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MANAGEMENT OF SUPPLY CHAIN BUSINESS CONTINUITY IN THE FACE OF DISASTERS

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ABSTRACT.

Organizations are increasingly subject to many types of disruptions and catastrophes, with little or no predictability, and with increasing frequency and high impact. In response to these, organizational risk management has been pursued broadly in two different ways. One approach has been to adopt procedures like business continuity management (BCM), enterprise risk management (ERM), and related approaches. On the other hand, operations management and supply chain professionals have focused their efforts on cultivating various types of flexibility, agility, and resilience to cope with increasingly volatile business conditions. The first set of approaches has tended to be more structured, reflected by the emergence of standards like ISO 22301. Currently, there is a critical need to reconcile and synthesize both approaches, which forms the main objective of this paper. We first provide a summary of BCM methods, followed by a description of the disparate risk management attempts of supply chain professionals. A framework for business continuity management for supply chain risk management is developed based on the structure provided by ISO 22301, and drawing on the strengths of both approaches.

1. INTRODUCTION

Organizations are operating in an increasingly global, complex, and risky context. Economic, social, political, technical, environment-related events can interrupt core business. Natural disasters, diseases, terrorist attacks, strikes, financial crises, unreliable systems, logistics, supply chain failures, as well as unexpected lack of essential production inputs, can severely affect growth and performance. Each disruption might have different effects on organizational resources. It has become almost impossible to predict their nature, time, and extent.

Organizations are subject to many types of catastrophes, with little or no predictability. Catastrophic events may arise in the form of security breaches, economic crises, volcano eruptions, earthquakes, weather-related incidents like hurricanes and tornadoes, astronomical events like meteor hits, and, as experienced currently, the onset of pandemics like Covid-19.

Global supply chains have been exposed to a wide range of catastrophes during the last two or three decades, which have tended to occur with increasing frequency and impact. Unlike catastrophic events experienced in the past two or three decades, catastrophic events have proved to be different in many ways. They often involve collateral damage to other systems, affecting both upstream and downstream systems. Catastrophic events can be detrimental to economic, social, cultural systems, and biological systems. The term common cause failure is often used to describe a situation where global system failure is caused by a single event with tightly coupled systems components. Common cause failures, also referred to as command mode failures, are dependent, multiple failures that can be traced to one common cause (Hagen, 1980).

Common cause failures are often viewed as one-in-a-billion, “black swan” events (Taleb, 2007). Given such an environment, it has been recognized that organizations require a proactive approach, equipped with a structured decision support framework to protect themselves against disruptive events.

In recent years, the focus has shifted from individual organizations to entire supply chains. Accordingly, the planning for, and managing disruptions is now an integral part of managing supply chains. Responding to these potential disruptions primarily addresses: a) mitigation: actions aimed at reducing the probability of a disruption taking place; and, b) recovery: measures aimed at reducing the impact of the disruption once it occurs.

Organizational risk management efforts have been pursued in essentially two different ways. One approach has been to adopt the procedures of business continuity management (BCM), enterprise risk management (ERM), and related approaches. Operations management and supply chain professionals, on the other hand, have adopted a second approach of cultivating various types of flexibility, agility, and resilience in supply chains to cope with the demands of increasingly volatile business conditions. The first set of approaches has tended to be more structured, compared to the methods adopted by operations and supply chain management professionals. This is reflected by the fact that BCM procedures have become codified into ISO standards like ISO 22301, whereas supply chain methods have tended to remain fragmented and unstructured.

At this juncture, there is a critical need to reconcile and synthesize both approaches to enable supply chains to adopt a coherent methodology for this vital function. The reconciliation of business continuity management, and risk management methods with the various flexibility, agility, and resilience constructs for improving supply chains forms the main objective of this paper. We first provide a summary of BCM methods, followed by a description of the disparate attempts made by supply chain professionals. A common framework of business continuity management for supply chains is developed below, drawing on the strengths of both approaches and minimizing the limitations. The proposed framework follows the structure provided by ISO 22301 as a structured BCM approach for supply chain risk management.

