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Supply Chain Resilience in a Pandemic: The Need for Revised Contingency Planning

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Abstract: Organizations have worked over the years to develop efficiencies to their supply chains, which includes efforts to reduce waste, lower costs, consolidate suppliers and distributors, better manage costs of goods sold and inventory, develop efficiencies in packaging, storage, and shipping of product, as well as utilizing digital analytics to manage consumer choices and demands. These are all by-products of world-class manufacturing which have promoted systematic organizational and supply chain efficiencies. However, under economic shocks that are sustained over longer periods of time (e.g., Covid-19 Pandemic) and that affect supply chains from a variety of disruptions, a supply chain that is not prepared or adaptable may be broken or at a minimum weigh down the organization. Therefore, the ability to manage and control risk is a key aspect of effective supply chain management. However, the literature on pandemic risk mitigation is nascent. Thus, this paper offers a review of the extant literature, provides a strategic mitigation model covering five dimensions: leadership, preparedness, digitalization, resilience, and pivoting. These dimensions are designed to help organizations in the future to be more adaptive to events such as global pandemics and other large-scale disruptions and discuss implications for future research.

Keywords: supply chain; risk management; resilience; organizational pivot; pandemic.

Introduction

Former U. S. President Dwight Eisenhower (1957) once said, "plans are worthless, but planning is everything" (p.818). This statement is still relevant today and can be applied to supply chain management. Planning has become an important issue over the last few years as many organizations have experienced threats to their supply chains emerge, such as government tariffs (e.g. U.S.-China tariffs), Brexit, and most recently the COVID-19 pandemic.

Historically, supply chains have gone through life cycle stages (MacCarthy, Blome, Olhager, Srai, & Zhao, 2016). Much of the literature discusses how supply chains follow the life cycle of a product (Klepper, 1996; Windrum & Birchenhall, 1998; Georgiadis et al., 2006) and go through emergence, growth, maturity, and decline. For example, new supply chains arise due to technological advancements and new product developments (Hahn, 2015), and as a result of firms diversifying into new territories (Russo, Sun-Basorun, & Van Wamelen, 2012). Moreover, some firms choose to proactively differentiate their supply chains to adapt to market needs (Fisher, 1997). However, they may also decline due to insufficient demand (Wang, Wallace, Shen, & Choi, 2015).

Recently, due to the COVID-19 pandemic, supply chains have experienced unprecedented significant disruptions. This is a unique development as it has occurred on a global scale and created a rapid disruption in the supply chain both up-stream and down-stream and most organizations had not considered all the risks (Handfield, Graham, & Burns, 2020). Supply chain risk has been defined as an unplanned and unexpected incident that disrupts the flow of goods or services within the supply chain literature (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Scholten, Stevenson, & Van Donk, 2019; Wilson,

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2007). Supply chain (SC) risks are multifaceted and can be classified into operational and disruption risks (Craighead et al., 2007; Fahimnia, Pournader, Siemsen, Bendoly, & Wang, 2019; Govindan, Fattahi, & Keyvanshokooh, 2017; Tang, 2006; Tomlin, 2006; Sawik, 2011; Xu, Zhang, Feng, & Yang, 2020).

"Operational risks are referred to the inherent uncertainties such as uncertain customer demand, uncertain supply, and uncertain cost. Disruption risks are referred to the major disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, terrorist attacks, etc., or economic crises such as currency evaluation or strikes. In most cases, the business impact associated disruption risks is much greater than that of the operational risks" (Tang, 2006, p.453).

Research suggests that economic, political, and social developments are increasing the risk of supply chain disruption, particularly as supply chains get longer and more complex and involve more partners owing to the increase in global sourcing (Hendricks & Singhal, 2005). Over the years many OEMS and their Tier 1 suppliers have relied to an increased degree on global supply networks in pursuit of delivering products and services to customers at lower costs. They have also adopted lean systems models to optimize their supply chains, which often means retaining lower inventories. However, under pandemic conditions, other policies may need to be considered to mitigate the risk associated with supply disruption (Craighead et al., 2007).

Extant literature has studied supply risk (e.g. Bogataj, 2007; Chopra & Sodhi, 2004; Harland, Brenchley, & Walker, 2003; Kumar, Tiwari, & Babiceanu, 2010; Tang & Tomlin, 2008; Tummala & Schoenherr, 2011; Wu, Blackhurst, & Chidambaram, 2006; Vakharia & Yenipazarali, 2009), demand risk (Christopher & Peck, 2004; Blackhurst, Scheibe, & Johnson, 2008; Manuj & Mentzer, 2008; Wagner & Bode, 2008), manufacturing risk (Lin & Zhou, 2011; Olsen & Wu, 2010; Tang, 2006;), financial risk (Carvinato, 2004; Liu & Nagurney, 2011; Tsai, 2008), and other more macro risk such as environmental risk, natural disasters, political and social risk (Jüttner, Peck, & Christopher, 2003; Ravindran, Bilsel, Wadhwa, & Yang, 2010; Trkman & McCormack, 2009). Limited research has also examined effects on the supply chain due to the Avian flu pandemic (Kumar, 2012). However, to date, there is limited risk assessment examining supply chain management under a pandemic situation such as COVID-19 for which effects are global and longer-lasting rather than regional and episodic ones (e.g. a tsunami, earthquake, or natural disaster), with the body of the research remaining under humanitarian logistic literature (Queiroz, Ivanov, Dolgui, & Wamba, 2020). The disruption of COVID-19 extends over many countries, industries, and supply chains. The disruption is fluid in nature as it moves in waves from region to region and from one type of supply chain disruption to another. Moreover, the duration of the combined disruptions is undetermined and may endure for an extended period ranging from one year to several years.

