Quality Management and Supply Chain Resilience: Establishing a Missing but Important Link

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This research argues that through the implementation of Quality Management Systems, organizations acquire resources and capabilities that may enhance resilience in their supply chain operations. Using the relevant literature that advances the conceptual understandings of both the Quality Management and the Supply Chain Resilience domains, and utilizing the theoretical arguments of the Cumulative Capabilities framework, six research propositions are developed that link the conceptual elements of Quality Management Systems with key Supply Chain Resilience elements. Thus, this study provides an alternative and novel way to conceptualize supply chain resilience by linking two literature steams that have hitherto existed in non-converging domains.

INTRODUCTION

Supply chain resilience has been a pertinent topic of interest recently, receiving increasing attention from both academics and industry practitioners. This interest comes at a time when supply chain disruptions, fueled by efficiency-driven initiatives, and other aggressive performance improvement initiatives such as globalization, abound (Habermann *et al*., 2015). Up to 80% of organizations consider supply chain resilience as a top priority (Wright, 2013; Ambulkar *et al*., 2015), and not without reason, as supply chain disruptions have been empirically linked with severe consequences for the firm. Empirical studies demonstrate that supply chain disruptions have significant detrimental effects on a firm's operational performance (Wagner and Bode, 2008), financial performance (Hendricks and Singhal, 2005), and market performance (Hendricks and Singhal, 2003). Furthermore, the closely interlinked nature of contemporary supply chains suggests that an organization's financial distress may affect their suppliers and customers (Hertzel *et al*., 2008), and as demonstrated recently by the effect of depressing oil prices on suppliers of oil drilling firms (Aeppel, 2014). Thus, the importance of organizations to ensure that their supply chain operations are resilient to disruptions cannot be understated.

Current academic conceptualizations of supply chain resilience only gives what firm and/or supply chain resources contribute to resilience. For example, Christopher and Peck (2004) conceptualize supply chain resilience as a multidimensional formative construct consisting of supply chain (re)engineering, supply chain collaboration, agility, and the creation of a risk management culture. Alternatively, Craighead et al., 2007 conceptualize supply chain resilience as the combination of warning and recovery capabilities. Conversely, Blackhurst et al. (2011) detail resilience resources from the perspective of human resources, organizational and inter-organizational resources, and physical capital resources. More recently, Ambulkar *et al.,* 2015 conceptualize supply chain resilience as the combination of resource

reconfiguration capabilities and the existence of a risk management infrastructure. Thus, these aforementioned examples serve to demonstrate that there has been substantial progress made in the conceptual identification of key resources that contribute to the development of the underlying multi-dimensional components of supply chain resilience. However, despite this substantial progress, the method through which these key supply chain resilience resources can become embedded in a firm's supply chain operations are still unclear. Therefore, conceptual supply chain resilience literature is commonly criticized as lacking on providing managerial guidance on how to acquire resilience resources (Bode *et al.,* 2011; Blackhurst *et al.,* 2011; Ambulkar *et al.,* 2015). Thus, the current stance of extant supply chain resilience literature implies that firm can/should acquire supply chain resilience resources through building them from the ground up (with little guidance on how to build them up), rather than leveraging potentially existing firm resources. Therefore, it is in this context that this research study is contextualized. Specifically, we address this research gap by positing that firms can acquire resilience in their supply chain operations through leveraging resources acquired by other initiatives undertaken by the firm. Specifically, we posit that firms can acquire supply chain resilience through the leveraging of resources acquired from the implementation of Quality Management Systems (QMS). While there have been prior researchers that have noted several conceptual overlaps between supply chain management and QMS (such as Yeung, 2008 and Kern et al., 2012), this idea has not been developed further.

Thus, there are three main objectives to this research study: to highlight contemporary conceptual understandings of QMS, (2) to highlight contemporary conceptual understandings of supply chain resilience frameworks, and (3) to demonstrate the conceptual points of convergence between QMS and supply chain resilience, and, through utilizing the cumulative capabilities framework, demonstrate how the implementation of QMS can lead to the acquisition of supply chain resilience resources. The aforementioned objectives are formalized in the following research question:

***RQ**: What is the relationship between Quality Management Systems and Supply Chain Resilience?*

In doing the aforementioned research objectives, this conceptual note makes three noteworthy contributions. First, building on the existing literature base and the cumulative capabilities framework, this study details how resources acquired from the implementation of QMS may be an alternative and more powerful approach to acquiring supply chain resilience, as opposed to building resilience from the ground up. In reference to prior research, this is a significant gap and important issue that needs to be addressed. For example, Blackhurst *et al.,* (2011) mention in the conclusion of their study that "the literature on how to increase resiliency is fragmented and provides a more general overview of supply resiliency." Similarly, Bode *et al.,* (2011), note that "to date, little attention, however, has been devoted to the strategic behavior that firms employ in the wake of supply chain disruptions." In addition to the aforementioned examples, several supply chain risk and resilience management scholars note the lack of significant managerial guidance in to how managers can acquire resilience in their supply chain operations. Second, this study contributes to the established literature on quality management. Most studies examine the benefits of QMS implementation by linking them to various metrics of operational and financial performance (Nair, 2006). To the best of the authors' knowledge, this is the first study that explicitly details supply chain resilience as a benefit of the implementation of QMS. Third, this study contributes to the theoretical development of Cumulative Capabilities framework. With minimal variations, most versions of the Cumulative Capabilities framework include the traditional cost, quality, delivery, and flexibility metrics. Thus, in this study, a compelling case is made as to why resilience may be included in the Cumulative Capabilities framework.