2. BUSINESS CONTINUITY MANAGEMENT (BCM)

Business continuity management (BCM) seeks to provide organizations a systematic approach to augment the continuity of operations in the event of a crisis or disaster. It is a holistic management process that identifies potential threats to an organization and the possible impacts of these threats to business operations, thereby providing a framework for building organizational resilience, safeguarding the interests of its key stakeholders, reputation, brand, and value-creating activities (Disaster Recovery Institute, 2017).

Historically, BCM originated three decades ago among information systems (IS) practitioners, as disaster recovery planning (DRP). DRP function was focused mostly on the Information Systems department, but daily operations involved almost every department in the firm. The primary purpose of DRP was to minimize the effects of unanticipated events on a firm’s ability to meet customer requirements without disruption of products and services.

Over the years, DRPs evolved to a broader concept and practice of business continuity planning (BCP) to expand its scope to the entire organization, and, subsequently, to upstream and downstream partnering firms of the supply chain. In addition, DRP expanded from primarily a recovery orientation to include mitigation tactics as an integral part of BCP. BCP relies on the integration of formalized procedures and resource information of the firm.

Many companies also had strategic Enterprise Risk Management (ERM) programs in place for identifying risks, determining a firm’s risk propensity, and utilizing risk control strategies to achieve an acceptable level of risk exposure (Dickinson, 2001). Safety programs have also been adopted extensively by firms, complementing BCP and ERM programs.

Limitations of ERM programs became evident over time. ERMs were viewed as being rooted in a “reductionist” worldview. Where each risk was identified and addressed independently and where hidden interactions were seldom recognized. Moreover, the focus was on discrete events rather than the gradual buildup of stresses. This approach can lull companies into complacency why may be shattered when an unexpected event occurs, such as the oil spill in the Gulf of Mexico on the part of British Petroleum (BP). The BP oil spill served to expose major inadequacies in safety programs that were in place. Problems also arise from organizational cultural patterns and perceptions of risk (DuHadway et al., 2018). The complex, dynamic nature of global supply chains requires constant vigilance to sense potential vulnerabilities and exceptional agility to respond to unexpected shocks. Consequently, the notion of strengthening resilience took hold, requiring new analytical tools as well as significant cultural shifts.

All these type of initiatives are currently being subsumed into the concept and practice of business continuity management (BCM). BCM refers to a set of principles, policies, and tools to support organizations in keeping their critical business processes functioning when disruptive events occur. Unlike standard risk management units, the focus of BCM departments is typically on disruptive events that are characterized by high impact and low probability, leaving decisionmakers with a very short reaction timeframe. The historical evolution of BCM has been summarized by Ferguson (2019), as shown in Figure 1.

The end goal of BCM is to make the organization more resilient to potential threats and enabling continued operations even under very adverse or abnormal conditions. Many definitions of resilience have emerged over the years within BCM context. Resilience refers to the ability of an organization to absorb and adapt in a changing environment (ISO 22316). Resilience has also been defined as the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change (Fiksel, 2006). The ability of firms to learn from past disruptions and shift to a stronger posture has also been emphasized (Sheffi, 2005). Organizational resilience denotes an organization's proficiency in keeping its capabilities at a stable level despite the challenging business environment in which it activates. It requires the ability to identify, communicate, respond, and recuperate itself from business risk, as well as the ability to be flexible to shifting business conditions. Organizational resilience also helps to distinguish between strong and weak aspects of a firm and then establish essential issues concerning business continuity planning (Quendler, 2017).