Epidemic outbreaks are a special case of supply chain risks which is distinctively characterized by a long-term disruption existence, disruption propagations (i.e., the ripple effect), high uncertainty, and simultaneous disruptions in supply, demand, and logistics infrastructure (Ivanov, 2020). The research on the impacts of pandemics on supply chains is nascent and still emerging (Ivanov & Dolgui, 2020). "Unlike other disruption risks, the epidemic outbreaks start small but scale fast and disperse over many geographic regions" (Ivanov, 2020, p.2).

While organizations have made some temporary changes in their supply chains to adapt to business interruption due to COVID-19, new infectious diseases are emerging due to "multifactorial circumstances including population growth, globalization of trade, changes in nutritional, agricultural, and trade practices, shifts in land-use including accelerated urbanization, deforestation, and encroachment on wildlife" (Coker, Rushton, Mounier-Jack, Karimuribo, Lutumba, Kambarage, & Rweyemamu, 2011, p.326). These circumstances are becoming overlapping driving factors, which promote the need to focus

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more attention on disaster risk from "natural" hazards and provide new risk contingencies based on this threat.

Over the past decade, the world has been challenged by unprecedented emerging infections disease (EID) outbreaks (Chew, Choi, Heidner, & Leung, 2004; Nigmatulina & Larson 2009), such as Ebola, influenza, MERS, SARS, and most recently COVID-19. Shreve, Davis, and Fordham (2016) indicate that epizootic management dealing with diseases and within nonhuman animal populations tends to be siloed among those involved in agriculture or farming, which may limit risk awareness. They advocate that greater recognition of the diverse human, social, and environmental impacts of "animal" diseases are needed to improve preparedness.

We contend that in addition to governments, communities, and the medical community preparing for pandemics, organizations need to be better equipped as well to manage these risks, particularly as it applies to their supply chains. The global disruption of the supply chain caused by the coronavirus (COVID-19) epidemic, has become the greatest challenge to the global economy since the Second World War, according to the Brookings-Financial Times Tracking Indexes for the Global Economic Recovery (TIGER) (Prasad & Wu, 2020). The associated disruption of demand and capacity has increased uncertainty and financial instability forcing a reassessment and restructuring of business operations (Cortez & Johnston, 2020). More managerial attention is required to assess how the disruption affects customers and employees (Klaus & Manthiou, 2020; Sheth, 2020; Tuzovic & Kabadayi, 2020). Therefore, this paper seeks to shed light on supply chain management and risk assessment under pandemic conditions. We offer a brief literature review on pandemics and advocate for the need to develop better risk contingency plans to better manage pandemics. In addition, we offer a model and provide practical implications for its adoption.

Literature review

The literature review on pandemics in the context of COVID-19 is emergent, however, the extant literature suggests that "the supply chain business continuity plans had both the wrong data and the data wrong. Top management literally couldn't see what was happening — or needed to happen — to ensure safe and reliable deliveries under duress." (Schrage, 2020, p.n.d.). According to Araz, Choi, Olson, and Salman (2020), the COVID-19 dispersal is breaking many global supply chains, and the supply chain network is experiencing poor resilience to the pandemic. In the U.S. alone, an estimated 94% of Fortune 1000 companies have experienced supply chain disruptions due to COVID-19 (Sherman, 2020). One study by Dun & Bradstreet showed that 51,000 companies worldwide, 163 of which are in the Fortune 1000, have one or more direct or tier 1 suppliers in the impacted Wuhan, China region (Smith, 2020). Also, 938 firms have one or more tier 2 suppliers, which support the first tier, in this same impacted area (Smith, 2020). Another study by McKinsey & Company revealed that 73% of U.S. organizations experienced problems in their supplier base, and 75% had problems with their production and distribution (Alicke, Gupta, & Trautwein, 2020).

Other industries experienced even more disruption. For example, 100% of the food industry experienced issues with production and distribution, and 91% with their supplier base (Alicke et al., 2020). Overall, due to COVID-19 multiple sectors (e.g. manufacturing, aviation, restaurants, and hospitals) across the globe have experienced severe disruptions, which have impacted global supply chains at unprecedented levels (Ivanov & Dolgui, 2020; World Economic Forum (WEF), 2020).

