Business Continuity Management for Supply Chains Facing Catastrophic Events

—NALLAN C. SURESH
Operations Management, SUNY Buffalo, Buffalo, NY 14260-4000 USA

—G. LAWRENCE SANDERS
Management Science and Systems, SUNY Buffalo, Buffalo, NY 14260-1660 USA

—MICHAEL J. BRAUNSCHEIDEL
Operations Management and Strategy, State University of New York at Buffalo, Buffalo, NY 14260-1660 USA

(Corresponding author: G. Lawrence Sanders.)

IEEE DOI 10.1109/EMR.2020.3005506

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 article. 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.*

Key words: Business continuity management (BCM), catastrophic events, risk management, supply chain agility, supply chain resilience, supply chain risk management

I. 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, *pandemic* 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 on 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 are 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 BCM, and risk management methods with the various flexibility, agility, and resilience constructs for improving supply chains forms the main objective of this article. 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 BCM 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.

II. Business Continuity Management (BCM)

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 *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 which 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 *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 decision-makers 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 BCP [Quendler, 2017].

This enlarged notion of BCM has been widely adopted in the 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, 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 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 BC 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

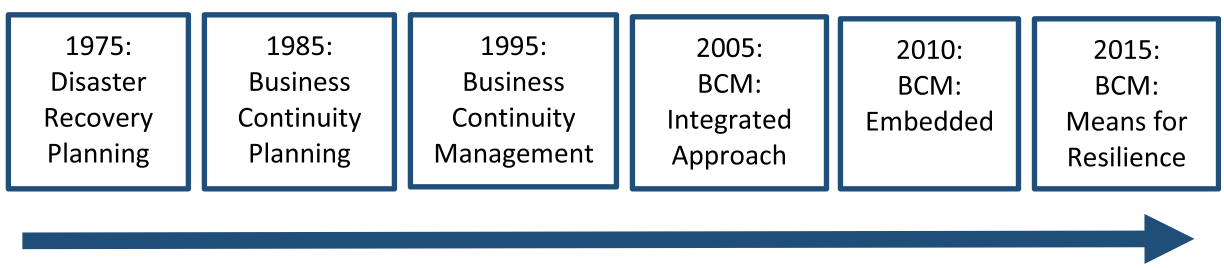

Figure 1. Evolution of BCM ([Elliott *et al.*, 2010]; [Ferguson, 2019]).

catastrophic events. These 12 steps are listed in Table 1.

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 BC 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 BC 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.

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 BC; 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.

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. Postevent audit of SC disruptions standard operating procedures. 12. Share knowledge of SC continuity planning throughout the organization.

III. Supply Chain Risk Management

Managing supply chain risks, in an increasingly volatile world, have 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. In Chopra and Sodhi [2004], these risks are classified as the risk of disruptions, delays, information systems failures, demand forecast

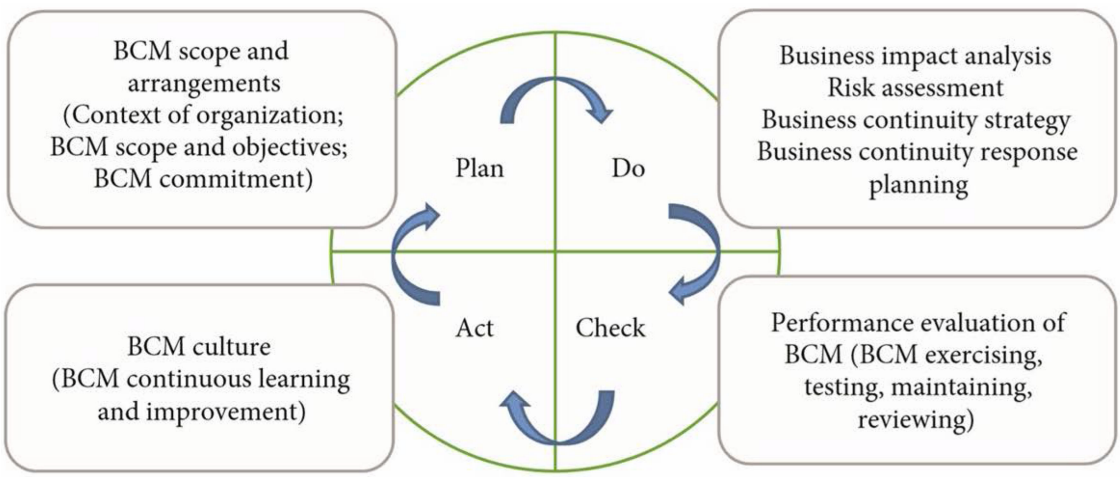

Figure 2. BCM Framework of ISO 22301: 2019 [Paunescu and Argatu, 2020].