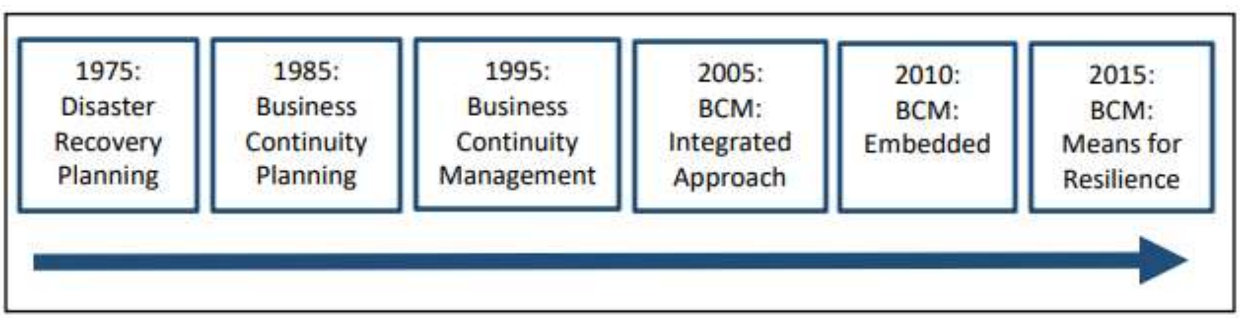

Figure 1. Evolution of Business Continuity Management (BCM)
(From Elliott et al., 2010; Ferguson, 2019)

This enlarged notion of business continuity management (BCM) has been widely adopted in industry. In 2012, the International Organization for Standardization (ISO) issued the ISO 22301 international standard to provide guidance to organizations on how to ensure continuity during and after a disaster (https://www.iso.org/standard/75106.html).

According to ISO 22301, business continuity (BC) is defined as the capability of the organization to continue the delivery of its products or services at acceptable predefined levels following a disruptive event, either natural or deliberate.

Many benefits have been claimed for BCM: 1) Augmenting a firm's ability for its goods and services

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to reach customers despite business risks; 2) Enabling better stakeholder interaction, with a well-defined framework for dealing with business risks; 3) Identification of vital directions to be taken to shield the essential functions of the company; 4) Recognition of possible threats and their impact on operations; 5) Efficient and transparent role assignments within the risk management process; and, 6) Reduction of financial loss in the eventuality of disruptions.

The limitations of BCM include 1) Inadequate commitments from senior management; 2) Insufficient allocation of resources for contingency procedures; 3) Ambiguous understanding of the tasks related to the set-up and running of BCM activities; 4) Improper assignment of responsibility to the team and not to line management; and, 5) Unsatisfactory training processes. BCM is highly dependent on an organization's human resources, and level of acceptance and participation of people at all organizational levels (Ghandour, 2014). These limitations are certainly not unique to BCM; instead, they may apply to a whole host of management initiatives such as quality management, safety programs, and risk management procedures.

Zdisin et al. (2005), addressing continuity planning specifically for supply chains, mentioned 12 actions for "supply chain continuity planning", under the categories of 1) Creating awareness within the organization about business continuity programs; 2) Formulation of prevention measures aimed at mitigation; 3) Remediation: Planning for disruptions and managing their impact, and 4) Continuous improvement and learning based on the lessons learned from past catastrophic events. These 12 steps are shown in Table 1.

Table 1. Supply Chain Continuity Planning (from Zdisin et al., 2005)

Phases	Action Steps
Awareness	1. Create internal awareness. 2. Drive awareness into the supply base.
Prevention	3. Prioritize suppliers and commodities to focus attention. 4. Understand both probability and impact of supply chain disruptions. 5. Eliminate/reduce exposure; buffer or mitigate if elimination not feasible. 6. Use multiple information sources to monitor risk. 7. Revisit these issues on a regular basis.
Remediation	8. Plan for disruptions. 9. Manage the impact of disruptions.
Knowledge Management	10. Take a continuous improvement view of SC continuity planning. 11. Post-event audit of SC disruptions standard operating procedures. 12. Share knowledge of SC continuity planning throughout the organization.

ISO 22301 guidelines specify BCM lifecycle with six professional practices (PP). The first two refer to management tasks and follow the objective of disseminating BCM within the organization: the development of policy and program management (PP 1) and its embedding into the organization's everyday business activities and organizational culture (PP 2). This roughly corresponds to the "Awareness" phase in Table 1.

The remaining practices are technical tasks aimed at developing a BCM strategy and a business continuity plan. Objectives and constraints are analyzed by business impact analyses, continuity requirements analyses, and risk analyses (PP 3). They provide the basis to develop a BCM strategy that states how recovery from a disruption of critical business processes could be achieved (PP 4). The BCM strategy is implemented using a business continuity plan that prescribes how to manage the disruption (PP 5).