Ivanov and Dolgui (2019) stress that complex networks become more vulnerable to severe disruptions, which change the supply chain structures and are involved with supply chain structural dynamics. They recommend greater visibility and communication along the supply chain to reduce the ripples caused by uncertainty. The authors also suggest that visibility may be a better approach to uncertainty than robustness. Other research contends that robustness is more important. Robustness refers to reliance on several suppliers rather than one supplier or having other suppliers in waiting as a contingency plan in the event of an emergency. However, these suppliers may be hard to rely on in a difficult or emergency for the supply chain to withstand a disruption (or a series of disruptions) without any structural and parametrical changes/adaptations. In contrast, resilience analysis explicitly allows the system to employ some recovery/adaptation to restore the disrupted operations and performance (Craighead et al., 2007; Ivanov & Sokolov, 2013; Zhao, Zuo, & Blackhurst, 2019).

Other research, by Holling (1996), integrates an ecological perspective and is based on the ability of a system to react to stressors, absorb and withstand shocks, and persist. Holling (1973) argued that resilience and stability were two important properties of ecological systems, and referred to resilience as the system's ability to absorb disturbances. Resilience is also based on knowledge understanding and its efficient processing (Bratianu & Bejinaru, 2020), as well as business competencies (Bratianu & Vatamanescu, 2017) needed for increasing an organization's chances for keeping its competitive advantage.

Another perspective argues for service innovation in the face of pandemics as a means of retaining customers in changing conditions, creating customer value, and implementing strategic reorientation as a managerial response to disruption (Heinonen & Strandvik, 2020). Their study discusses how the pandemic has: "forced organizations to stretch beyond existing business strategies. These imposed service innovations are characterized by spatial flexibility, social and health outreach and technology exploitation as the pandemic triggers changes of enduring relevance that include motives for service innovation; managerial sense-making; the role of customers; the role of external restrictions, and the dynamics of institutions, relationships and practices" (Heinonen & Strandvik, 2020, p.1).

Strategic pandemic mitigation model

Although the literature dealing with supply chain management in the context of COVID-19 is nascent, a few scholars have proposed models for dealing with pandemic conditions. For example, Queiroz et al.'s (2020) framework for operations and supply chain management offers six perspectives, i.e., adaptation, digitalization, preparedness, recovery, ripple effect, and sustainability. Also, Ivanov (2020) proposes a prediction model for measuring the impact of a pandemic on supply chain network and manufacturing resilience, which may aid leaders of organizations in making better decisions.

Hosseni, Ivanov and Dolgui (2019) argue that a firm's supply chain network resilience and manufacturing resilience are required to tackle the epidemic or such disruptive events. With disruptive events, material shortage and delivery delays occur in the downstream supply chain, causing the ripple effect which results in reduced performance in terms of service level, revenue, and process productivity (Dolgui, Ivanov, & Rozhkov, 2020; Ivanov, 2014).

In order to extend the literature and assist organizations with supply chain disruption both in the short-term as well as long-term, due to pandemics like COVID-19, we offer a Strategic Mitigation Model as seen in Figure 1.

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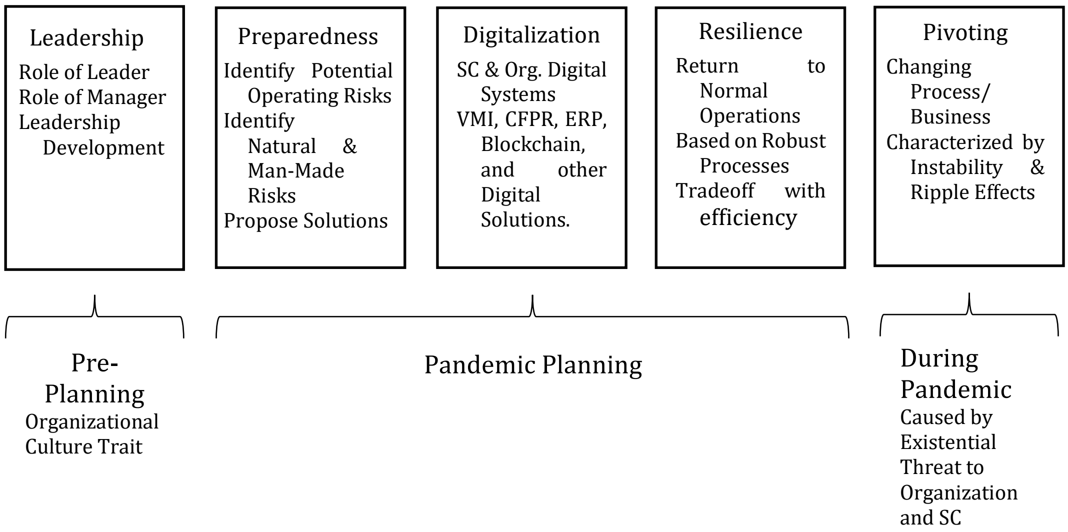

Figure 1. Strategic Mitigation Model

We believe that creating a way to deal with a future pandemic or some other globally complex, supply chain disruption may not always be perfect, but the alternative of having no plan or having not worked through the details of exploring risks and mitigating solutions is a worse situation. Moreover, this Strategic Mitigation Model is designed to deal with pandemics, but can also be adapted to other complex and large-scale supply chain disruptors, such as war and climate change effects. This framework adapts the supply chain risk definitions and mitigation approaches as described by Tang (2006) and Queiroz et al. (2020). The model covers five dimensions: leadership, preparedness, digitalization, resilience, and pivoting. These dimensions are discussed in the following section.

