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Facing supply chain disruptions: enhancers of supply chain resiliency

Ahmed Hamdi
Rabat Business School - Université Internationale de Rabat - BEAR-Lab

Tarik Saikouk
Excelia Business School, CERIIM

Bouchaib Bahli
Ryerson University - Ted Rogers School of Information Technology Management

Abstract

Supply chain disruptions are increasingly exerting negative effects on the economic and operational performance of firms. Hence, firms need to ensure business continuity and protect its economic value by enhancing supply chain resiliency. In our paper, we draw on the organizational information processing theory, and we consider the enhancement of supply chain resiliency as an information-based process. We posit that firms can pursue bridging and buffering strategies by implementing supply chain risk management practices and supply chain integration practices. Considering these two strategies will enable the firm to attenuate the high uncertainty resulting from supply chain disruptions through a reduction of the information processing needs of the firm and an increase of its information processing capacity. Analysis of data collected from 283 US and French manufacturers, supports our arguments and offers theoretical and managerial insights.

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Contact: Ahmed Hamdi - ahmed.hamdi@uir.ac.ma, Tarik Saikouk - saikoukt@excelia-group.com, Bouchaib Bahli - bahli@ryerson.ca.
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Ahmed Hamdi
International University of Rabat

Tarik Saikouk
International University of Rabat

Bouchaib Bahli
Ryerson University

Abstract

Supply chain disruptions are increasingly exerting negative effects on the economic and operational performance of firms. Hence, firms need to ensure business continuity and protect its economic value by enhancing supply chain resiliency. In our paper, we draw on the organizational information processing theory, and we consider the enhancement of supply chain resiliency as an information-based process. We posit that implementing supply chain risk management practices creates redundancy that enables a reduction of the information processing needs. Whereas, the investment in supply chain integration activities will help the firm increase its information processing capacity. Analysis of data collected from 283 US and French manufacturers, supports our arguments and offers theoretical and managerial insights.

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1. INTRODUCTION

The recent COVID-19 pandemic has demonstrated the importance and criticality of developing capabilities to enhance the supply chain's resiliency. Understanding and building supply chain resiliency is increasingly becoming a necessity as supply chains are becoming more complex, and supply chain disruptions often impact the organizations severely (El Abdellaoui and Pache, 2019). Thus, understanding the factors contributing to building resiliency will enable organizations to be better prepared to face disruptive events. Although previous scholars (Christopher and Peck, 2004; Pettit, Croxton and Fiksel, 2013) have examined several capabilities that are instrumental in building supply chain resiliency, yet, the interplay between the varying degree of uncertainty faced by a firm and capabilities to develop is still unclear. In line with extant literature (Sheffi and Rice, 2005; Wieland and Wallenburg, 2012), we consider supply chain resiliency formed by two closely related dimensions, namely agility, and robustness. As a proactive approach, robustness refers to the firm's ability to keep operations running to withstand disruptive events (Kitano, 2004). On the other hand, the reactive approach "Agility," refers to the speed at which a firm will react to disruptive events and return to a normal situation (Wieland and Wallenburg, 2012; Chowdhury and Quaddus, 2017). Considering the role played by both robustness and agility in preserving the operational and economic performance of the firm (Hendricks and Singhal, 2005b, 2005a), we view these supply chain resiliency dimensions as performance outcomes (Brandon-Jones *et al.*, 2014).

When faced with uncertain environments, firms seek to achieve stability both internally and externally (Meznar and Nigh, 1995). In this regard, firms will initiate responses to reduce uncertainty choosing one of the two alternatives buffering or bridging (Fennell and Alexander, 1987; Meznar and Nigh, 1995). Buffering actions attempt to protect the firm from external disturbances that might jeopardize its stability, whereas bridging actions strive to protect the firm against disturbances through boundary-spanning activities with exchange partners (Meznar and Nigh, 1995). To understand the capabilities necessary to enhance supply chain resiliency, we mobilize the Organizational Information Processing Theory (OIPT) (Galbraith, 1973, 1977). According to Galbraith (1973), the higher uncertainty faced by firms, the higher the need to gather and process information to reach a desired level of performance. Firms aim to balance their information processing needs with their information processing capabilities (Galbraith, 1974). In our study, we mobilize the OIPT framework to examine the relationship between Supply Chain Integration (SCI), Supply Chain Risk Management (SCRM) practices, and supply chain resiliency. By associating buffering and bridging strategies to SCI and SCRM, we posit that these practices are instrumental in reducing uncertainty to improve the supply chain resiliency. By implementing these supply chain practices, firms can balance their information needs and capacity to enhance their robustness and agility.