This paper is organized as follows. The next section details a literature background that highlights the current conceptual developments in QMS, and Resilience. In section 3, we introduce the cumulative capabilities framework, and then develop six research propositions that demonstrate how the implementation of QMS contributes to Supply chain resilience. In section 4, we conclude with a discussion on theoretical and managerial implications, as well as providing several avenues for future research opportunities.

LITERATURE BACKGROUND

The focus of our literature review is the research domains of supply chain resilience and QMS. As these research domains span several fields of academic research and encompass several methodologies, this study constrains the literature review in the following ways. First, we restrict the literature search to the top academic journals within the disciplines of operations management, supply chain management, and logistics. This list includes the following journals: *Production and Operations Management Journal, Journal of Operations Management, Decision Sciences Journal, Journal of Supply Chain Management, Journal of Business Logistics, International Journal of Operations and Production Management, International Journal of Physical Distribution and Logistics Management, International Journal of Production Research, International Journal of Production Economics, Supply Chain Management: An international Journal, and International Journal of Logistics Management.*

Second, we constrain the literature search only to those studies whose main objective is to detail the conceptual dimensions of QMS and supply chain resilience. Thus, we omit empirically and analytically based studies, as these studies rely on the conceptual studies for the development of their empirical frameworks. Third, we constrain the literature review to those articles in which QMS and supply chain resilience are the primary consideration. Thus, we omit studies that consider tangentially related topics. For example, we only include supply chain agility and supply chain visibility studies if they are mentioned as underlying dimensions of supply chain resilience. We place similar constraints on the QMS literature review. Finally, we examine studies from the perspective of the firm's internal supply chain, i.e., the elements of supply chain processes that either within the firm's domain of control or within the interaction of the firm and directly connected supply chain partners. This is in line with the Supply Chain Operations Reference (SCOR) conceptualization of supply chain (Swafford *et al.,* 2006; APICS-Supply Chain Council 2017). Thus, we omit studies that examine resilience from an extended supply chain perspective, such as studies that examine resilience from a larger supply chain network that consists of second and third tier suppliers and customers. In the following subsection, we detail the literature review that highlights the significant contributions to the conceptual developments of supply chain resilience.

Quality Management

In this section, we detail the significant conceptual contributions behind QMS frameworks. However, we point out with emphasis that as quality management has been extensively studied for the past two decades, it has developed into a mature field, whereby QMS have sound definitional and conceptual foundations, with substantial agreement regarding what the key quality management practices are (Sousa and Voss, 2002). Though there are new developments in QMS, the basic tenets remain the same (Zhang and Xia, 2013). The conceptual QMS framework detailed by Flynn *et al.,* (1994) draws parallels from the hitherto criteria of the Malcolm Baldrige National Quality Award, and contains seven interrelated dimensions, namely: Top management support, quality information, process management, product development, workforce management, supplier involvement and customer involvement. These basic elements have varied very little over time, and have been used by subsequent researchers, as detailed in Table 2 below. Extensions of the aforementioned QMS framework include; a greater emphasis on the supplier and customer relationship function in order to emphasize quality management within the paradigm of supply chain management (Foster, 2008; Kaynak and Hartley, 2008), and new developments in process improvement strategies such as Six Sigma. Six Sigma builds on the foundation of established QMS principles, and provides three major extensions, namely, (1) the use of structured methods of project selection and process improvement, (2) a heavy emphasis on process improvement metrics, and (3) well defined process improvement specialist roles supported with extensive training (Zu *et al.,* 2008; Schroeder *et al.,* 2008; Shafer and Moller, 2012). Thus, these idiosyncratic elements are incorporated into the following discussion on the dimensions of QMS.

Flynn *et al.,* (1994 p. 342) define quality management as "an integrated approach to achieving and sustaining high quality output, focusing on the maintenance and continuous improvement of processes and defect prevention at all levels and in all functions of the organization, in order to meet or exceed

customer expectations." As evidenced from this definition, assuring high quality output on a consistent basis requires the acknowledgement that quality management cannot be dealt with on an ad-hoc basis, but must involve the implementation of a holistic management philosophy that fosters all functions of an organization through continuing improvement and organizational change (Kaynak and Harltey, 2005; Sroufe and Curkovic, 2008; Kim *et al*., 2012).

TABLE 1
SAMPLE OF ARTICLES DELINEATING THE DIMENSIONS OF QUALITY MANAGEMENT

QMS Dimension	QMS Dimension Description	Citations
Top Management Support	The creation of quality goals, strategies, and evaluation criteria, as well as the allocation of resources to support them.	Flynn et al., 1994; Beserfield et al., 2003; Kim et al., 2012
Product Development	Cross functional, supplier, and customer involvement in product/service design.	Flynn et al., 1994; Schroeder et al., 2008
Supplier Quality Management	The prioritization of quality as a supplier selection criterion, and involvement of suppliers in key firm-level decisions.	Deming, 1986; Ahire et al., 1996; Foster, 2008;
Customer Focus	The Prioritization of customer specifications in product development and the creation of long-term relationships with valuable customers.	Schroeder et al., 2008; Kim et al., 2012
Quality Information	The collection of comprehensive and fine-grained data for the utilization in problem detection, resolution and process redesign.	Flynn et al., 1994; Molina et al., 2007; Kaynak & Hartley 2008; Zu et al., 2008; Schroeder et al., 2008; Kim et al., 2012
Process Management	Leveraging of information about organizational routines in order to ensure processes have minimal downtimes, and to redesign new, more effective routines.	Samson & Terziovski, 1999; Kim et al., 2012; Swink & Jacobs, 2012
Employee Relations	Providing employees with quality-orientated training, and empowering employees to make and execute decisions with respect to problem resolution and process re-design.	Flynn et al., 1994; Samson & Terziovski, 1999; Kaynak & Hartley, 2008; Schroeder et al., 2008; Shafer & Moller, 2012; Iyer et al., 2013