Leadership

Leadership is a primary success factor in world-class management (Flynn, Schroeder, & Sakakibara, 1995). Here we find that leadership provides a unifying vision and voice for strategy communication, development of corporate culture, and validation of approaches that may be different from day-to-day efforts of the organization, and encourages supply chain relationships that go beyond traditional cost standards. The development of a pandemic risk management framework will require communication along the supply chain to coordinate procedural, financial, and administrative knowledge. Without leadership support, the efforts to develop a pandemic risk management framework may not be successful.

Leaders are different from managers. According to Stogdill (1974), "leaders are agents of change, persons whose acts affect other people more than other people's acts affect them. Leadership occurs when one group member modifies the motivation or competencies of others in the group" (pp.43-44). Leaders are individuals who have a vision of where the organization should be headed and can persuade organizational members to move in that direction. They are the individuals in the organization who motivate others, work with uncertainty, set standards, and emphasize on effectiveness.

Managers, on the other hand, are administrative officers of organizations whose jobs deal with current systems, control during the short term, follow company objectives and emphasize efficiency (Reynolds & Warfield, 2010; Toor, 2011). Leadership training and development helps managers to better plan for risk mitigation efforts. The literature offers examples of leadership skill gaps. For example, Tang (2006) found that managers do not plan well for pandemic types of disruptions for a variety of reasons. For one, they do not use probability estimates well. Even though they have training in estimating probabilities of disruptions, managers do not regularly practice and apply this side of their training to a large degree. Also, while they understand full crises, they underestimate the degree of severity and allocate sufficient time and resources to mitigate the supply chain risk. Furthermore, managers are often hampered by the lack of data to accurately estimate the potential cost/benefit of pandemic risk management, particularly as it applies to the supply chain (March & Shapira, 1987).

As managers are rewarded for their performance, they also tend to be risk-averse when they have to plan for risk management contingencies. They may see the need for a course of action that could help their organization, but they are torn by thinking in contingencies that would lead to lower levels of performance (Closs & McGarrell, 2004; Tang, 2006). However, problems and issues that arise due to pandemics such as Covid-19 require organizations to move beyond the role of management, which is suited to daily operations. They must become proactive leaders and make decisions on the future state of the organization.

Preparedness

Preparedness is the great unknown because there are things we do not know we do not know. Yet, preparedness for a future pandemic involves creating a strategy for a future unknown disruptive event and pre-allotting resources to carry out the plan (Queiroz et al., 2020). The planning process uses inputs based on epidemiology modeling, supply chain processes, simulation methods, forecasting, and other quantitative and qualitative methods. According to Currie, Fowler, Kotiadis, Monks, Onggo, Robertson, and Tako (2020), pandemic creates numerous issues. Each one of the issues often requires a separate model for the disease and other operational disruptions. Modelers work to provide these various simulations into a framework that addresses the generated repertoire of required solutions. Modeling is also used to define network redundancy optimization to determine the ideal network configuration and allow for exigency strategies, which take into account potential supplier and demand disruptions (Pavlov et al., 2019).

In addition to modeling, detailing supply processes provides an idea of a supply chain network requirements. One such method, the order fulfillment process, analyzes the order process backwards from the customer to the beginning of the supply chain. The order fulfillment process is multifaceted due to the variety of entities and objectives involved in the delivery of the product. The objective of the order fulfillment process to balance efficiency and resilience (Lin & Shaw, 1998).

Tang (2005) further refines the process by providing more detail in the planning process. He refers to a two dimensional model for the pandemic risk management framework identification: supply chain risk and mitigation approaches. The supply chain risk dimension deals with evaluating the degree of inherent operational uncertainty consisting of customer demand, supply, and cost risks. These inherent operating risks occur when supply chains are disrupted by factors usually found within the organizations in the supply chain. Tang (2005) also refers to the risks found in natural catastrophes and man-made disruptions and these tend to be broader and more severe than the inherent operating-type risks. In our model, we ascribe these natural catastrophes to pandemics. In fact, the pandemic natural catastrophe can cascade and, in turn, and create additional operational risks. Quantifying the potential risks of operational uncertainty and pandemic natural catastrophes are made difficult by their infrequency, size, and complexity.

The preparedness dimension serves to quantify the degree of risk, identify operational and disruption risks, and allocate resources to mitigate the effect of risk. The outputs of preparedness are input for resilience planning (Queiroz et al., 2020), which is detailed

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below. Subsequent dimensions of the pandemic risk management framework will provide mitigation efforts in more detail.

Digitalization

Digitalization of information systems serves to improve communication among supply chain members. The term digitalization was initially defined by Brennen and Kreis (2014) who referred to it as the numerous manifestations of social life that are rewritten as a digital interchange and media structures. We further define it here as all organizational and supply chain digital systems consisting of infrastructure, applications, and media that make up the input data and information, processing, and output knowledge used by an organization and its supply chain stakeholders, principally, suppliers and customers. Digitalization is by nature an enterprise-wide and supply chain effort that requires detailed planning and execution over time. It does not happen overnight. It also becomes a part of the formal organizational culture for problem-solving. It cannot be designed and executed in the middle of a pandemic. Digitalization tends to exist to a high degree in technology firms with complex supply chains and a lesser degree in short and less complex supply chains in primary and some non-durable secondary industries.