To establish a permanent and effective BCM within the organization, the results of technical practices must be continuously validated (PP 6). These practices are structured in terms of Deming's Plan-Do-Check-Act (PDCA) cycle (Walton, 1988; Deming, 2000), as shown in Figure 2 below.

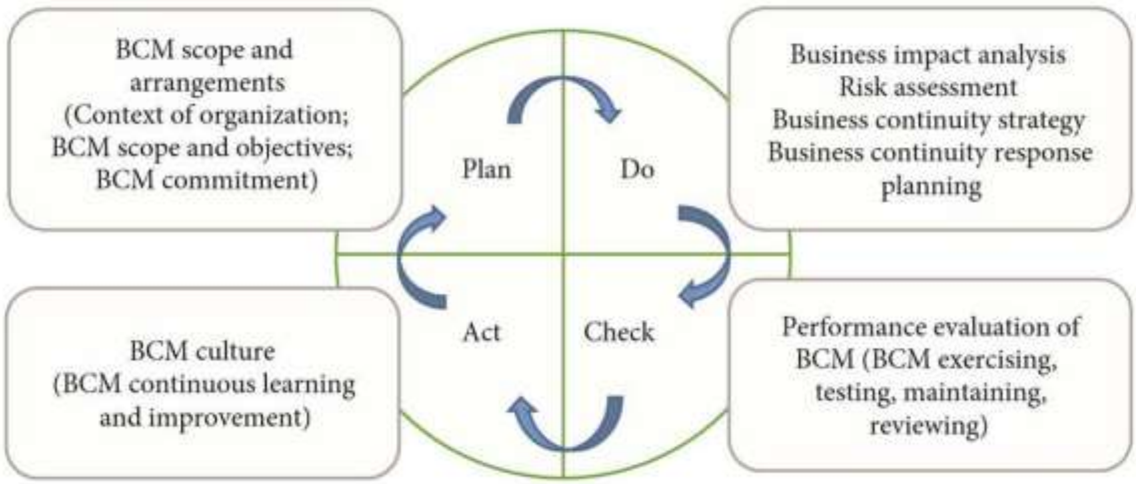

Figure 2. BCM Framework of ISO 22301: 2019 (Paunescu and Argatu, 2020)

Zeng and Zio (2017) suggested four types of metrics for BCM: 1) Protection measures, which do not allow threats to cause malfunctions to the organization, fostering business continuity; 2) Mitigation measures, that come into place if the protective measures do not meet the goal; 3) Emergency measures, applied when the mitigation procedures do not stop the threat; and 4) Recovery measures, to restore the normal business flow of the organization.

3. SUPPLY CHAIN RISK MANAGEMENT

Managing supply chain risks, in an increasingly volatile world, has been addressed by supply chain professionals under two broad categories: 1) Development of supply chain risk management tools, techniques and methodologies to identify, evaluate and manage risks; 2) Development of methods to cultivate flexibility, agility and resilience to cope with volatility and unexpected changes in the entire supply chain. Each of these categories is considered briefly below.

3.1 Supply Chain Risk Management Tools

Many types of risk faced by supply chains have been identified over the years. Chopra and Sodhi (2004) classified these risks as the risk of disruptions, delays, information systems failures, demand forecast errors, loss of intellectual property (IPR), Procurement-side risks, accounts receivable risk, inventories, and capacity. Correspondingly, several mitigation tactics such as the selective provision of additional capacity and inventory buffers, multiple sourcing, provision of flexibility, and pooling of demand. These are summarized in Table 2. Similarly, other studies such as Kleindorfer and Saad (2005), and Tomlin (2006) deal with identifying and coping with various types of supply chain risk.

Numerous tools and techniques for risk management, such as failure mode and effects analysis (FMEA), cause and effect (Ishikawa) charts, and Bayesian approaches have been developed. These are applied for analyzing the causes, their possible consequence, impact analysis, and corresponding mitigation and recovery tactics. For brevity, these tools and techniques are not repeated here.