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 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.

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 *et al.,* 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 listed 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

Table 2. Supply Chain Risk Categories, Drivers, and Mitigation Tactics [Chopra and Sodhi, 2004].

Risk Categories and Drivers of Risk		Mitigation Tactics
Disruptions	Natural disaster, Labor dispute, Supplier bankruptcy, war, terrorism Dependency on a single source of supply	• Increase Capacity • Acquire Redundant Suppliers • Increase Responsiveness • Increase Inventory • Increase Flexibility • Pool or Aggregate Demand • Increase Capability
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	

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

IV. BCM Framework for Supply Chain Risk Management

Based on the abovementioned 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 *BCP*, listed 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 a 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 a part of the proposed BCM framework for supply chains.

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

The utility of the abovementioned 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

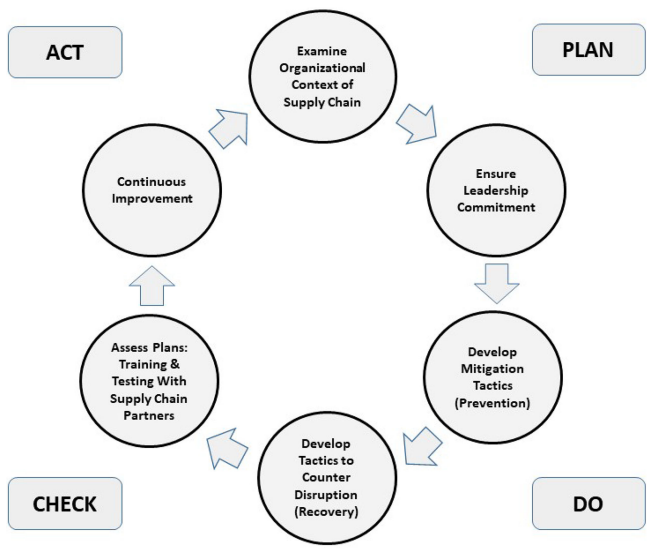

Figure 3. Proposed BCM framework for supply chain risk management.

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 and 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]).

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 mentioned 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 the 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 mentioned 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, toward 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

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).
6. Continuous Improvement	Archiving experiences and documenting lessons learned from disruptions for future occurrence, training people and the system for greater agility, etc. Formal assessment and identification of procedures which worked well and those which did not work well, in accordance with “Act” phase of PDCA cycle.

emphasized in step 3 mentioned above. Similarly, the absence or the inadequacy of the measures emphasized in steps 4–6 of the abovementioned methodology can be seen noticeably with the recent pandemic experience.

Thus, the methodology presented above serves to 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.

V. Conclusions

This article has presented an approach to reconciling and synthesizing two different approaches that have been adopted to address organizational risk management. The first approach, BCM, has been well-structured, reflected by the emergence of standards like ISO 22301. But BCM and related approaches have had a single-company orientation and do not sufficiently address the interorganizational 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 BCM. This is in part due to the maturity and comprehensiveness of BCM, 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 article, based on the strengths of both approaches, should be of value to supply chain management professionals and consumers.

Acknowledgments

This research was supported in part by the National Science Foundation under Grant DGE-1754085.

References

Braunscheidel, M. J., and Suresh, N. C., 2009, “The organizational antecedents of a firm’s supply chain agility for risk mitigation and response,” *Journal of Operations Management*, 27(2), 119–140.

Braunscheidel, M. J. and Suresh, N. C., 2017, “Cultivating supply chain agility: Managerial actions derived from established antecedents,” in *Supply Chain Risk Management: Advanced Tools, Models, and Developments*. (Ed. Y. Khojasteh), Springer, New York, NY, USA, 2017.