Information sharing is one preventive way to reduce pandemic risk and disruption (Tang, 2005). Information management systems can reduce uncertainty risk by providing forecasts and order responses for short-term product life cycles through more frequent response information systems. Likewise, information sharing helps longer life cycle products through better visibility of inventory along the supply chain to reduce the bullwhip effect, which is the accumulation of safety stock along the supply chain due to supply uncertainty (Lee et al., 1997).

Increasing vendor management inventory (VMI) provides more visibility, efficiency, and less uncertainty to the upstream manufacturer or distributor (Waller, Johnson, & Davis, 1999). However, it also requires supply chain digitalization services and places more responsibility on the manufacturer or distributor responsible for holding the inventory.

Collaborative forecasting replenishment planning (CFPR) is a digitalized inventory practice and it is a step beyond VMI. It requires more information sharing from both sides of the manufacturing and retail equation. In the supply chain relationship, both firms must trust each other and work together for mutual benefit. Also, Aviv (2001) demonstrated that CFPR in supply chains relationships decreases variance, uncertainty and risk.

Enterprise Resource Management (ERP) systems also function to share inventory, planning, human resource, manufacturing, and many other forms of digitalized information within an organization. Moreover, it is suited to share information between companies along the supply chain (Chen, 2001). A basic ERP information flow is shown in Figure 2. Typically, world-class management firms use ERP systems but are absent in less developed countries and in supply chains that are not known for technological prowess. According to Choi, Guo, & Luo (2020), those firms that employ digitalized systems, with ERP as the entry-level system, will fare much better in a pandemic than those firms that do not possess basic ERP systems.

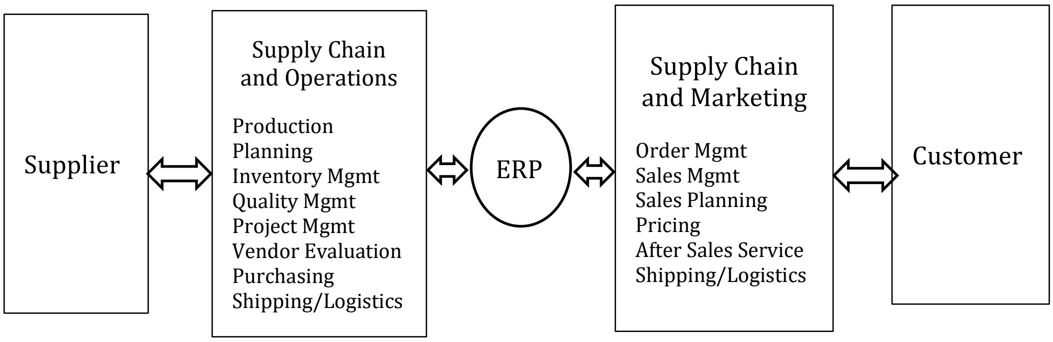

Figure 2. Information Flows of a Supply Chain ERP System
(Adapted from Chen, 2001)

Blockchain is an innovative software tool that functions as a decentralized register that records confirmable and incorruptible transactions amid a group of multiple parties. It functions beyond the security capabilities of traditional ERP systems. Current ERP cannot determine which partner systems are safe and trusted. The purpose of blockchain in supply chain management "is to allow a limited number of known parties to protect their business operations against malicious actors while supporting better performance" (Gaur & Gaiha, 2020, p.97). In addition to visibility, blockchain adds transparency as it creates place and ownership documentation instantaneously. It creates an immutable digital record of the inventory pipeline.

Digital systems offer many promises. Digitalization services help in the planning of a pandemic risk management framework. Many are in the beginning stages of development, such as Artificial intelligence. Some are out reach of organizations that do not have a working ERP system.

Resilience

The concept of supply chain resilience is rooted in the work of ecologist (Holing, 1973) and later in the context of supply chain management we find the seminal works of Christopher and Peck (2004) and Sheffi (2005). From an engineering perspective, resilience is referred to as the ability of an organization to return to "normal" operations (Carpenter, Walker, Anderies, & Abel, 2001). According to Sheffi (2005), resilience is when firms learn from disruptions and shift to a stronger position. Fiskel (2006) refers to resilience as the capacity for an organization to survive, adapt, and grow when faced with turbulent change (Fiksel, 2006).

Over the years, research on resilience has expanded beyond single firms and local markets (e.g., Pournader, Rotaru, Kach, & Hajiagha, 2016) to take into consideration globalized supply chains (e.g., Azadegan & Jayaram, 2018). Resilience has been used to offset increasing complexity in supply chain networks (e.g., Golicic, Flint, & Signori, 2017), and by incorporation the more traditional concepts of risk management with resilience (e.g., Linkov & Florin, 2016). Resilience has also been used to integrate it with Lean Six Sigma (e.g., Govindan, Azevedo, Carvalho, & Cruz-Machado, 2015). As stated by Pettit, Croxton, and Fiksel (2019), "a firm's resilience is significantly affected by its customers' and suppliers' ability to anticipate and respond to disruptions" (pg. 59). They advocate that organizations move beyond traditional enterprise risk management practices and learn to imbue a culture of resilience (Pettit, Croxton, & Fiksel, 2019).