Table 2. Supply chain risk categories, drivers and mitigation tactics (Chopra & Sodhi, 2004)

Risk Categories and Drivers of Risk	
Disruptions	Natural disaster, Labor dispute, Supplier bankruptcy, war, terrorism Dependency on a single source of supply
Delays	High capacity utilization at supply source, Inflexibility of supply source, Poor quality or yield at supply source, Increased border crossings/changes in transportation modes
Systems	Information infrastructure breakdown, System integration, networking, and e-commerce systems
Forecast	Inaccurate demand forecasts Bullwhip effect: information distortion due to sales promotions, incentives, lack of supply-chain visibility and consumer hoarding
IPR	Vertical integration of supply chain, Global outsourcing and markets
Procurement	Exchange rate risk, Percentage of a key component or raw material procured from a single source, Industrywide capacity utilization Long-term versus short-term contract
Receivables	Number of customers, Financial strength of customers
Inventory	Rate of product obsolescence, Inventory holding cost, Product value, Demand and supply uncertainty
Capacity	Cost of capacity, capacity flexibility

Mitigation Tactics
• Increase Capacity • Acquire Redundant Suppliers • Increase Responsiveness • Increase Inventory • Increase Flexibility • Pool or Aggregate Demand • Increase Capability

3.2 Development of flexibility, agility and resilience

As a means to cope with the growing volatility of business conditions, many types of flexibility have been identified, along with many taxonomies of flexibility. In an early work by Slack (1987), flexibility was defined as the range of states a system can adopt, along with the ease, time, and cost with which changes can be made within the capability envelope. Based on this essential notion of flexibility, many types of flexibility were identified: machine, labor, product, mix, process, routing, and volume flexibilities, to name a few.

Flexibility subsequently came to be differentiated with agility. It has been argued that flexibilities are internally oriented competences, while agility is the external-facing capability of an organization of the supply chain (Swafford, Ghosh and Murthy, 2006). Flexibilities themselves can be categorized as internal and external (firm-level) flexibilities. Flexibilities were established to be important antecedents of agility, but other initiatives like supply chain integration with suppliers and distributors were also seen to be antecedents of agility as well (Braunscheidel and Suresh, 2009). In this light, the notion of agility can be seen in selected definitions shown in Table 3. The systematic cultivation of supply chain agility is viewed as an essential means for coping with the volatile business conditions faced today

The third stream of literature has been aimed at augmenting supply chain resilience. Resilience has been defined as the capacity of an enterprise to survive, adapt and grow in the face of turbulent change. (Fiksel, 2006). Resilience means improving the adaptability of global supply chains, collaborating with stakeholders, and leveraging information technology to assure continuity, even in the face of catastrophic disruptions. Resilience goes beyond risk mitigation, enabling a business to gain competitive advantage by learning how to deal with disruptions more effectively than its competitors, and possibly shifting to a new equilibrium (Fiksel et al., 2015). Several antecedents for supply chain resilience have been identified, which include firm-level resilience, risk management infrastructure, resource reconfiguration capability, etc. Compared to agility, which may still be seen as a means to an end,

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resilience may be argued to represent the end goal itself. It may be noted that the definition of resilience adopted in supply chain literature is quite similar to the definition adopted in BCM literature mentioned earlier.

Table 3. Risk Management Elements: Flexibility, Agility, and Resilience.

Elements	Representative Definitions
Flexibility	Range of states a system can adopt, along with the ease, time and cost with which changes can be made within the capability envelope (Slack, 1987).
Agility	Capability to adapt or react to changes, or seize/exploit opportunities with speed and quickness; Agility is an externally-focused *capability*, while flexibilities are internally-focused *competences* (Swafford et al., 2006). The capability of the firm, internally, and in conjunction with key suppliers and distributors, to adapt or respond (mitigation & response) in a speedy manner to changing markets, contributing to the agility of supply chain. (Braunscheidel and Suresh, 2009) A firm's ability to quickly adjust tactics and operations within the supply chain to respond or adapt to changes, opportunities, or threats in its environment. (Gligor et al., 2015)
Resilience	The capability to anticipate and overcome supply chain disruptions (Pettit et al., 2013) The capacity for an enterprise to survive, adapt and grow in the face of turbulent change (Fiksel, 2006; Fiksel et al., 2015).