Top Management Support

Top management support is essential for the implementation of all strategic initiatives within the organization. The implementation of QMS systems is no different, as it requires corporate-wide cultural changes, as well as tremendous resource support (Deming, 1986) As top management is instrumental in developing a clear strategy for identifying the direction of the organization, it plays a key role in (1), the establishment of quality goals and strategies, (2) setting standards for the evaluation of quality performance for the employees within the organization, and (3) cultivating a work environment that fosters the growth of a quality-oriented culture within the employees of the organization that emphasizes the trusting, rather than controlling, of employees (Flynn *et al.,* 1994; Besterfield *et al.,* 2003; Kim *et al.,* 2012). Moreover, top management is also responsible for the allocation of resources needed to implement quality management initiatives (Yeung *et al.,* 2005)

Employee Relations

As with top management support, QMS are critically dependent on successful workforce management. QMS put strong emphasis on placing the responsibility of quality on all employees and all departments in an organization (Kim *et al.,* 2012). Thus, to effectively implement QMS, an organization needs to allocate resources that provide employees with training related to quality management (Flynn *et al.,* 1994; Samson and Terziovski, 1999; Kaynak and Hartley, 2008; Schroeder *et al.,* 2008). This emphasis on quality-oriented training is reinforced in Six Sigma process improvement initiatives, in which Six-Sigma projects are driven by extensively trained process improvement specialists (Zu *et al.,* 2008; Schroeder *et al.,* 2008; Shafer and Moller, 2012). Employee training also occurs during the implementation of QMS. As employees pursue initiatives to implement quality management processes, their knowledge about processes increases, thereby increasing their ability to identify process-related problems, bring processes under control, and identify opportunities for improvement (Kim *et al.,* 2012; Iyer *et al.,* 2013). Moreover, investments in quality-oriented training achieve their maximum potential through employee empowerment in decision-making and execution. Employee empowerment is important, as effective QMS implementation relies on the ability to detect and solve problems as close to the source as possible (Flynn *et al.,* 1994). Thus, managers should trust employee decisions and actions rather than implement strict controls (Besterfield *et al.,* 2003) as employees are often closer to the problem areas and can take action in a timelier fashion.

Process Management

Effective process management forms a central tenet of QMS. In fact, quality management is often synonymous with process improvement. Drawing heavily from the notion that organizations are sets of interlinked processes, QMS emphasize that firm capabilities can be greatly enhanced through effective design and management of processes (Samson and Terziovski, 1999; Kim *et al.,* 2012). At a foundational level, effective process management consists of preventive maintenance and agile strategies that ensure organizational routines operate as expected with minimal downtime, all while documenting best practices (Flynn *et al.,* 1994). Kim *et al.,* (2012) note two important activities in effective process management: (1) repeating routines, through which processes with their outcomes are identified, and (2) enhancing processes, in which through the documentation of process, best practices may be identified and be applied to process innovation. These activities may result in the designing of new, more effective routines (Schroeder *et al.,* 2008).

Product Development and Customer Focus

Product development plays an important role in QMS, as design weaknesses are a major source of product failure with significantly high external failure costs. Moreover, sound product ensures that products designed meet or exceed the needs and desires of customers better than competitors (Flynn *et al.,* 1994). Thus, in addition to sound product engineering, a critical component of product development in QMS involves the inclusion of the voice of the customer into the product design phase, with a heavy emphasis on customer requirements as critical-to-quality metrics (Schroeder *et al.,* 2008). Additionally, QMS emphasize the involvement of all departments of the organization in product development processes. In particular, the engineering department cannot be solely responsible for product design (Kim *et al.,* 2012). Thus, sound product development also requires the development of infrastructural resources and the cultivation of relationships both at the intra and inter-organizational level that facilitate the acquisition of customer requirements and disseminate these specifications to the relevant parties responsible for product development.

Similarly, a customer focus in quality management systems involves leveraging relationships with customers. Customer requirements are key criteria in determining product/service specifications, and also form the baseline for process improvement metrics in six sigma projects (Schroeder *et al.,* 2008; Kim *et al.,* 2012). Thus, creating relational and structural links that prioritize customer requirements and ensuring that customer needs are disseminated throughout the entire organization are essential components of QMS (Flynn *et al.,* 1994; Samson and Terziovski, 1999).

Quality Information and Analysis

Quality information and analysis refers to the provision of timely and accurate information about the status of processes (Flynn *et al.,* 1994). Reliable information on processes aids in the ability to keep processes in control, and in identifying potential problems (Molina *et al.,* 2007). As QMS emphasize problem detection and resolution as close to the source as possible, emphasis is placed on the collection of detailed, exhaustive, low-level data at each process execution phase, and the systematic collection of data at every phase in the problem solving cycle. Data that are both comprehensive and fine-grained facilitate easier identification of critical problems, analysis of root causes, and meticulous generation of solutions (Kaynak and Harltey, 2008; Zu *et al.,* 2008). Thus quality information plays an important role in the improvement of current process configurations and/or process redesign for the generation of new, enhanced process configurations (Schroeder *et al.,* 2008; Kim *et al.,* 2012).