Supply chain resilience is an important topic in supply chain risk management inquiry. It is at the core of preparing the organization to resist environmental forces and to provide a guide for ongoing practices in the face of ongoing stressors. Ponomarov and Holcomb (2009) consider supply chain resilience from a multifaceted approach encompassing environmental, societal, psychological, economic, and organizational dimensions. They

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define resilience 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" (p.131). We would add that a pandemiological dimension should also be included in this definition.

Tang (2005) includes resilience in his model and states that firms, in the face of a potential threat, will add a certain amount of robust features to their supply chain practices to mitigate disruptions. These practices should involve operational efficiency as part of the mitigating practice and ensure the sustainability and recuperation of organizational operations after a disruption. We list four general areas of resilience practices that an organization can build into an organization and its supply chain or deploy once stressor disruptions are manifest. The first resilience group relates to supply management strategies. The efficient supply practice has revolved around single supplier arrangements. To avoid work stoppage from a supplier disruption, a firm should increase resilience by determining where it should arrange for multiple suppliers and the determination should be based on quantitative analysis. In addition, sourcing from firms in a variety of countries reduces exchange rate risks. If multiple suppliers are difficult to find in a limited production market, it would make sense to develop trust-based relationships that encourage cost-sharing and other relationship-building practices. There is some validity to the notion of having backup suppliers in case one supplier is not able to deliver products. This concept could also be extended to contract producers, shipping suppliers, and alternate distribution channels.

The second resilience group relates to demand management strategies (Tang, 2005). When a firm engages in product development they may choose to enlarge their offerings so that in the event of a demand disruption, they can shift production emphasis from one product to a related item. This strategy offers firms the ability to increase efficiency and profit. Demand postponement is another strategy wherein a firm is able to defer product delivery by offering discounts to customers who can wait a little longer to receive a product.

A pandemic risk management framework, as mentioned earlier, should take into account that a pandemic will last longer than one year and up to two or three years. There is no way to forecast the duration from a planning perspective so resilience should be built into the period of the pandemic risk management framework. Creating accurate resilience strategies depends on knowledge of the spread of the disease, infection rate, waves or resurgence periods, potential treatment and vaccination effectiveness, and social and industrial acceptance of social distancing measures. These and other elements that are unknown during planning will become apparent during the lifecycle of the pandemic. This lack of foreknowledge leads to deep uncertainty. Deep uncertainty poses a great challenge for supply chain managers when planning resilience strategies (Paul & Venkateswaran, 2020).

Once your pandemic risk management framework is finished there is a probability that you may not need to use it for a long time. At this point, it is awaiting its implementation that may never occur. However, in the event that you do need to implement the plan, here are some mitigating strategies to employ along with the plan. They are contingencies that may require a decision in a go-no-go situation.

Pivoting

Pivoting is the organizational action of changing from one process or business line to another. Gilly, Kechidi, and Talbot (2014) refer to pivot organizations as those having the capacity "to manage a disturbance to its environment and to develop a new pathway" (p.596). The decision to pivot is contingent on an assessment of the current strengths and weaknesses of the firm in relation to changing opportunities and threats in the external environment with little time or resources to evaluate what the new organizational pathway should be and whether to pivot. The decision is not solely an organizational decision; it also involves pivoting with current or new suppliers and or customers. Possessing digitalized processes can also facilitate pivot decision (Queiroz et al., 2020).

However, the decision to pivot is not a decision that is easily planned. It usually involves a major existential threat to the organization with little warning. Pivoting also requires leadership talent and foresight in helping steer the organization onto a new pathway. Therefore, the top management team must be involved in the development and implementation of any plans to pivot.

Pivoting strategies will involve new network designs and guidelines as a firm reconfigures its new supply chain partners and with changes to its internal workforce deployment (Ivanov, Dolgui, Sokolov, Werner, & Ivanova, 2016). Shortages of labor and material inputs, as well as transportation of inputs and outputs, may strain the new supply chain configuration. Supply chains are not easily set up in a short period. Identifying, qualifying, and developing suppliers to provide quality, cost, delivery, and technological and financial capacity goals are planned for long-term requirements (World Economic Forum, 2020).

Pandemics considerably affect a supply chain's stability and will generate ripple effects along the supply chain (Ivanov, 2020). Under normal market conditions, the ripple effect is not noticeable or may be as simple as the bullwhip effect that can be treated by better information and visibility of inventory among supply chain members (Brandon-Jones, Squire, & Van Rossenberg, 2015). Under a pandemic, however, the stress is accentuated by concurrent disruptions in both supply and demand linkages. When pivoting, the firm should concentrate on identifying and controlling supply chain ripple effects through trust-building practices and increased use of information technology visibility and communication systems.

While pivoting is considered to be an appropriate business practice in the face of an existential threat in a changing environment where there may be no other alternative, the best method of preparing for a pivot is to design resilience into an organization and its supply chain.