Chopra, S. and Sodi, M. S., 2004, “Managing risk to avoid supply chain breakdown,” *Sloan Management Review*, 46(1), 53–61.

Deming, W. E., 2000. *Out of the Crisis*. MIT Press, Cambridge, MA, USA.

Dickinson, G., 2001, “Enterprise risk management: Its origins and conceptual foundation,” *The Geneva Papers on Risk and Insurance*, 26(3), 360–66.

Disaster Recovery Institute, 2017, [Online]. Available: www.drii.org.

DuHadway, S., Carnovale, S., and Hazen, B., 2017. “Understanding risk management for intentional supply chain disruptions: Risk detection, risk mitigation, and risk recovery,” *Annals of Operations Research*. [Online]. Available: https://doi.org/10.1007/s10479-017-2452-0

DuHadway, S., Carnovale, S., and Kannan, V. 2018, “Organizational communication and individual behavior: Implications for supply chain risk management,” *Journal of Supply Chain Management*, 54(4), 3–19.

Elliott, D., Swartz, E., and Herbane, B., 2010, *Business Continuity Management: A Crisis Management Approach*. 2nd ed., Routledge, London, U.K.

Faertes, D., 2015, Reliability of supply chains and business continuity management. *Procedia Computer Science*, 55, 1400–1409. [Online]. Available: https://doi.org/10.1016/j.procs.2015.07.130

Ferguson, C. S., 2019, "Assessing the KING IV Corporate Governance Report in relation to business continuity and resilience," *Journal of Business Continuity & Emergency Planning*, 13(2), 174–185.

Fiksel, J., 2006, "Sustainability and resilience: Toward a systems approach," *Sustainability: Science, Practice and Policy*, 2(2), 14–21.

Fiksel, J., Polyviou, M., Croxton, K. L., and Pettit, T. J., 2015, "From risk to resilience: Learning to deal with disruption," *Sloan Management Review*, 56(2), 79–86.

Gasparro, A., Smith, J., and Kang, J., 2020, "Grocers stopped stockpiling food. Then came the coronavirus," *Wall Street Journal*. Mar. 23, 2020. https://www.wsj.com/articles/grocers-stopped-stockpiling-food-then-came-coronavirus-11584982605

Ghandour, A., 2014, "Identifying dimensions of business continuity plan from common expressions among business continuity professionals," *International Journal of Business Administration*, 5(3), 136–141.

Gligor, D. M., C. L. Esmark, and M. C. Holcomb, 2015, "Performance outcomes of supply chain agility: When should you be agile?," *Journal of Operations Management*, 33, 71–82.

Hagen, E.W., 1980, "Common-mode-common cause failure—A review," *Nuclear Safety*, 21(2), 184–192.

Hubbard, D. W., 2009, *The Failure of Risk Management: Why It's Broken and How to Fix It*. Wiley, Hoboken, NJ, USA.

Kleindorfer, P., and Saad, G., 2005, "Managing disruption risks in supply chains," *Production and Operations Management*, 14(1), 53–68.

Paunescu, C. and Argatu, R., 2020, "Critical functions in ensuring effective business continuity management: Evidence form Romanian companies," *Journal of Business Economics and Management*, 21(2), 497–520.

Pettit, T. J., Croxton, K. L., and Fiksel, J., 2013. "Ensuring supply chain resilience: Development and implementation of an assessment tool," *Journal of Business Logistics*, 34(1), 46–76.

Pettit, T. J., Croxton, K. L., and Fiksel, J., 2019, "The evolution of resilience in supply chain management: A retrospective on ensuring supply chain resilience," *Journal of Business Logistics*, 40(1), 56–65.

Quendler, E., 2017, "Organizational resilience: Building business value in a changing world," *Journal for International Business and Entrepreneurship Development*, 10(2), 101–119.

Sheffi, Y., 2005, *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*. MIT Press, Cambridge, MA, USA.

Slack, N., 1987, "The flexibility of manufacturing systems," *International Journal of Operations and Production Management*, 7(4), 35–45.

Smith, J., Apr. 15, 2020, "Divided supply chains are challenging producers, retailers," *Wall Street Journal*. [Online]. Available: https://www.wsj.com/articles/divided-supply-chains-are-challenging-producers-retailers-11586974088

Swafford, P. M., Ghosh, S., and Murthy, N., 2006, "The antecedents of supply chain agility of a firm: Scale development and model testing," *Journal of Operations Management*, 24(2), 170–188.

