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How Does Firm Innovativeness Enable Supply Chain Resilience? The Moderating Role of Supply Uncertainty and Interdependence

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Abstract

Despite its potential benefits in a wide range of circumstances, firm innovativeness received scant attention in relation to managing the various risks and uncertainties in the global business environment. Likewise, there is still a limited understanding of firms' supply chain resilience and its related antecedents in the strategic management literature. This research focuses on exploring the relationship between firm innovativeness and supply chain resilience in an attempt to facilitate bridging the gap between two important research streams and shed some light on the contingent value of firm innovativeness against disruptions and adversities. The moderating role of supply uncertainty and interdependence in the focal relationship was also hypothesized and tested. Findings suggest that firm innovativeness is positively associated with firm supply chain resilience, and supply uncertainty negatively moderates this relationship but interdependence does not. We argue that this could be due to the dual nature of interdependence in supply networks.

Key Words: Firm innovativeness, Environmental uncertainty, Interdependence, Supply chain resilience

1. Introduction

Managers face a number of serious challenges on a daily basis as they deal with various uncertainties and adversities surrounding their operations. Nevertheless, an element of risk and its structural complexity is often undervalued or not taken seriously (Golgeci and Ponomarov 2013). As a result, only a small percentage of firms are prepared to continuously handle adversities and disruptions due to risk situations in the long run. Such an approach leaves many firms vulnerable and weak against the plethora of challenges they face, and their survival becomes threatened in the face of enduring adverse incidents. Consequently, resilience is a subject of great interest to management and strategy scholars (Carmeli and Markman 2011). In fact, interest in resilience has ascended in recent years in the wake of increasing turbulence in the global business environment (Ponomarov and Holcomb 2009). It is especially important in the supply chain context since companies can also benefit from the resilience of their supply chain partners (Ponomarov and Holcomb 2009) and face the risk of deterioration of their organizational resilience if other supply chain members are not resilient.

Previous research indicates that supply chain resilience (SCR) is a relatively new area of supply chain research that is related to risk management (Ponomarov and Holcomb 2009, Pettit, Fiksel et al. 2010). At the same time, it differs from traditional risk management approaches and requires additional exploration and empirical testing. Drawing on previous research that highlights the ignored role of innovativeness in uncertain and risky environments (Bierly, Gallagher et al. 2014), we focus on studying firm innovativeness as one of the hypothesized antecedents of SCR in this research. More specifically, we explore whether and under what conditions firm innovativeness can be leveraged to mitigate and avert adversities and foster a higher level of firm SCR. We subscribe to the recent literature concerning the necessity of such exploration in the face of the very important issue of managing supply

chain disruptions and anomalies as firms around the world are increasingly exposed to disruptions (Bode, Wagner et al. 2011).

Thus, the purpose of this research is to investigate the linkages between firm innovativeness, supply uncertainty, interdependence, and SCR at the firm level of analysis. We seek to uncover the potential role of firm innovativeness in firm SCR under the contingencies of supply uncertainty and interfirm interdependence. While firm innovativeness is viewed as an organizational capability that contributes to firms' SCR, environmental uncertainty and interdependence are hypothesized as moderators of such a relationship. We aim to facilitate bridging the gap between innovation and SCR research streams and intend to contribute to both supply chain management and strategic management literature by exploring the nature of the relationship between firm innovativeness and SCR. We trust that exploring the potential influences of supply uncertainty and interdependence on the relationship between firm innovativeness and SCR can help us to answer the question of how and under what conditions firm innovativeness could be utilized to enhance firm SCR.

Our paper is organized as follows. First, the relevant literature is reviewed through the resource-based view that lays the ground for discussing relevant variables and assists developing our conceptual model. The methodology section is presented next. Finally, the research findings as well as theoretical and managerial implications are discussed, followed by acknowledging limitations and offering future research directions.

2. Theoretical background and hypotheses development

Supply chains and supply chain resilience

For more than two decades, an extensive body of literature has been emerging to study and explain various aspects of supply chain management. Supply chain management (SCM) refers to the

comprehensive and strategic management of business activities (particularly procurement, logistics, production, and marketing) as well as product, service, and information flows across interorganizational boundaries (Mentzer, Stank et al. 2008). Though supply chains extend beyond single firms, supply chain management is a strategic management approach taking place at the firm level that allows the firm to leverage its supply chain for its benefit (Mentzer, Stank et al. 2008). This position is also consistent with a view that SCM is a business model and a function (Simchi-Levi, Kaminsky et al. 2009) rather than a colossal system that no single firm can truly manage singlehandedly. Therefore, a firm's supply chain capabilities, one of which is SCR, can have strategic implications for the firm (Ponomarov and Holcomb 2009, Golgeci and Ponomarov 2013).