Conclusion

We contend that our paper fills an important gap in the literature. As seen in Figure 3 (see next page), firms must be vigilant for a wide variety of risks, ranging from low magnitude and low time of anticipation, such as theft, to high magnitude with sufficient time to plan for an infrequent disruptive event.

Much of the literature on risk management concentrates primarily on the singular, low magnitude, and low time of anticipation of disruptive events. This paper, however, concentrates on the possibility of large magnitude, global events that pose sufficient planning time. Our risk mitigation model also makes a significant contribution by reorienting organizational objectives from a low-cost supply chain model susceptible to frequent disruptions to one of resilient supply chain networks that will withstand an increasingly disruptive world. As stated by Schatteman, Woodhouse, and Terino (2020, p. 1), "low-cost supply and minimal inventory were the key tenets of supply chain management. But in an increasingly turbulent world, supply networks that are overly dependent on the lowest-cost supplier and minimal inventory levels can rapidly imperil the business".

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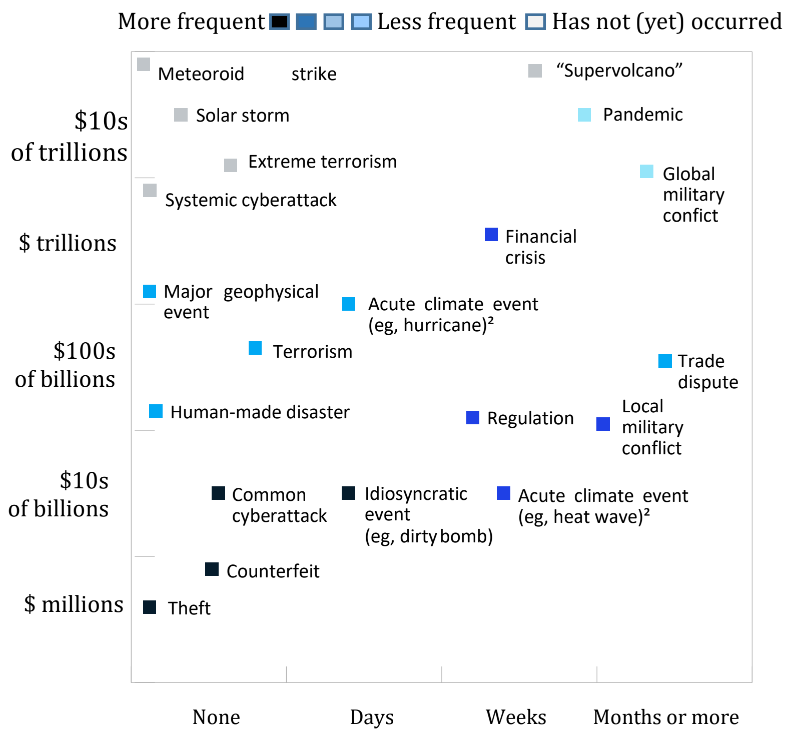

Figure 3. The magnitude of disruption, frequency, and ability to anticipate a disruptive event
(Adapted from: Baumgartner, T., Malik, Y. & Padhi, A., 2020).

Further suggestions for supply chain risk management

Supply chain networks now encircle the globe and link commodity markets to global consumers. Since their inception in the 1960s among the Mexican supplier industries and US automotive manufacturers, supply chains have spread from durable manufacturers to non-durable, commodity products and services. These global supply chains now deliver a larger variety of products to consumers and have helped develop the economies of emerging countries (Gereffi & Lee, 2012).

One of the primary factors, however, for achieving supply chain profitability is derived from cost reduction at each stage of the supply chain, from the commodity product until it is delivered to the final consumer. Research has shown that fewer products, lower geographic range, lower amounts of extra capacity, and lower inventory slack are positively predictive of supply chain performance (Kovach, Hora, Manikas, & Patel, 2015). Traditionally, a major method of reducing costs and improving supply chain efficiency has been to reduce the number of suppliers (Sarkar & Mohapatra, 2006) as supply chains with fewer suppliers tend to be more cost-effective and have improved logistics (Paulraj & Chen, 2007). A reduced supply base, however, forces a greater degree of mutual dependency between the supplier and purchaser (Hillman et al., 2009). Moreover, supply risk also increases with long-distance supply routes (Busse, Kach, & Bode, 2016). As a result, scholars such as Hutchins (1992) proposed a simple heuristic where the risk of working with a smaller supply base is usually offset by performance gains. In addition, Nishiguchi (1994) found that a smaller supply base results from working with trusted suppliers.

Despite the advantages of having a smaller network of suppliers, as evidenced by the COVID-19 pandemic, supply chains can be sensitive to disruptions. Disruptions increase costs and may; if sufficiently severe as with a pandemic, eliminate the original justification for setting up highly efficient supply chains, particularly over a diversified geographical area. For this reason, we suggest several strategies to reduce supply chain risk.

Operational Slack

We advocate that in addition to adopting some of the proponents of our model, organizations may need to consider allowing a bit slacker in their supply chain. Research by Hendricks, Singhal, and Zhang (2009) supports this argument. Their research found that firms with higher levels of operational slack (defined as sales, cash-cycle, and on-hand inventory levels) experienced less adverse disruption in their supply chains during market disorder. Kovach et al. (2015) also found that increased operational slack is linked to better supply chain performance during unpredictable business cycle environments.