Supplier Quality Management

Managing quality with respect to suppliers is an important part of QMS, as raw materials and other purchased parts are often considered a source of quality problems (Flynn *et al.,* 1994; Foster, 2008). Thus prioritizing quality as a supplier selection criterion is an important foundational step in the assurance of quality (Ahire *et al.,* 1996). Additionally, product quality can be enhanced through the formation of long-term relationships with suppliers based on loyalty and trust (Deming, 1986). These relationships may be leveraged to acquire high quality raw materials at discounted rates. Additionally, long-term relationships with suppliers may be leveraged to facilitate joint innovation and expertise that may not otherwise have been developed in arms-length types of relationships (Lemke *et al.,* 2003; Dyer and Singh, 1998).

Supply Chain Resilience

In this section, we highlight key conceptual advancements in the Supply Chain Resilience literature domain. While there is significant conceptual clarity regarding QMS, conceptual developments in supply chain resilience are still in their nascent phase. Earlier research on supply chain risk mitigation consisted of efforts to identify and categorize supply chain risks as an initial step to manage these risks (e.g. Kleindorfer and Saad, 2005; Cucchiella and Gastaldi, 2006; Blackhurst *et al.,* 2008). However, as detailed by Sodhi *et al.,* (2012) researchers approach risk categorization from widely different perspectives. While, there is a general consensus of categorizing risks based on supply side, operational side, and demand side risks (e.g. Bogataj and Bogataj, 2007; Tang and Tomlin, 2008), there are additional dimensions proposed that may include, but not limited to, environmental (Jüttner *et al.,* 2003; Rao & Goldsby 2009), informational risks (Spekman and Davis, 2004), and security (Manuj and Mentzer, 2008; Williams *et al.,* 2008). Furthermore, extensions of traditional risk management approaches to the supply chain level face significant limitations, as they may not be able to adequately deal with unforeseeable events, and prove difficult to do risk assessments (Pettit *et al.,* 2010). Thus, supply chain resilience provides a more holistic approach to managing supply chain risks, due to a lower reliance on the risk identification & quantification process (Scholten *et al.,* 2014).

Ponomarov and Holcomb (2009 p. 131) define supply chain resilience as "the adaptive capability of a firm's supply chain to prepare for unexpected events, respond to disruptions, and recover from them in a timely manner by maintaining continuity of operations at the desired level of connectedness and control." Thus, resilience is a comprehensive approach to managing risks in supply chains that entails re-designing and/or reconfiguring the supply chain in such a manner that it has proactive elements that detect and avoid potential disruptions, and reactive elements that detect actual disruptions and quickly recover from them (Blackhurst *et al.,* 2005; Speier *et al.,* 2011; Wieland and Wallenburg, 2013). Taking the aforementioned points into account, our discussion on supply chain resilience resources focuses on (1) the proactive and reactive elements of managing risks and disruptions, and (2) the structural and behavioral features of a firm's supply chain that characterize enable the proactive and reactive elements of supply chain resilience.

Proactive elements of supply chain resilience refer to the existence of supply chain resources that enhance the ability to detect a pending disruption, disseminate the information to relevant entities within

the supply chain, and coordinate a disruption-avoidance response (Craighead *et al.,* 2007; Scholten *et al.,* 2014). Thus, flexible and agile capabilities commonly identified as key enhancers of supply chain resilience. Flexible and agile capabilities refer to the ability to reconfigure resources with minimal transition times and cost penalties (Koste and Malhotra, 1999; Bernardes and Hanna, 2010). Thus, possession of these capabilities enhance the ability to reconfigure resources within the organization or with the firm's supply base in order to avoid potential disruptions (Christopher and Peck, 2004; Pettit *et al*., 2010; Ambulkar *et al.,* 2015).

However, the deployment of flexible and agile capabilities would only be effective in avoiding disruptions with the existence of the ability to detect impending disruptions. Consequently, supply chain visibility plays a key role in enhancing proactive responses to disruptions. Visibility is defined as "the extent to which actors within a supply chain have access to or share information which they consider as key or useful to their operations and which they consider will be of mutual benefit" (Barratt and Oke, 2007 p.1218). Achieving visibility requires the generation of infrastructural resources that facilitate both the collection and transmission of information to relevant supply chain partners. Thus, in the context of resilience, supply chain visibility enhances the ability of organizations to identify the location of resources and potential risks, and increases the ability to understand how potential disruptions propagate throughout the supply chain (Speier *et al.,* 2011; Blackhurst *et al.,* 2011; Brandon-Jones *et al.,* 2014). This enhanced ability to detect potential disruptions allows for preventative measures to be taken before the disruption occurs.

Beyond structural characteristics of the supply chain, the human element also plays a key role in enhancing the proactive elements of resilience. The human element is important because organizations respond not to objective assessments of risks, but to perceptual assessments (Zsidisin and Wagner, 2010; Zsidisin, 2003). Furthermore, researchers note that there are multiple valid supply chain design strategies associated with mitigating specific types of risk (Habermann *et al.,* 2015). Thus, different organizations may respond to the same nominal risk in different ways with varying degrees of effectiveness (Ellis *et al.,* 2011). These concerns may be addressed via investments made to increase the employee understanding of the supply chain configuration. This increased understanding of the supply chain configuration allows for the ability to detect potential vulnerabilities in current configurations, as well as detect potential disruptions with increased precision (Ellis *et al.,* 2011). Additionally, through a good understanding of the supply chain, employees may be able to redesign the supply chain with resilience as an embedded capability (Christopher and Peck, 2004; Blackhurst *et al.,* 2011; Scholten *et al.,* 2014).