Supply chains are systems consisting of numerous actors and processes with different vulnerabilities and risk propensities (Hearnshaw and Wilson 2013) as well as tight couplings and complex interactions between these actors and processes. Accordingly, supply chains become highly susceptible to various risks that could stem from one or more activities or actors (Hearnshaw and Wilson 2013). Thus, it becomes important to develop a better understanding of the resources and capabilities that could be utilized to overcome adversities and disruptions and attain SCR against such disastrous incidents. Resilient capabilities of the networks or supply chains generally translate into increased resilience of their constituents. Therefore, resilience is more meaningful if it is developed, deployed, and utilized by supply chain members jointly rather than through discrete and possibly ineffective efforts of individual firms within a system that includes weak members.

Firm innovativeness

Firm innovativeness is a multidimensional concept that refers to openness and capacity to introduce innovation in the organization (Hurley and Hult 1998, Hult, Hurley et al. 2004). Innovativeness is a valuable and essential resource for firms (Hadjimanolis 2000) and is particularly

relevant in turbulent environments (Santos-Vijande and Álvarez-González 2007). Innovativeness, as a capability, is a major source of various types of innovations (Azadegan and Dooley 2010), including technological innovations (Santos-Vijande and Álvarez-González 2007, Huang 2011).

Innovative firms are less resistant to change and more open to creating and leveraging niches (Schot and Geels 2008). Such firms also exhibit a higher capability to adopt, adapt, execute, and leverage new ideas effectively. Firm innovativeness is strategically relevant since it can be utilized to prosper in dynamic business settings. It imperative that firms exploit innovations in both good and challenging times (Santos-Vijande and Álvarez-González 2007). As a result, firm innovativeness, one way or another, can be linked to a wide variety of other capabilities including resilience (Tait 2007).

Linking firm innovativeness and supply chain resilience

While exploring the role of innovativeness in common performance outcomes is important (Hult, Hurley et al. 2004), it is also necessary to consider an increased importance of responding to high adversity and disruptions. Nearly all supply chains may face disruptions and unexpected or enduring adversity of varying severity and types. Thus, defined as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function" (Ponomarov and Holcomb 2009) *supply chain resilience* (SCR) arises as a crucial desirable capability for firms and their supply chains (Golgeci and Ponomarov 2013). Drawing on this formal definition and in line with the previous studies (e.g., Khan, Christopher et al. 2012), we view firm's SCR as a strategic capability emanating from the characteristics of firms' supply chains.

Risks and disruptions in supply chains could lead to severe negative impacts on a firm (Hearnshaw and Wilson 2013). Hence, as Ponomarov and Holcomb (2009) argue, understanding the capabilities leading to firms' SCR becomes extremely important under uncertain and adverse conditions.

Accordingly, firm innovativeness can be built, deployed, and leveraged against disruptive and disastrous events taking place in the firm's supply chain. Intuitively, innovative firms are more likely to adopt innovative solutions to be deployed to hedge, fence off, or overcome negative impacts of unpredictable adversities and disruptions taking place in their supply chains.

Furthermore, observation of a rare disruptive event increases the perception of its probability (Tversky and Kahneman 1973). Hence, firms can re-assess the effects of risks of disruptions and invest more in innovative solutions to minimize similar problems in the future. Consequently, a firm's capability to create ideas rapidly to solve problems and implement them to achieve long-term solutions against risks, i.e., its innovativeness, can be essential when facing disturbances and adversities in supply chains (Mitroff and Alpaslan 2003).

Likewise, SCR could be viewed as a desired outcome of specific firm capabilities such as firm innovativeness. Furthermore, resilience involves activism, alertness, and dynamism, and it can be a part of proactive strategies to avoid falling into an undesired state in the wake of disasters and disruptions (Ponomarov and Holcomb 2009). In short, we argue that firm innovativeness could help firms to react to disruptive and adverse events that occur at their supply chains making those firms and their immediate supply chains more resilient by restoring the system that constitutes their value offerings.

H1: Ceteris paribus, firm innovativeness is positively associated with firm supply chain resilience.

Nonetheless, it is highly unlikely that the impact of firm innovativeness on SCR is homogenous and universal. Therefore, revealing potential contingencies on the relationship between firm innovativeness and SCR may offer valuable insights. Thus, in this research we seek to reveal the role of some contingent factors in the relationship between firm innovativeness and SCR, starting with the potential impact of supply uncertainty as a key external factor.