Although adding operational slack may decrease operational efficiency, we contend that it may be applied sensibly when forecasts are showing probable future business instability or as a systemic safety level when business is stable. In each situation, slack levels need to be determined according to industry and competitive market benchmarks.

Diversification

Organizations may also need to develop more diversification in the number of direct suppliers, manufacturing processes, logistics, and other third-party operations. As evidenced by the amount of suppliers that were directly sourced to the Wuhan, China area, by many Fortune 1000 companies, lack of diversity has resulted in organizational vulnerability. Thus, it may be appropriate to not only rethink the number of suppliers but also reconsider the geographic location of suppliers. This recalculation may result in a smaller supply chain geographic reach (Gereffi & Lee, 2012; Marsden, Banks, & Bristow, 2000). Hendricks et al. (2009) found that supply chains that are more geographically dispersed over a variety of locations experience more disruption than those that are less dispersed. Kovach et al. (2015) tested operational scope, defined in their study as "narrow product offerings, low geographical diversification, low levels of excess capacity, and low inventory slack are each positively associated with firm performance" (p.1). They found support for the general notion that operational scope supports enhanced performance in volatile business settings.

Vertical Integration

While we are strongly in favor of supply chain networks, there may be times that it makes sense for firms to draw inward and establish in-house or vertical integration manufacturing and distribution practices. Research supports vertical integration operations for firms seeking to avert supply chain disruptions. Hendricks et al., (2009) determined that firms that established vertical integration operations tended to weather supply chain disruptions to a better degree than firms that kept their supply chains intact. In stable growth times, it does make sense that supply chains that seek efficient performance may venture back to working with suppliers. Alternating between in-house and suppliers, however, does not lead to close relationships, which are the hallmark of efficient operations.

Flexibility

We also suggest that organizations may need to be flexible in adapting their manufacturing facilities to more readily accommodate the manufacturing of other products or services (e.g., small-batch products vs mass production) due to changes in consumer preferences but also for risk mitigation. In some situations, it may also make sense to partner with competitors and suppliers for small amounts of capacity at a local or relatively close production facility.

Directions for future research

Researchers have indicated that people, as well as organizations, face more future risks from emerging infectious diseases, like Ebola, influenza, MERS, SARS, and COVID-19 (Chew et al., 2004; Nigmatulina & Larson, 2009). Most organizations have demonstrated that they have been ill-prepared for such issues and that their risk management plans are lacking. Thus, we seek to contribute to helping organizations thru our Strategic Mitigation Model. We contend that this may help better prepare organizations for the present as well as future supply chain disruptions both on a short term basis as well as long term.

In our development of the model for this paper, we found that there is a need for research on many of the risk mitigation practices under a pandemic context and that current research is limited. Although there is a dearth of research on leadership, more research needs to be dedicated to coordinating the preparation and execution of a pandemic strategy. As mentioned by Tang (2006), managers do not prepare well for future probabilities that will require the development of a plan that will reduce the performance of their area of responsibility. Leadership for risk management of the magnitude of a pandemic requires another mindset that leads to lower performance but increases sustainability.

We hope that our Strategic Mitigation Model will draw more attention to leadership in both planning and execution, particularly under pandemic conditions. We also contend that future research empirically tests the model as well. We believe that there is also a need to study the types of preparedness to determine optimum solutions. As discussed earlier, the planning process uses inputs based on epidemiology modeling, supply chain processes, simulation methods, forecasting, and other quantitative and qualitative methods. While there is an idea of what should work, there is no firm understanding of what firm leaders will ultimately choose to use and to what degree of efficacy.

Digitalization is another focus of future research. Digitalization allows an organization to better manage supply chain coordination by utilizing ERP-types of software and data to create visibility among supply chain members. However, these systems require development prior to the arrival of a pandemic. The research focus here should concentrate on the degree of efficacy of various digitalization efforts during a pandemic and the issues inhibiting digitalization (Anthony Jnr, & Abbas Petersen, 2020).

Future research should also focus on the drive for the resilience of supply chain networks. As noted earlier, supply chains were created to decrease costs and waste. These world-class manufacturing practices along the supply chain also increase disruption risk. The solution may be to increase resilience even though it can increase costs and may reduce efficiency. Overall, more research is needed to guide managers to determine the optimum balance between efficiency and supply chain sustainability (Golan, Jernegan, & Linkov, 2020).

Furthermore, we contend that more research should focus on leadership's decision to pivot during a pandemic. To be sustainable, an organization may need to pivot by changing its products or services. One of the major research questions for pivoting centers on why business leaders decide to pivot and what are the factors that facilitate successful pivots (Morgan, Anokhin, Ofstein, & Friske, 2020).

The most recent COVID-19 pandemic provides researchers with the opportunity to develop more research in the field of supply chain risk management. While we have supplied one model in the hopes of extending the research, it is evident that researchers, as well as organizations, have a long way to go to be better prepared and help supply chains be more resilient to short-term as well as long-term disruptions.

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