Employee understanding of the supply chain may be increased via managerial investments in training programs that (1) promote the breadth and depth of employee knowledge of internal processes and the nature of the external environment (Braunscheidel and Suresh, 2009; Ellis *et al.,* 2011), (2) endorse a willingness to learn from past disruptions in order to develop better preparedness for future events (Bode *et al.,* 2011; Scholten *et al.,* 2014), and (3) aid in reducing the complexity of the interactions in the supply chain (Vorst and Beulens, 2002; Skilton and Robinson, 2005; Ponomarov and Holcomb, 2009).

Ultimately, behavioral elements also play a key role in enhancing proactive responses to disruptions. The formation of relationships play a key role in enhancing supply chain visibility because supply chain relationships increase the willingness to make sensitive information visible to partners (Cousins and Menguc, 2006; Wieland and Wallenburg, 2013). Intra-firm relationships, established via the pursuit of cross-functional integration and the elimination of the "silos mentality" reduce the possibility of sub-optimization occurring when functional groups act independently (Blackhurst *et al.,* 2011). Similarly, inter-firm relationships between organizations and their supply chain partners may result in idiosyncratic knowledge-sharing routines and complementary capabilities (Dyer and Singh, 1998). These shared resources and capabilities may enhance flexibility and agility at the supply chain level, due to an enhanced ability to develop coordinated responses to potential disruptions (Gligor and Holcomb, 2012). They may also be leveraged to redesign inter-firm processes for increased resilience.

The structural and behavioral elements that enhance the proactive components of supply chain resilience also play a role in enhancing the reactive components of resilience. The reactive elements of supply chain resilience refer to the extent to which resources and processes can be deployed after a

disruption has occurred in order to minimize the impact of the disruption as well as enhance rapid recovery (Craighead *et al.,* 2007; Bhamra *et al.,* 2011; Wieland and Wallenburg, 2013). Flexible and agile capabilities may be utilized in a post-disruption situation to initiate disruption-recovery processes that minimize downtimes, or to quickly realign resources in a manner that diverts business processes away from disrupted supply chain entities (Ambulkar *et al.,* 2015). Visibility also plays a role in post-disruption situations, as it allows for (1) quicker tracing of resources that were impacted by the disruptions, and (2) faster dissemination of disruption related information to relevant supply chain partners thereby minimizing the time it takes to begin the disruption recovery process (Blackhurst *et al.,* 2005; Skilton and Robinson, 2005; Scholten *et al.,* 2014).

The behavioral elements as well play a key role in reactive responses to disruptions. In particular, the knowledge sharing routines and complementary capabilities acquired from the development of intra/inter-firm relationships may enhance the ability to communicate and also to execute coordinated disruption recovery plans in a timely manner. Further, investments in increasing the breadth and depth of employee knowledge may play a role in enhancing rapid recovery from disruptions, as their process knowledge may allow them to recognize disruption affected resources in a timelier manner. This process knowledge may also result in reduced times to develop and implement disruption recovery plans (Christopher and Peck, 2004; Scholten *et al.,* 2014).

The development of supply chain resilience requires tremendous investments in infrastructural, human, organizational and inter-organizational capital (Blackhurst *et al.,* 2011). Thus, successful implementation of supply chain resilience largely relies on the recognition of its importance by top managers. Top management support is essential to establishing a supply chain disruption orientation, as well as allocating resources required to develop supply chain resilience resources (Christopher and Peck, 2004; Bode *et al.,* 2011). Thus, having reviewed pertinent dimensions of supply chain resilience, the upcoming section details how the development of QMS plays a foundational role in the acquisition of both the proactive and reactive elements of resilience.

A FRAMEWORK FOR LINKING QMS WITH RESILIENCE

Cumulative Capabilities

The Cumulative Capabilities framework is a theory on performance improvement in manufacturing companies that was developed in response to the tradeoff theory, which suggested that firms cannot achieve high levels of performance on multiple competitive priorities simultaneously (Slack, 1991). Specifically, the tradeoff theory suggested that firms cannot compete simultaneously on cost, quality, dependability and flexibility, as an improvement in one area necessitates a decrease in another (Skinner ,1969). However, the tradeoff theory came under increased scrutiny, when it was noted in the 1980s that high performing Japanese manufacturers were able to compete on multiple competitive capabilities simultaneously (Nakane, 1986). Thus, the Cumulative Capabilities framework posits that manufacturing performance does not tradeoff, but is cumulative, i.e., firms are able to achieve improvements on multiple fronts because the improvements re-inforce each other (Schroeder *et al.,* 2011).

Moreover, the improvements on multiple capabilities occur when they are pursued in a specified sequence. These capabilities are layered upon each other, therefore certain trajectories of improvement are more effective than others (Flynn and Flynn, 2004). The most commonly cited sequence is the sand cone model of Ferdows and De Meyer (1990), which links quality performance as the foundation, leading to improvements in dependability, leading to improvements in speed, with the final improvements occurring in cost efficiency. While several optimal sequences have been proposed (Schroeder *et al.,* 2011), there is a general consensus that quality forms the foundation of the sequences. The notable exception is the sequence proposed by Hall and Nakane (1990) that has company developed culture as its foundation. However, company developed culture has been integrated into QMS frameworks.