4. A BCM FRAMEWORK FOR SUPPLY CHAIN RISK MANAGEMENT

Based on the above independent streams of studies on BCM, and supply chain agility and resilience, we propose an integrated methodology for supply chain risk management procedures to be adopted more formally and coherently within the BCM framework. This procedure extends and modifies the structure advanced by Zdisin et al. (2005) for business continuity planning (BCP), shown in Table 1 earlier. Newer developments within both BCM and in the supply chain areas are incorporated here, as outlined below. Specific actions to be undertaken at the supply chain levels are drawn from Braunscheidel and Suresh (2017). The structure advanced here adheres to the structure suggested in ISO 22031, 2019 version, and the adoption of the PDCA cycle. In addition, ISO 22316, which deals with systematic procedures to ensure business resilience, is also part of the proposed framework, since resilience is the end goal of BCM, as stated earlier. Likewise, the adoption of systematic risk management procedures, addressed by ISO 31000, is also part of the proposed BCM framework for supply chains.

The proposed framework consists of six phases. The steps involved in each phase are shown in Table 4 and Figure 3 below.

Table 4. Proposed Framework: BCM for Supply Chain Resilience.

Phase	Activities Involved
1. Examine Organizational Context of Supply Chain	Understanding the supply chain, end-customer requirements, products and services offered to end-customers, end-market conditions, competitive priorities, needs of member firms, and supply context. Formation of the steering committee for the supply chain, enlisting the membership of key players in the chain. Creation of a supply chain map and formulating joint strategies for the supply chain. Formulation of BCM plan aimed at resilience of the supply chain (ISO 22316), and ensuring its awareness amongst all firms involved in the coalition.
2. Leadership	Ensuring leadership and commitment of senior-level executives on the steering committee as well as functional management within the organizations.
3. Prevention (Mitigation Tactics)	Examination of supply chain map for vulnerable elements and sources of risk in all stages of the chain: procurement, internal operations, and distribution-side risks. Risk management procedures (ISO 31000) involving risk identification, impact assessment, and mitigation tactics to address each source of risk. Mitigation tactics such as selective buffers of inventory, redundant capacity, avoiding overdependence on single sources, internal integration, better integration of vendors and distributors, etc. A more detailed list of mitigation tactics is seen in Braunscheidel and Suresh (2017). Ensuring right mix of various types of *flexibility, agility* and overall resilience. Information systems to guarantee upstream and downstream visibility. Planning and role assignments for staff disaster management teams. Identification of crucial coordination points. Training with vendors and customers. All the above may correspond to "Plan" and "Do" phases in the PDCA cycle.
4. Recovery (Response Tactics)	Planning for disruptions: Development of contingency plans (alternate suppliers, rerouting capabilities, etc.) to address disruptions in supply, internal operations and distribution. ("Check" and "Act" phases in the PDCA cycle). Managing the financial and other impacts of disruptions by adopting a proper system of priorities for emergency resource allocation to minimize overall disruption.
5. Assessment of Plans	Testing the procedures developed, with vendors, customers and key service providers through simulated disruptions ("Check" phase of the PDCA cycle).

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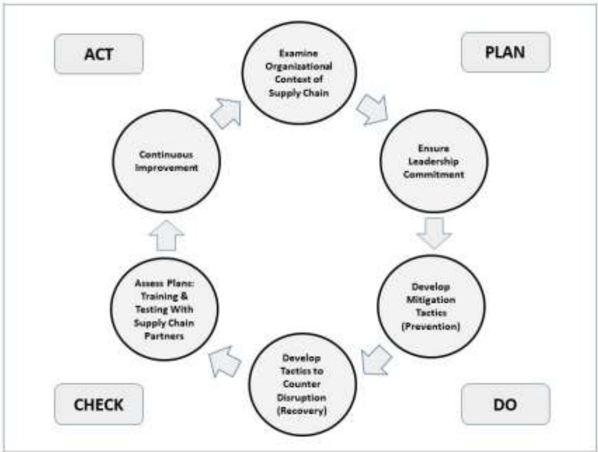

Figure 3. Proposed BCM Framework for Supply Chain Risk Management.