The moderating role of supply uncertainty

In a dynamic and globalizing economy, uncertainty is inevitable. Unlike disruptions that refer to adverse events that actually happened, uncertainty is unaccountable and uncontrollable. The key influence of uncertainty on firm behavior is that uncertainty clouds judgment and obscures meaning and the utility of firm behavior (Carson, Madhok et al. 2006). In uncertain environments, firms lose sight of their prospective future, and outcomes of their strategy and activities become ambiguous. Thus, given volatility and ambiguity in the nature and behavior of the firm's external environment (Carson, Madhok et al. 2006), firms are likely to make less unorthodox decisions and follow more conservative and cautious practices (Bierly, et al. 2014). They may become less certain about the outcomes of their behavior in the wake of disruptive and disastrous events in uncertain environments.

As an important element of the uncertainty in firm's environment, *supply uncertainty* refers to the unpredictability and variability of changes in and the general nature of a firm's supply chain (Elmaghraby 2000). It has significant implications on inputs, operations, and outputs of supply chain operations. For example, supplier business risks, production capacity volatility in the supply market, quality and delivery problems, and changes in technology and product design could be viewed as major sources of supply uncertainty (Zsidisin, Panelli et al. 2000). They could tie up firm resources and threaten the efforts of achieving resilience through innovative behavior. Firms operating in an uncertain environment could choose relatively conservative activities such as buffering and bridging (Bode, Wagner et al. 2011) and follow a "wait-and-see" approach. Thus, the assumed positive impact of any strategic behavior or capability, including innovativeness, may be diminished under high uncertainty conditions. Likewise, an innovation undertaken to achieve or foster SCR may become ineffective or even have an unexpectedly negative effect when the firm's external environment is highly uncertain. Thus, the following moderating hypothesis is proposed.

H2: Supply uncertainty negatively moderates the relationship between firm innovativeness and supply chain resilience at the firm level.

The moderating role of interdependence

The very premise of both the relational view and the network theory suggest that organizations are interdependent and can benefit each other by sharing their resources and capabilities (Dyer and Singh 1998, Borgatti and Foster 2003). In particular, inter-organizational innovation networks provide opportunities to exploit complementary resources that reside beyond the boundaries of the firm (Capaldo 2007) and that are essential for firms like SMEs with internal resource scarcity. Perceived interdependence in response to challenges posed by business environments and expectations that the exchange generates benefits for the actors involved are two key drivers for firms that form interorganizational networks (Gulati and Gargiulo 1999). Consequently, *interdependence* refers to the extent of mutual dependence between exchange partners (Gulati and Gargiulo 1999).

On the one hand, interdependence may pose challenges to firms that face disruptions (Kleindorfer and Saad 2005, Wagner and Bode 2006). Increased interdependence to buyers and suppliers handcuffed by the lack of control could make those supply chains highly vulnerable to disruptions (Hendricks, Singhal et al. 2009). Likewise, the degree of interdependence and reliance on outside entities is argued to be a key vulnerability factor that could undermine firms' SCR (Pettit, Fiksel et al. 2010), especially considering co-existence of both collaborative and competitive behaviors between partners (Park, Srivastava et al. 2014). Specifically, increased dependence usually leads to decreased opportunities for operational flexibility, and the high connectivity in turn leads to a lack of reliable alternatives (Hearnshaw and Wilson 2007). In short, extant theory indicates that interdependence may have some negative implications for innovativeness-SCR linkage.

On the other hand, interdependence may also have numerous benefits in the wake of disasters and adversities. For example, interorganizational linkages could serve as a buffer against disruptions (Miner, Amburgey et al. 1990). Firms may have more opportunities to innovate and leverage their innovativeness when they are interdependent. Interdependence is inextricably intertwined with commitment (Geyskens, Steenkamp et al. 1996), collaboration, collective utilization of resources, and cross-pollination of practices (Borgatti and Foster 2003) that are all conducive to higher realization and leverage of innovations (Mahapatra, Narasimhan et al. 2010). Innovative behavior of one actor is more likely to be adopted by supply chain partners with high interdependence and strong structural and relational embeddedness (Mahapatra, Narasimhan et al. 2010). For example, new environmental practices are argued to be diffused at higher degrees in networks with high structural and behavioral embeddedness (Tate, Ellram et al. 2013). Interdependence and commitment can also facilitate interorganizational learning and knowledge transfers (Geyskens, Steenkamp et al. 1996). In fact, the very premise of the diffusion of innovations principle suggests that innovations and their positive outcomes spread out faster and more effectively when actors in the network are highly connected and interdependent (Borgatti and Foster 2003). Thus, innovative solutions to supply chain disruptions and disasters are likely to be diffused faster and more effectively through firms' networks when network members are more interdependent. Subsequently, a growing body of literature offers relatively strong support for potential strengthening of the role of interdependence in the relationship between firm innovativeness and SCR.