The mechanism through which capabilities are accumulated sequentially relies on the notion that the acquisition of each capability facilitates organizational learning in a path dependent fashion (Roth, 1996). Thus, as the organization advances in the proposed progression of cumulative capabilities, operational

know-how and capabilities are expanded because each stage in the progression sequence calls for increasingly higher levels of process knowledge, integration and co-ordination (Rosenzweig and Roth, 2004). For example, operational know-how and capabilities that are derived from the implementation of quality management initiatives results in greater understanding of the nature of the processes and capabilities of the organization. The resultant understanding of processes and newly acquired capabilities are then utilized to expand further, increasing performance in dependability and speed, and ultimately, towards efforts to develop cost efficiencies. Since capabilities are acquired in a cumulative, path dependent fashion, they are more likely to be firmly embedded in the organization's processes in an inter-related manner. Thus, this manner of process improvement is more likely to lead to long-term improvements, when compared to capabilities built from the ground up and/or at the expense of other capabilities (Noble, 1995; Amaoko-Gyampah and Meredith, 2007).

Drawing from the arguments set forth by this framework, this study posits that supply chain resilience is a capability can be developed in a path dependent fashion, through the leveraging of resources, operational know-how, and capabilities that have been acquired as a result of the implementation of QMS. This premise is explicitly further expounded on in the following section through detailing how each conceptual QMS dimension relates to specific dimensions of supply chain resilience.

Employee Relations

As discussed earlier, employee training and employee empowerment are two essential components of effective workforce management in QMS due to the emphasis on having problem detection and problem solving as close to the source as possible. These facets play a role in enhancing an organization's resilience in key ways. First, employee training about problem detection and process improvement techniques greatly enhances the understanding and configuration of the organization and its supply chain. Thus, trained and empowered employees are better positioned to detect vulnerabilities in current supply chain configurations, and re-design these processes to exhibit the resilience principles of flexibility and agility, thereby enhancing the proactive responses to disruptions. Further, knowledgeable and empowered employees can utilize their knowledge to trace resources affected by disruptions, and implement disruptions recovery plans quicker, relative to an organization that relies on more centralized decision-making.

Taken together, drawing from the path-dependent acquisition of capabilities, as denoted by the cumulative capabilities framework, we posit that the QMS emphasis of employee training and empowerment plays a role in enhancing supply chain resilience, through increased ability to redesign supply chain processes with embedded resilience capabilities, increased ability to detect vulnerabilities in current supply chain configurations, and through the reduced time it takes to implement disruption recovery plans upon disruption detection. Thus:

> Proposition 1: QMS investments in employee training and empowerment are positively associated through the increased ability to redesign processes, detect vulnerabilities and trace disruptions.

Process Management

In summary, effective process management in QMS consist of developing strategies to ensure organizational routines operate as expected with minimal breakdowns using preventive maintenance strategies, documenting and incorporating best practices, and utilizing this tacit knowledge to design new, more effective processes. The assurance of operating with minimal disruptions in planning and scheduling operations is a major tenet of supply chain resilience. Thus, these business continuity principles extend towards maintaining supply chain processes in the face of potential and/or actual disruptions. In addition, the identification of best practices through the implementation of effective process management techniques may result in increased understanding of the configuration of the supply chain. Thus, the organization is better positioned to respond to disruptions because employees are better equipped to understand vulnerabilities, trace disruptions faster, and design and implement appropriate recovery plans

in a timelier manner. Additionally, this knowledge base may be leveraged to redesign new, more effective process configurations that also exhibit the resilience principles of flexibility and agility. Ultimately, this understanding of process built from QM oriented praxis may enhance the ability of the organization to reconfigure and redeploy resources such that the effect of disruptions on operations may be effectively mitigated.

Taken together, drawing from the perspective of the cumulative capabilities framework which suggests that capabilities are acquired in a cumulative and path-dependent fashion, we posit that the acquisition of knowledge and capabilities as a result of pursuing process management strategies will significantly enhance a firm's flexibility and agility resilience capabilities in their supply chain operations.

Thus,

> Proposition 2: QMS investments in process management strategies are positively associated with supply chain resilience through increased ability for process redesign, increased vulnerability detection capabilities, and increased disruption traceability.

Product/Service Development and Customer Focus

In order to effectively implement product/service development and acquire a customer focus, QMS emphasizes, (1) involving the customer during the product development phase, (2) utilizing customer requirements as key critical-to-quality metrics when designing products/services, and (3) facilitating cross-functional communication and cooperation such that all departments of the organization are involved in product design. Thus, the implementation of QMS-oriented product development involves the creation of resources that enhances supply chain resilience in key ways. First, the pursuit of cross-functional involvement creates of managerial incentives and infrastructural links that facilitate communication between departments. Cross-functional co-operation is also enhanced via the cultivation of relationships between departments within the organization in order to eliminate the 'silos' mentality. These infrastructural and relational links between departments increase the ability within the organization to exchange information about potential and/or actual disruptions. As organizational processes are inherently interdepartmental, cross-functional cooperation may also enhance the organization's ability to implement coordinated responses to potential/actual disruptions. These arguments may be extended beyond firm boundaries to inter-firm links with customers. Creating infrastructural and relational links with customers creates a foundation of resources that allow for faster dissemination of disruption-related information, an augmented ability to develop coordinated responses to disruptions, as well as facilitating joint innovation of inter-firm processes that exhibit resilience principles.

Taken together, drawing from the perspective of the cumulative capabilities framework which suggests that capabilities are acquired in a cumulative and path-dependent fashion, we posit that the acquisition of knowledge and capabilities as a result of QMS related product/service development and Customer focus strategies, will significantly enhance a firm's visibility and collaboration resilience capabilities in their supply chain operations.

Thus:

> Proposition 3 (a): QMS-related product development strategies are positively associated with supply chain resilience through increased cross-functional visibility and collaboration.
>
> Proposition 3 (b): QMS-related strategies to acquire a customer focus are positively associated with supply chain resilience through increased inter-firm visibility and collaboration.