The utility of the above methodology can be realized in the context of recent situations like the Covid-19 pandemic, based on the impact it has had on two major supply chains — grocery chains and supply of medical devices.

In the case of grocery chains, demand volatility, caused by panic buying and hoarding on the part of consumers led to unexpected shortages of items such as sanitizing wipes and toilet tissues. The industry was caught by surprise, even though grocery chains have been making impressive advances in supply chain management, offering plentiful and affordable supply of a wide variety of products to consumers. However, the industry had become too lean in recent years, operating with very low inventory levels, and sacrificing resilience for leanness (Gasparro, et al., 2020). Resilience, after all, is the fundamental goal of BCM, as emphasized in step 1 above. Grocery chains found that the lessons learned from the past, the era of hurricanes, were ineffective in handling pandemic situations, which have proved to be different. In the case of hurricanes, demand surge for products can be met by shipments from other, unaffected regions. But in a pandemic, there is demand surge across the nation, or even globally, limiting shipments from other regions. Pandemics impose constraints on the supply side as well, by having to ensure safer working conditions, social distancing, etc., thereby reducing the ability to scale up production quickly.

The grocery chain industry has also revealed a distinct lack of coordinated response within supply chains. Such supply chain-wide organization, leadership, and coordination through a steering committee are emphasized in step 2 in the above methodology. Other factors such as contractual rigidities in supply chains, have contributed to the inability to redistribute supplies from restaurant channels, which experienced a downturn in demand, towards consumer channels, which faced demand surges (Smith, 2020).

Likewise, the absence of risk management procedures across the supply chain has also been evident. Step 3 in the proposed methodology addresses this issue and it requires the systematic examination of risk in all stages of the supply chain map. The vulnerabilities in the upstream, supply network have come to the fore in the case supply chains for medical devices. Medical devices like ventilators, masks, and personal protection equipment (PPE) rely on a globally dispersed supply chain, originating from global regions which have themselves been affected by the virus, thereby limiting supplies. The absence of systematic risk identification in the supply network, emphasized in step 3, has been felt. The risks emanating from overreliance on a limited number of suppliers or distributors, excessive concentration of suppliers, distributors, and other entities in certain geographical regions, etc. can all be avoided by systematically examining the risks in all segments of supply and distribution, as emphasized in step 3 above. Similarly, the absence or the inadequacy of the measures emphasized in steps 4 to 6 of the above methodology can be seen noticeably with the recent pandemic experience.

Thus the methodology presented above servesto provide a valuable structure for: 1) ensuring resilience through coordinated BCM, spanning multiple firms in the supply chain; 2) systematic identification of risks and mitigation tactics in all stages of supply and distribution; 3) developing recovery tactics, which are actively tested and assessed with other firms in the chain; and, 4) continuous improvement and learning of lessons from every episode.

5. CONCLUSIONS

This paper has presented an approach to reconciling and synthesizing two different approaches that have been adopted to address organizational risk management. The first approach, business continuity management, has been well-structured, reflected by the emergence of standards like ISO 22301. But BCM and related approaches have had a singlecompany orientation and do not sufficiently address the inter-organizational processes involved in supply chain management.

The second approach, on the part of supply chain management scholars and practitioners, has approached this in a fragmented manner, pursuing issues such as flexibility, agility, and resilience somewhat disjointedly. The recent shortcomings of supply chains pertaining to grocery items, medical supplies, etc. have pointed out a lack of structure in risk management and the ability to cope with unexpected demand volatility. The second set of approaches requires a more concerted and coherent strategy, warranting an infusion of the structure, sound systems, and procedures prevalent in the first approach. Supply chain approaches for risk management stand to gain significantly by adopting the more structured approach of business continuity management. This is in part due to the maturity and comprehensiveness of business continuity management, and the fact that it is more widely adopted in practice.

The challenges of pandemics and other catastrophic events demand new strategies for addressing common cause failures that can cripple an entire world. The integration of the two paradigms presented in this paper, based on the strengths of both approaches, should be of value to supply chain management professionals and consumers.

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