Taleb, N. N., 2007, *The Black Swan: The Impact of the Highly Improbable*. Random House, New York, NY, USA.

Tomlin, B., 2006, "On the value of mitigation and contingency strategies for managing supply chain disruption risks," *Management Science*, 52, 639–657.

Walton, M., 1988. *The Deming Management Method: The Bestselling Classic for Quality Management*. Penguin, New York, NY, USA.

Zeng, Z. and Zio, E., 2017, "An integrated modelling framework for quantitative business continuity assessment," *Process Safety and Environmental Protection*, 106, 76–88. [Online]. Available: https://doi.org/10.1016/j.psep.2016.12.002

Zsidisin, G. A., Melnyk, S. A., and Ragatz, G. L., 2005, "An institutional theory perspective of business continuity planning for purchasing and supply management," *International Journal of Production Research*, 43(16), 3401–3420.

Nallan C. Suresh is UB Distinguished Professor with the Department of Operations Management and Strategy, The School of Management, State University of New York at Buffalo, Buffalo, NY, USA, and an Associate Director of Stephen Still Institute for Sustainable Transportation and Logistics. Specializing in manufacturing, logistics, and supply chain management, he has authored and coauthored widely in academic and professional journals such as *Management Science, Decision Sciences*, *Journal of Operations Management, International Journal of Production Research, International Journal of Production Economics, IIE Transactions, International Journal of Flexible Manufacturing Systems, European Journal of Operational Research, Computers and Industrial Engineering, International Journal of Operations and Production Management, Journal of Manufacturing Systems, Production and Inventory Management, and Journal of Intelligent Manufacturing.* His contributions include the co-edited book *Group Technology and Cellular Manufacturing: A State-of-the-Art Synthesis of Research and Practice* (Kluwer). He has taught, lectured, and worked with many firms in North America, Europe, and Asia, and has held the position of Visiting Professor with the Faculty of Management and Organization, University of Groningen in Netherlands. He is the recipient of the Alfred Bodine / Society of Manufacturing Engineers Award for Studies in Machine Tool Economics; Joseph T.J. Stewart Faculty Scholarship, etc.

G. Lawrence Sanders, Ph.D., degree. He is a Professor with the Department of Management Science and Systems, School of Management, the State University of New York at Buffalo, Buffalo, NY, USA. He has served as the Department Chair and the Chair of the Ph.D., program. He played a leadership role in developing a new bachelor of science degree in information technology and management that was launched in 2019. He is an Associate Editor for *Decision Support Systems* and a Review Editor for the section "Smart Contracts" for the *Frontiers in Blockchain* journal. He is currently a co-pi on a $2.39 million grant from the National Science Foundation to train future cybersecurity experts. His current research interests include psychological profiling of hacking behavior, privacy and security, business continuity, blockchain economics, game design, game addiction, and the role of gamification in social networking. He has authored and coauthored papers in a variety of outlets such as *Decision Support Systems, The Journal of Business, MIS Quarterly, Information Systems Research*, the *Journal of Management Information Systems*, the *Journal of Strategic Information Systems*, the *Journal of Management Systems*, *Decision Sciences*, and *Communications of the ACM*.

Michael J. Braunscheidel received the Ph.D. degree from the School of Management, State University of New York at Buffalo, Buffalo, NY, USA. He is currently a Clinical Assistant Professor of operations and supply chain with the School of Management, State University at Buffalo. Prior to that he was an Associate Professor of management with the Richard J. Wehle School of Business, Canisius College, Buffalo, NY, USA and an Assistant Professor with the College at Brockport. Prior to his academic career, he spent 24 years in the industry in a variety of engineering and management positions including plant management. His research interests include supply-chain management, supply-chain agility and resilience, operations management, quality management, and organizational behavior. His research has been published in the *Journal of Operations Management, Human Resources Management, Decision Sciences Journal of Innovative Education, International Journal of Production and Operations Management, Academy of Information and Management Sciences Journal, The BRC Journal of Business and Academic Exchange Quarterly*. He has also presented at various national (DSI, POMS, INFORMS) and international conferences (EurOMA).