Given the alternative accounts on the influence of interdependence on capability development and utilization across firms, there is a need to weigh the pros and cons of interdependence. An overall evaluation of theoretical evidence signals that the potential benefits of interdependence are likely to outweigh its caveats. Therefore, we argue that higher levels of interdependence among the members in

supply networks also enhance a firm's potential to benefit from a higher level of innovativeness when it comes to SCR at the firm level. In other words, the influence of firms' innovativeness on their SCR is likely to be stronger with increased interdependence among the members of firms' business networks.

H3: Interdependence positively moderates the relationship between firm innovativeness and supply chain resilience at the firm level.

3. Methodology

This research is a part of a larger project that investigates SCR from a broad perspective. Currently relevant variables, namely *supply chain resilience*, *firm innovativeness*, *supply uncertainty,* and *interdependence* were presented and measured within this larger survey.

Sample, procedure, and measures

A target population of full-time managers working in American and European firms, many of which had international presence, was surveyed. The participants held executive positions in operations, purchasing, and logistics management functions with at least several years of relevant work experience. The presence of relevant work experience was essential to obtain reliable responses from the respondents to survey questions.

This study was conducted at the firm level of analysis. We acquired the sample base of the US-based firms from Dun & Bradstreet Corporation. The European sample was drawn from the additional database of professional business contacts. The sample base initially totaled 1,300 potential participants. We administered the online survey and sent three reminders in 10-day intervals.

The phone calls to the managers from the US sample resulted in removing 256 names from the database as bad contacts (mainly because the manager was no longer working at the focal firm, firms had some structural changes, or went bankrupt). Consequently, we reduced the US sample base to 1044.

We obtained 121 responses to the survey (corresponding to 10.16% raw response rate). However, twelve responses were eliminated because of the minor missing data, and only 109 fully usable responses remained. Furthermore, following initial residual analysis, we removed 5 outliers based on the outlier labeling rule (Tukey 1977) to control for erroneous data and alleviate potential misleading effects. Thus, only 104 good responses were used in the final analysis. As can be seen in Table 1, respondent firms represented a variety of product related industries and sizes, while medium and larger firms represented a relatively higher share of respondents than small firms. We adopted Mentzer and Flint's (1997) approach to address non-response bias. Hence, we called some of the non-respondents after our initial data collection. The responses acquired from these non-respondents did not differ significantly from the original responses based on the analyses of variance.

[Insert Table 1 here]

We used a 7-point Likert scales to measure variables of interest. The details include factor loadings, standard deviations, and means and they are provided in Appendix 1. The scales for *firm innovativeness* were borrowed from marketing and management science literature (Scott and Bruce 1994, Hurley and Hult 1998, Jambulingam, Kathuria et al. 2005). We also considered expert opinions when adopting these scales. More specifically, we added three new items to the frequently used scales by Hurley and Hult (1998). This approach allowed us to capture the nature of firm innovativeness better. Likewise, the scales for *interdependence* and *supply uncertainty* were adopted from the management literature. Six multi-item scales were used for *interdependence* (Monczka, Petersen et al. 1998), four multi-item scales were used for *supply uncertainty* (Chen and Paulraj 2004, Wong, Boon-itt et al. 2011), and six multi-item scales for *supply chain resilience. S*everal of the 22 initial items we reverse-coded in order to mitigate potential common-method bias. Furthermore, the reliability and validity of the adopted scales was also assessed and confirmed

Scale reliability and validity

An exploratory factor analysis (EFA) was conducted for firm innovativeness, SCR, interdependence, and supply uncertainty items in order to verify their respective factor loadings. The EFA using principle components extraction and varimax rotation resulted in confirming sphericity (χ^2=1428.163, p<0.001). Additionally, the high values (0.734) of the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy indicate that there are sufficient items for each factor and factor analysis is appropriate for these data and measures. Based on the factor loadings of this exploratory factor analysis, one item (INV2) was dropped from the firm innovativeness scale and one item (ITD1) was dropped from the interdependence scale as their loadings were below the cut-off value that was set to 0.6 (Bagozzi, Yi et al. 1991) and they exhibited cross-loading to several factors. Remaining items loaded onto their factors with no indication of significant cross-loadings, and factor loadings ranged from 0.60 to 0.88. The results of the EFA also attenuate the possibility of a common-method bias as a potential threat to this research since none of the factors explained more than 16 % of the variation following Harman's one-factor test (Schilke 2014). Following the factor analysis, composite reliability of the variables resulting from the items with significant loadings was tested. The Cronbach's alpha for firm innovativeness, SCR, interdependence, and supply uncertainty were 0.84, 0.90, 0.82, and 0.84 respectively, which was above the commonly accepted cut-off value of 0.7 (Nunnally and Bernstein 1994). Overall, the results provide support for sufficient levels of reliability and validity in this research (Churchill 1979).