Past studies have demonstrated the disastrous effect that supply chain risks can have on firm performance (Hendricks and Singhal, 2005a). Since supply chain disruptions are a form of risk (Chopra and Sodhi, 2004), firms need to implement supply chain risk management (SCRM) practices to withstand its adverse effects. Besides, previous studies and meta-analysis demonstrated the benefits of supply chain integration in its external and internal form on the organization's performance (Flynn, Huo and Zhao, 2010; Schoenherr and Swink, 2012; Ataseven and Nair, 2017). Although it is fundamental to investigate the impact of SCI on classical forms of firm performance, an organization can derive other benefits from SCI. Thus, by investigating SCI's role in building supply chain resiliency, we argue that integrating with supply chain partners allows the firm to improve its resiliency and protect its value from disruptive events. In our paper, we intend to study how companies can deal with uncertainty from an organizational information processing theory (OIPT) to enhance resiliency by either adopting bridging options to increase access to information or buffering options to reduce its need for information. We set to contribute to the literature on supply chain resiliency, by studying the mechanisms through which the firm can balance its information needs and information capacity to mitigate disruptive events in a reactive and proactive manner. We empirically test the effects of Supply Chain Integration (SCI) and Supply Chain Risk Management practices (SCRM) on Supply Chain Resiliency (SCRE). Thus, we intend to answer the following research question:

RQ: To what extent can supply chain integration and supply chain risk management practices enhance supply chain resiliency?

We contribute to the literature on supply chain resiliency by studying supply chain risk management, supplier and customer integration impact as enhancers of robustness and agility. Based on the OIPT, we view the development of resiliency as an information-based process, where information processing needs and information processing capacity act as levers to reduce the high uncertainty characterizing the identification, processing, and mitigation of disruptive risks. In the following sections, we will review the literature on our primary constructs and develop the hypotheses for our research model. Then, we will discuss the methodology and results found after testing our hypotheses. Finally, we will discuss the results and suggest theoretical and managerial implications for our paper.

2. THEORETICAL BACKGROUND AND HYPOTHESES

According to OIPT, when facing high uncertainty stemming from their business environment, organizations need to deploy adequate processing needs to improve their organizational performance (Tushman and Nadler, 1978). Therefore, organizations need to collect, transform, and interpret the information to reduce uncertainty (Daft and Lengel, 1986). For Galbraith (1974), organizations can manage low uncertainty contexts through a coordination mechanism by utilizing rules, hierarchy, targets, and goals to overcome exceptional situations. However, when the level of uncertainty increases, such a "mechanistic approach" is no longer feasible. Galbraith (1974) suggests that organizations can adjust by decreasing their information processing needs by creating slack or buffers or increasing their information processing capacity through lateral relations and investing in vertical information systems. These two approaches can be linked to buffering and bridging actions (Fennell and Alexander, 1987; Meznar and Nigh, 1995). In the present study, we associate bridging with SCI and the risk identification practices of SCRM, whereas the risk mitigation practices of SCRM are associated with buffering actions.

From the OIPT perspective, bridging seeks to manage uncertainty by creating a "bridge" that will enable the firm to access reliable and timely information to mitigate possible supply chain disruption. This coping strategy can be associated with SCI and some practices of SCRM. Indeed, SCI, in the form of external integration, creates lateral relationships with suppliers and customers, allowing to increase its information processing capacity. Similarly, risk identification practices of SCRM in the form vendor and supplier rating programs, contingency programs or early warning systems (Manuj and Mentzer, 2008; Blome and Schoenherr, 2011) are considered to be linked to bridging strategies (Bode *et al.*, 2011). Conversely, buffering strategies are associated with the mitigation practices of SCRM, namely rethinking and re-evaluating the supply and distribution strategy and supplier development (Manuj and Mentzer, 2008; Blome and Schoenherr, 2011) as they seek to build slack resources that will absorb shocks in the preparation of disruption occurrence. The choice of adopting buffering or bridging strategies is not mutually exclusive, as a firm can use both approaches to enhance supply chain resiliency.

