi & Rice Jr, 2005) argue that flexibility can be achieved through five areas: supply and procurement, conversion process, distribution channels, systems, and corporate culture. Robust strategies suggested by (Tang, 2006) enable a supply chain to be more resilient to encounter disruption, and simultaneously enable the supply chain

networks to be efficient. In face of disruptions, efficiency alone is inadequate, and companies must consider other factors in supply chain network design like adaptability, agility, and alignment (Lee, 2004). (Manhart, Summers, & Blackhurst, 2020) found that cultural differences impact bridging strategy (e.g. collaboration between supply chain members) and therefore on firms' resiliency.

Supply chains are not rigid network systems, instead supply chains change and develop their configurations, shape, size over time (Dolgui & Ivanov, 2020; MacCarthy, Blome, Olhager, Srari, & Zhao, 2016). Catastrophic disruptions like COVID-19 might cause some suppliers or a cluster of suppliers to fail to deliver supplies (Dolgui & Ivanov, 2020; Ivanov, 2020; Pournader et al., 2020). Therefore, besides economic factors, shortage in supplies of many products (e.g. personal protective equipment) during disruptions cause supply chain structural design to change (Dolgui & Ivanov, 2020; Lund et al., 2020). Supply risk is evaluated based on different criteria: make-or-buy opportunities, number of suppliers, storage risks and substitution possibilities, availability, and competitive demand (Kraljic, 1983). Based on the precedent criteria, a company classify its purchased products into: noncritical (low profit impact, low supply risk), leverage (high profit impact, low supply risk), bottleneck (low profit impact, high supply risk, and strategic (high profit impact, high supply risk) (Kraljic, 1983). The strategic (high profit impact, high supply risk) purchased products such as PPE should be treated differently from other purchased products categories (Dai, Bai, & Anderson, 2020).

Around 80% of car brake pads are only manufactured by four companies in one area in China (Handfield, Graham, & Burns, 2020). China accounts for 60% of global exports of some pharmaceutical products such as acetaminophen, sedatives, antibiotics, and ibuprofen (Lund et al., 2020). China produces around 40% of the world's active pharmaceutical ingredient (Horner, 2020). India makes 20% of global exports for generic drugs (Lund et al., 2020). Both India and China source 75%-80% of the active pharmaceutical ingredient to the United States market (Horner, 2020). (Handfield et al., 2020) argue that the new supply chain designs are moving from focusing solely on efficiency to include other metrics like lower working capital, low emissions and better risk-recovery strategies, resiliency, sustainability, and lean production. Some production processes are expected to move to local markets for noneconomic factors like national security, self-sufficiency, and national competitiveness (Lund et al.,

2020). A trend of moving supply chain facilities from global to local markets has already emerged due to political and pandemic events (Handfield et al., 2020).

3. Research Methodology

This study used previous literature from 2004 to 2020 to do content analysis. Results are generated on the basis of literature review.

4. Empirical Results & Conclusion

This study attempts to investigate that how Black Swan and related Supply Chain Disruptions influence the Supply Chain Design and how can firms manage it. Previous studies show there are many types of risks but in this study our focus is on external risk such as supply risk, demand risk, and environmental risk. This risk can be managed by effective SCRM (Supply Chain Risk Management) which comprises four stages: risk identification, risk assessment, risk mitigation, and risk monitoring. Risk identification is considered as the most important stage of SCRM process then risks are assessed upon their likelihood of occurrence and the expected severity of impact. The next stage is risk mitigation where specific strategies (passive, reactive, or proactive) are adopted to manage risk and these strategies are adopted in advance. Risk can be mitigate by continues monitoring of changes in the previous three stages. Moreover, building in redundancy or flexibility can enhance supply chain resiliency which help companies to manage risks. Another objective of the study is how has the COVID-19 pandemic change the supply chain design for multinational enterprises. Recent studies tell that supply chains are not rigid network system instead these develop their configurations, shape and size over time. Catastrophic disruptions like COVID-19 might cause some suppliers or a cluster of suppliers to fail to deliver supplies. Therefore, besides economic factors, shortage in supplies of many products during disruptions can cause supply chain structural design to change. In past studies researchers argue that the new supply chain designs are moving from focusing only on efficiency to include other metrics like low emissions, lower working capital, low emissions and better risk-recovery strategies, sustainability, resiliency, and lean production. So, this study is helpful for future researchers and practitioners as it tells how events like Covid-19 changes the supply chain

design and also suggests measures to manage supply chain under such circumstances.

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