Results

Table 2 displays Pearson correlations among the focal variables. Moderate correlations among the variables suggest the absence of significant multicollinearity. Furthermore, following the calculation of variance inflation factors (VIF) for all variables, we concluded that multicollinearity is not a serious

threat to the validity of the analyses, as all VIF values including interaction terms remained below 2.2 and average VIF values ranged between 1.2 and 1.6 (Kleinbaum, Kupper et al. 1988).

[Insert Table 2 here]

A linear regression analysis was employed to test the three posited hypotheses using SCR as a dependent variable as shown in Table 3. We controlled for the *industry and the firm size* effects to account for potential spurious effects on the tested relationships throughout all models tested in our research. These variables were selected due to the possibility that SCR and supply uncertainty levels may vary across hyper-competitive versus niche industries and the possibility that smaller firms might be more vulnerable to disruptions and adversities. For testing a firm size effects, given values were treated as ordinal measures and tested accordingly. For testing the industry effects, we followed the procedure suggested by Cohen et al. (2003, pp. 303–307). All identified industries were dummy-coded while the "Automotive" industry was used as the baseline for testing. The first hypothesis was supported. As predicted in H1, we found that firm innovativeness has a significant and positive influence on SCR ($t=4.551$, $p<0.001$). Models were also tested for moderation. Accordingly, products of two variables involved in all moderations were calculated. All variables in moderation tests were mean centered in order to attenuate possible multicollinearity threats. The interaction term of firm innovativeness and supply uncertainty predicted ($t=-2.330$, $p<0.05$) SCR above and beyond firm innovativeness and supply uncertainty alone. Thus, the hypothesis, H2, suggesting negative moderation of supply uncertainty was also supported. As seen in Figure 1, the impact of firm innovativeness on SCR was strongest ($R^2 = 0.504$) when supply uncertainty was low, somewhat weaker when supply uncertainty was moderate ($R^2 = 0.172$), and nearly non-existent ($R^2 = 0.024$) when supply uncertainty was high.

[Insert Table 3 here]

[Insert Figure 1 here]

However, consequent moderation tests failed to support H3. Thus, H3 was not supported since interdependence did not show a significant moderating effect ($t=-0.655$, $p>0.05$) on the link between firm innovativeness and SCR. As adjusted R-squares suggest, efficiency of the Model 4 was weaker than the efficiency of the Model 3, indicating superiority of the second model among other alternatives with single negative moderating effect of supply uncertainty. Residuals of variables for all tests were also checked to confirm models' utility. A review of the models' residuals revealed that standardized residuals were consistent and normally distributed.

4. Discussion

Obtaining, sustaining, and utilizing effective capabilities are essential to firms' long-term success and survival, especially in turbulent, ambiguous, and adverse environments (Helfat and Winter 2011). In this study, we highlighted the argument that supply chains are more prone to risks and disruptions than single firms, and the impact of firms' supply chains on the resilience of individual firms is undeniable. We empirically tested the linkage between firm innovativeness and SCR as well as key contingencies that can shape this link. First, we discovered that firms of various sizes and from various industries with innovative capabilities have higher likelihood of establishing and maintaining their SCR. The conventional mainstream innovation literature has viewed innovation as a part and outcome of a proactive strategy to foster the performance of what is already somehow working (e.g., Damanpour 1991, Ahuja 2000). However, our findings indicate that innovations can also be triggered by negatively perceived and adverse incidents, and in turn can be leveraged as a long-term response to a hostile and ambiguous environment, possibly following a managerial mindset stimulated through increased perception of risk (Tversky and Kahneman 1973). Second, we scrutinized possible contingent effects on the hypothesized relationship to provide a deeper and more consistent explanation of the influence of

firm innovativeness. Specifically, the moderating roles of supply uncertainty and interdependence were hypothesized and tested.

Theoretical contributions

Several theoretical contributions and managerial implications are particularly important. First of all, our core theoretical contribution is that our study establishes firm innovativeness as one of the essential antecedents of firms' SCR, enhancing our understanding of "What are the outcomes of innovativeness?" research question. This research contributes to the existing literature by examining the role firm innovativeness plays in creation of SCR and discovering additional potential benefits of innovativeness. Thus, our study unlocks the potential of new research venues that may examine innovation and innovativeness in new settings such as supply chain resilience and a broader area of risk or disaster management. This contribution underlines the value of bridging SCM and strategic management fields and reaping the benefits of interdisciplinary research opportunities between the two fields (Hitt 2011).