Quality Information

Quality information and analysis in QMS relates to the emphasis on collecting information about process capabilities and status, with a heavy emphasis on collecting as detailed information as is possible, and as close to the source as possible. The net result is the generation of infrastructural resources that enhance system-wide visibility, as well as a resulting increased understanding of organizational processes.

Evidently, these resources may play a role in enhancing supply chain resilience. As disruptions may be one of several causes of process abnormalities, status monitoring of processes may increase the speed and precision with which disruptions may be detected, with the benefit of reducing the time it takes to implement disruption recovery plans. Moreover, the information gathered as a result of status monitoring processes may reveal the existence of vulnerabilities and potential threats, thereby improving the ability to generate proactive responses. Additionally, this information may be utilized as an aid while redesigning processes in order to minimize and/or eliminate vulnerabilities, as there is an increased ability to compare the efficacy of processes before and after redesign.

Taken together, drawing from the perspective of the cumulative capabilities framework which suggests that capabilities are acquired in a cumulative and path-dependent fashion, we posit that the acquisition of knowledge and capabilities as a result of QMS related quality information initiatives, will significantly enhance the firm's visibility resilience capability in their supply chain operations.

Thus:

> Proposition 4: QMS investments in quality information and analysis, through the increased ability to detect and communicate vulnerabilities and threats positively contribute to the acquisition of supply chain resilience.

Supplier Quality Management

Supplier Quality Management in QMS systems involves (1) the prioritization of quality as a supplier selection criteria, (2) supplier development processes, and (3) the development and maintenance of relationships with suppliers that are characterized by knowledge-sharing routines and complementary capabilities. Thus, effective supplier quality management in QMS results in the generation of infrastructural resources and relational linkages that facilitate communication and cooperation with suppliers. These resources may enhance supply chain resilience in three ways. They may be utilized to disseminate pertinent information about potential and/or actual disruptions between organizations and their suppliers and second, they may enhance the ability to generate coordinated responses to interfirm disruptions. Ultimately, relationships between organizations and their suppliers may be leveraged for joint innovation of processes that exhibit the resilience principles of flexibility and agility.

Taken together, the pursuit of supplier quality management initiatives in QMS plays a role in enhancing supply chain resilience through the generation of infrastructural resources and relational linkages between organizations and suppliers that may be leveraged to (1) mitigate supply-side risks, (2) disseminate information about potential disruptions, (3) trace actual disruptions and implement coordinated disruption recovery plans easier and faster, and (4) facilitate joint inter-firm process innovation for redesigning more resilient processes.

Taken together, drawing from the perspective of the cumulative capabilities framework which suggests that capabilities are acquired in a cumulative and path-dependent fashion, we posit that the acquisition of knowledge and capabilities as a result of QMS related Supplier Quality Management initiatives, will significantly enhance a firm's visibility and collaborative supplier responsiveness, thereby enhancing the resilience capabilities in their upstream supply chain operations.

Thus:

> Proposition 5: Through increased inter-firm visibility and collaboration, supplier quality management strategies are positively associated with supply chain resilience.

Top Management and Leadership

Top management support is important in the implementation of QMS through their fostering of a quality oriented culture within the organization, establishing reward structures related to quality outcomes, and in allocating resources. These resources may be used for the purposes of employee training, resources for the acquisition of structures that enhance quality information, process management. Thus, the relationship between top management support in QMS and supply chain resilience is indirect,

albeit significant, because top management is responsible for the allocation of QMS resources that enhance supply chain resilience. Additionally, fostering a quality oriented culture, and creating quality-oriented performance evaluations play a role in the acquisition of behavioral resources that enhance supply chain resilience.

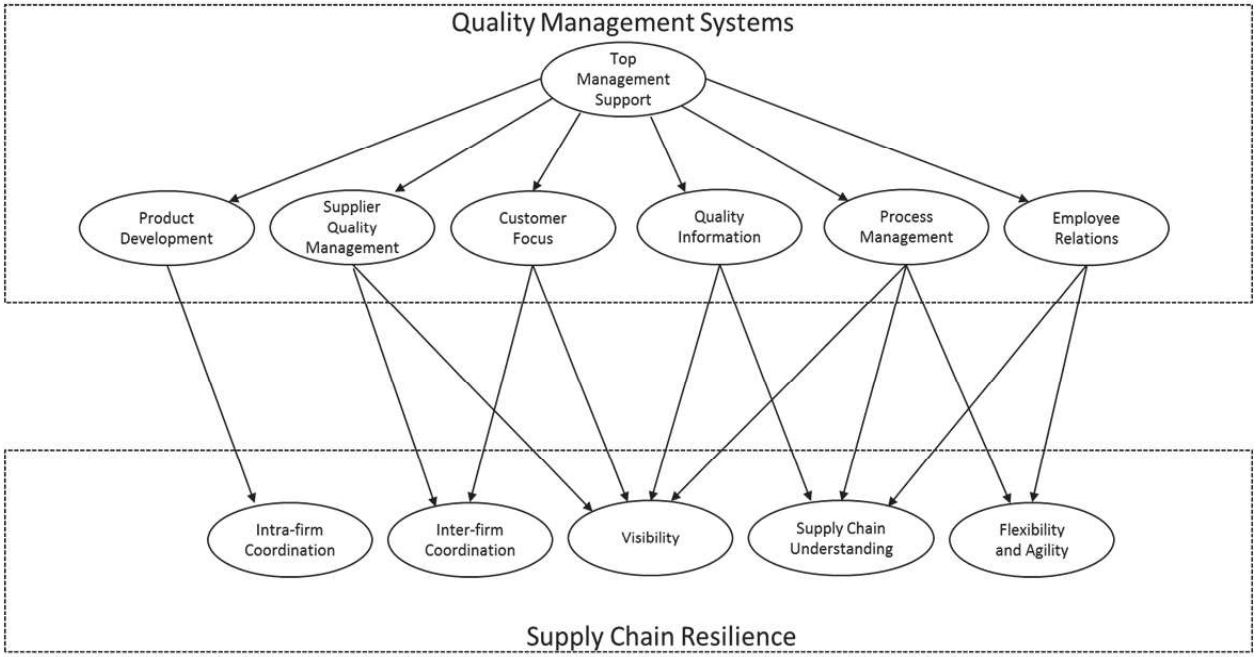
Thus:

> Proposition 6: Top management support for QMS implementation is indirectly and positively associated with supply chain resilience.

CONCLUSION

Building on prior studies, the purpose of this study was to conceptually advance a supply chain resilience framework that details how supply chain resilience can be acquired in a path dependent fashion based on resources and capabilities that have been acquired as a result of QMS implementation. Building on the underlying dimensions of supply chain resilience identified in the literature, and the significant conceptual overlap between QMS and supply chain resilience, this study utilizes the rationale of the cumulative capabilities framework to develop six propositions that detail how QMS implementation develops a strong managerial, structural and behavioral foundation through which supply chain resilience may be acquired and/or enhanced. Figure 1 below details the salient features of the relationship between QMS dimensions and supply chain resilience.

FIGURE 1
SUMMARY OF THE RELATIONSHIP BETWEEN QMS AND SUPPLY CHAIN RESILIENCE



Theoretical Contributions

Though largely conceptual, this study makes noteworthy contributions to three different literature streams. First, it contributes to the conceptual developments of supply chain resilience frameworks. While there have been significant advancements in conceptual advancements in supply chain resilience, most studies develop resilience frameworks by identifying and isolating a set of strategies, practices and resources that contribute to resilience (Bode *et al.,* 2011; Blackhurst *et al.,* 2011; Ambulkar *et al.,* 2015).

In this study, an alternative and novel view, which complements current literature by suggesting that supply chain resilience may be acquired indirectly through the implementation of QMS, is presented. Furthermore, as the cumulative capabilities framework suggests, since supply chain resilience is acquired in a cumulative fashion, it is likely to be a lasting embedded capability within the supply chain. Second, this study contributes to the quality management literature stream. Empirical research on quality management typically link the benefits of QMS implementation to various metrics of operational and financial performance (Nair, 2006) with a few studies linking QMS to organizational learning (Rosenzweig and Roth, 2004; Molina *et al.,* 2007), innovation (Kim *et al.,* 2012), and productivity (Iyer *et al.,* 2013). To the best of the authors' knowledge, this is the first research article that suggests supply chain resilience is developed in consonant with the implementation of QMS**.** Third, this study contributes to the theoretical development of cumulative capabilities theory. Literature detailing and testing the cumulative capabilities theoretical model traditionally only consider quality, cost, delivery and flexibility. Some researchers include innovation (Noble, 1995), dependability (Flynn and Flynn, 2004) and other variations of the sequence such as quality, dependability, flexibility, and cost (Swink and Way, 1995). In this study, resilience is presented as a capability enhanced through QMS. While it is not explicitly specified where resilience falls in the sequence, as it is beyond the scope of this study, a compelling case has been nonetheless made for its inclusion in the cumulative capabilities sequence.

Practical Implications

The propositions developed may aid and enhance the practitioner's understanding on an effective means through which Supply Chain Resilience can be acquired. In particular, the developed propositions suggest that through the implementation of QMS systems, firms have already acquired resources and capabilities necessary to achieve Supply Chain Resilience. Thus, given that extant literature provides significant empirical evidence of the operational and performance benefits of the QMS implementation (Nair, 2006), the propositions detailed in this study suggest that managers continue to implement QMS systems and leverage the resources acquired from this implementation, rather than trying to build supply chain resilience resources completely anew.

Limitations and Opportunities for Future Research

While we are confident that the developed propositions have sound theoretical and logical support, the most evident limitation in this study is the lack of empirical support of the developed propositions. Thus, the most apparent future research opportunity is the empirical validation of the developed propositions.

However, beyond the empirical validation of the developed propositions, there are several opportunities for further research based on this study. The most evident future research opportunity is to further develop the cumulative capabilities framework. In particular, research opportunities exist to conceptually incorporate supply chain resilience into the sequence of quality, delivery, flexibility and cost. In particular, there are sound arguments that supply chain resilience is a capability that can significantly affect all the other capabilities. Secondly, the QMS literature stream details the inter-related nature of each of the QMS elements. For example, the employee relations dimension may be positively associated with quality data, process management, and product/service design (Kim *et al.,* 2012). Thus, future research opportunities exist in detailing how the interrelatedness of QMS dimensions affect the relationship between QMS and resilience. Third, future research studies may enhance the conceptual framework by exploring additional characteristics at the firm, industry or macro level that may affect the relationship between QMS and resilience. For example, studies note that the effectiveness of QMS implementation may vary by firm size, industry, and country (Sila, 2007). Similarly, studies empirically examining the cumulative capabilities framework note salient differences exist at the industry level (Rosenzweig and Roth, 2004) and at the country level (Amaoko-Gyampah and Meredith, 2007). Thus, incorporating these moderating effects into our conceptual framework will facilitate a greater understanding of the relationship between QMS and resilience.

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