Moreover, two contingent factors on the critical link between firm innovativeness and SCR were also empirically evaluated. Therefore, the study provides valuable insights into the possible contingent factors that moderate the impact of firm innovativeness. First, the impact of supply uncertainty implies that the utility of firm innovativeness in challenging times is contingent upon reliable and consistent supply of resources as well as product and service inputs. Thus, supply uncertainty appears to be a serious threat to innovative behavior and SCR of firms by weakening the effects of innovative efforts. Second, interdependence appears to play no significant role in the relationship between firm innovativeness and SCR. It is in contrast with the assumptions of the relational-based view (Dyer and Singh 1998) in networks. However, it is possible that "the dark side" of network interdependence as well as resulting complexities (e.g., Labianca and Brass 2006) cancel out its benefits, especially in terms of

the leverage of innovative behaviors in disruptive times. It is also possible that negative effects of interdependence as well as negative interfirm behaviors in networks and reduced flexibility often associated with interdependence nullify its extensively highlighted benefits in supply chains. Consequently, this theoretical implication necessitates further research with the objective of clarifying the unexpected results and verifying validity of the related assumptions.

Finally, insignificant results for industry and firm size controls indicate that the role of firm innovativeness in firms' SCR is not bound by size and industry variations. Thus, though it is evident that firm size and industry may have important implications for firm behavior and structure, they are not likely to exert overt influence on how firms utilize their innovative capabilities to deal with adversities and disruptions and foster their resilience in the face of challenging times.

Managerial implications

We offer several implications for management practice as well. First, the model provides some additional insights into the area of strategic management when managerial decisions are especially pivotal to survival of firms in challenging circumstances. Managers are encouraged to deploy innovative capabilities and design their supply chain in a way that could ensure more effective structure and more efficient and enduring response to adverse incidents. New ways to increase SCR in the face of difficulties could be used to maintain continuity of supply chain flows in the long run. Managers may also focus on how to cultivate firm innovativeness and leverage innovative capabilities for attaining and sustaining resilience in supply chains that can result in firms staying intact, in control, and alive in a turbulent global environment.

Furthermore, it appears that it is particularly important to hedge against supply uncertainty, because, as findings suggest, supply uncertainty may pose a serious threat to exploitation of innovative

capabilities in the pursuit of SCR. Firms are advised to consider managing their innovations and innovative activities more vigorously and channeling their innovativeness into risk and continuity management strategies while being alert to supply uncertainties and adversities when realizing innovations for SCR. In summary, it becomes ever more pivotal from a managerial perspective to comprehend and actively manage all relevant factors that could reduce supply uncertainty in adverse and turbulent times. These strategies are likely to affect business continuity, resilience, and even survival of the firms in the long run.

Limitations and future research

The key limitation of the current study is that it only focuses on supply uncertainty and interdependence as moderating variables for the link between firm innovativeness and SCR. Hence, future researchers need to determine whether there are other potential external and internal moderators of the relationship between firm innovativeness and SCR. For example, the role of organizational culture, risk sharing routines, and top management support could be also explored (Ponomarov and Holcomb 2009).

Beyond these limitations, our study offers several future research possibilities that could be undertaken. First, further research can address the broad question of "How do firms utilize their innovativeness against adversities and challenges in turbulent environments?" This study found that firm innovativeness *can* be utilized to attain and sustain SCR and its utility will change under varying degrees of supply uncertainty. However, the more qualitative and explorative question of how firms leverage their innovativeness for achieving SCR remains unaddressed and entails further explorative investigation possibly through qualitative field studies. Moreover, the relationships among supply chain members can have a significant impact on the linkage between firm innovativeness and SCR. That is especially important for supply chain buyer-supplier dyads or their extended supply networks. Literature

shows that highly embedded, tightly coupled, and interdependent supply chains can be particularly susceptible to disasters and adversities (Kleindorfer and Saad 2005, Wagner and Bode 2006). On the other hand, such factors as embeddedness and interdependence appear to bring in considerable rents to each party in terms of their innovative capabilities (Capaldo 2007). Thus, the characteristics of these complex linkages need to be examined more in-depth to reconcile seemingly conflicting or inconclusive roles of interdependence in SCR. Such future research could result in better understanding of the effective responses to possible adversities and enablers of SCR.

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Appendix 1 – Measures and Their Loadings

Item		Standardized Loading	Mean	Standard Deviation
	Firm innovativeness (FRMINV)			
INV1	Our firm's management actively seeks innovative technologies, processes, techniques, and/or product ideas	0.788	5.74	1.043
INV2	People are penalized for new ideas that don't work (R)	0.461	5.88(RB)	1.337
INV3	Innovation in our firm is perceived as too risky and is resisted (R) (Hurley and Hult 1998)	0.665	5.56(RB)	1.309
INV4	Our firm is known as an innovator among firms in our area.	0.712	5.47	1.192
INV5	Our firm investigates and secures funds needed to implement new ideas.	0.712	5.37	1.258
INV6	Our firm constantly experiments with new ideas. (Scott and Bruce 1994, Jambulingam, Kathuria et al. 2005)	0.785	5.30	1.217
	Supply Chain Resilience (SCRES)			
SCR1	Our firm's supply chain is able to adequately respond to unexpected disruptions by quickly restoring its product flow.	0.773	5.06	1.273
SCR2	Our firm's supply chain can quickly return to its original state after being disrupted.	0.830	5.00	1.364
SCR3	Our firm's supply chain can move to a new, more desirable state after being disrupted.	0.806	4.60	1.381
SCR4	Our firm's supply chain is well prepared to deal with financial outcomes of supply chain disruptions.	0.829	4.84	1.311
SCR5	Our firm's supply chain has the ability to maintain a desired level of control over structure and function at the time of disruption.	0.793	4.98	1.290
SCR6	Our firm's supply chain has the ability to extract meaning and useful knowledge from disruptions and unexpected events. (Ponomarov 2012)	0.698	5.18	1.293
	Interdependence (BSINTER)			
ITD1	Our firm can easily terminate existing supplier alliance/partnerships and establish another strategic supplier alliance/partnerships (R).	.513	4.64(RB)	1.474
ITD2	Our firm can easily find new customers if it loses one of the existing major customers (R).	.684	4.87(RB)	1.500
ITD3	The time to establish another strategic supplier alliance/partnership in place of a terminated one would be extremely long for our firm.	.810	4.60	1.359
ITD4	The time to replace a lost strategic customer would be extremely long for our firm.	.744	4.92	1.412
ITD5	The cost to establish another strategic supplier alliance/partnership in place of a terminated one would be extremely high for our firm.	.770	4.47	1.398
ITD6	The cost to find establish a new strategic customer partnership would be extremely high for our firm. (Monczka, et al. 1998)	.776	4.85	1.431
	Supply Uncertainty (SUPUNS)			
SUC1	Our suppliers consistently meet our firm's requirements (R)	0.875	3.00(RB)	1.235
SUC2	Our suppliers produce materials with consistent quality (R)	0.817	2.54(RB)	1.002
SUC3	Our suppliers' product deliveries are consistent (R)	0.871	2.69(RB)	1.16
SUC4	Our suppliers performance is unpredictable (Chen and Paulraj 2004; Wong, et al. 2011)	0.598	2.97	1.301

Table 1: Participants by Industry and Firm Size

Industry	Frequency	Percent	Annual Sales	Frequency	Percent
Automotive	9	8.70%	Less than $1 million	4	3.80%
Aerospace	3	2.90%	$1-50 million	18	17.30%
Apparel / Textiles	4	3.80%	$51-500 million	26	25.00%
Appliances	4	3.80%	$501 million - $1 billion	20	19.20%
Electronics	17	16.30%	Greater than $1 billion	36	34.60%
Industrial Products	22	21.20%			
Chemicals/plastics	7	6.70%			
Consumer Packaged Goods	16	15.40%			
Medical/Pharmaceutical	11	10.60%			
Other	11	10.60%			
Total	**104**	**100.00%**	**Total**	**104**	**100.00%**

Table 2: Pearson correlation matrix (N=104)

Variables	FRMINV	SCHRES	SUPUNC	BSINTER
FRMINV	1			
SCHRES	0.348**	1		
SUPUNC	-0.208*	-0.368**	1	
BSINTER	-0.096	-0.172	0.134	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

	Standardized Estimates (t-value)				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Intercept	27.859 (8.475)	13.755 (3.196)	32.429 (5.235)	21.638 (2.650)	37.237 (4.295)
Independent Variables					
Firm innovativeness		**0.441 (4.551)*****	**0.342 (3.484)** **	**0.424 (4.222)*****	**0.327 (3.213)****
Supply uncertainty			**-0.326 (-3.505)** **		**-0.316 (-3.342)** **
Firm innovativeness * Supply uncertainty			**-0.230 (-2.330)** *		**-0.231 (-2.324)** **
Interdependence				-0.108 (-1.108)	-0.070 (-0.762)
Firm innovativeness * Interdependence				-0.066 (-0.655)	-0.057 (-0.596)
Controls					
Firm size	-0.004 (-0.034)	0.002 (0.024)	0.007 (0.073)	0.005 (0.051)	0.008 (0.076)
Aerospace	0.005 (0.046)	-0.051 (-0.486)	-0.107 (-1.079)	-0.056 (-0.534)	-0.109 (-1.097)
Apparel / textiles	-0.016 (-0.132)	-0.009 (-0.082)	-0.050 (-0.487)	-0.010 (-0.095)	-0.050 (-0.480)
Appliances	0.078 (0.645)	0.027 (0.242)	-0.031 (-0.299)	0.016 (0.141)	-0.038 (-0.360)
Electronics	0.012 (0.075)	-0.052 (-0.363)	-0.115 (-0.844)	-0.033 (-0.228)	-0.099 (-0.716)
Industrial products	0.217 (1.314)	0.043 (0.280)	-0.016 (-0.108)	0.058 (0.373)	-0.004 (-0.025)
Chemicals/plastics	0.116 (0.894)	0.006 (0.053)	-0.070 (-0.610)	0.021 (0.171)	-0.058 (-0.496)
Consumer packaged goods	0.155 (1.004)	0.054 (0.379)	0.064 (0.476)	0.047 (0.328)	0.058 (0.426)
Medical/pharmaceutical	-0.054 (-0.369)	-0.161 (-1.191)	-0.163 (-1.263)	-0.149 (-1.093)	-0.156 (-1.204)
Other	0.090 (0.638)	0.059 (0.455)	0.045 (0.360)	0.054 (0.413)	0.039 (0.314)
R^2	**0.063**	**0.235**	**0.349**	**0.247**	**0.354**
Adjusted R^2	**-0.037**	**0.144**	**0.255**	**0.138**	**0.244**
F	0.628	**2.575****	**3.709*****	**2.269***	**3.219*****

N=104, Effects are significant at: $^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$

Table 3: Linear regression results

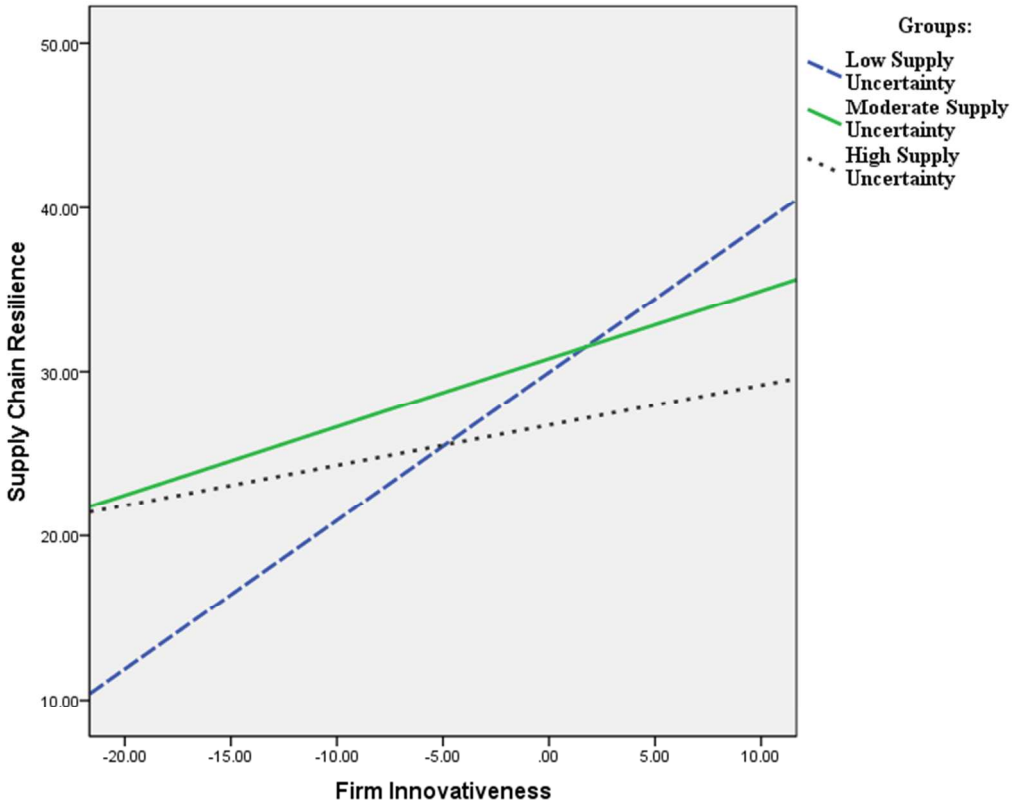

Figure 1: Moderation Effect of Supply Uncertainty