2.1. Supply Chain Integration Effect on Supply Chain Resiliency

External integration is oriented towards external partners of the firm, namely suppliers and customers. It refers to the extent to which a firm collaborates with external partners through inter-organizational practices to synchronize and streamline processes and improve the supply chain performance (Stank and Keller, 2001). Since we are investigating how the need for information – by increasing the capacity to capture information or reducing the need for it - is crucial to managing disruptive events, we will focus only on external integration as a bridging strategy that creates external linkages with supply chain partners in order to collaborate and share information. Facing disruptive events exerts a high level of uncertainty on managers to make adequate decisions. OIPT suggests to firms in similar cases to deal with increased uncertainty by adopting bridging strategies to increase their information processing capacity through lateral relations (SCI) and risk identification practices of SCRM or by adopting buffering strategies to create slack (Galbraith, 1973). Respectively, engaging in supply chain integration activities with the upstream and downstream partners will allow the firm to leverage its inter-organizational linkages to reduce the uncertainty (Koufteros, 2014; Wong, Wong and Boon-itt, 2015). Based on OIPT, closer integration with customers and suppliers enables the firm to gather, transform, and exploit the information collected thanks to its external linkages (Galbraith, 1974; Srinivasan and Swink, 2015). Previous studies have demonstrated that tighter integration with supply chain partners allows the firm to access more accurate and high-quality information (Barratt and Oke, 2007). The development of information sharing among the firm and its suppliers and customers is instrumental in enhancing supply chain visibility (Christopher and Lee, 2004). Armed with enhanced visibility and established routines of information sharing, the firm can detect possible sources of disruptions in its supply chain and build adequate measures to face it proactively. For example, thanks to the sharing of production plans among partners, the firm can detect possible bottlenecks and work with partners to alleviate them to withstand disruptive events, hence demonstrating robustness in the face of a disruptive event. Therefore, we suggest the following hypotheses:

H_{1a}: Supplier integration is positively related to robustness
H_{1b}: Customer integration is positively related to robustness

Moving from an arm's length relationship to embedded relationships such as SCI entails the development of trust and commitment (Chen, Preston and Xia, 2013; Zhang and Huo, 2013). These relational antecedents have been shown to play an essential role in reinforcing the willingness of the firms to share risks and rewards (Mayer, Davis and Schoorman, 1995; Chen and Paulraj, 2004; Sambasivan and Yen, 2010). Furthermore, integration with suppliers and customers enables the supply chain partners to develop shared goals, understanding, codified routines, policies, and procedures (Rothaermel and Deeds, 2006). Subsequently, by integrating with its suppliers and customers, the firm will be able to share, interpret and act on the available information more quickly since the supply chain partners already have developed routines and procedures to operate their processes. Thus, they will be able to react more quickly to disruptive events since they can process and treat information quicker than others. Indeed, Liang & Huang (2006) have found that higher levels of external integration allow the firm to improve its agility and responsiveness to market uncertainty. Based on OIPT, bridging strategy in the form of closer integration with customers and suppliers allows the firm to increase its information processing capacity to gather and exploit data more effectively to improve its agility. As a result, we propose the following hypotheses:

H_{2a}: Supplier integration is positively related to agility
H_{2b}: Customer integration is positively related to agility

2.2. Supply Chain Risk Management Effect on Supply Chain Resiliency

Following Wiengarten et al., (2016) distinction between risk identification and risk mitigation practices of SCRM, we argue that managers can adopt both bridging and buffering strategies to attenuate the effects of increased uncertainty exerted by disruptive events. Based on OIPT perspectives, managers can increase their information processing capacity by adopting a bridging strategy in the form of risk identification practices to prepare for disruptive events through the identification of potential sources of risks to address them quickly, or reduce their information processing needs through a buffering strategy in the form of risk mitigation practices that seek to build redundancy in the form of safety stocks, the dual or multiple sourcing, maintaining capacity slack (Lavastre, Gunasekaran and Spalanzani, 2012). Consequently, the negative effects of external disturbances will be lessened. To effectively mitigate disruptive risks, the firm needs to identify the risks successfully.

Risk identification is a critical part of the SCRM process (Manuj and Mentzer, 2008; Blome and Schoenherr, 2011). Considered as bridging strategy, risk identification practices aim to leverage the external relationships with supply chain partners to detect potential sources of risks and proactively address them. Risk identification is defined as the firm's ability to systematically and exhaustively evaluate and recognize potential supply chain-related risks (Tummala and Schoenherr, 2011). If this latter is executed correctly, it will allow the firm to effectively create and allocate the slack in its different forms to manage the uncertainty accompanying SC disruptions. As a result, the firm can prepare ex-ante for disruptive events. For instance, after scanning its environment, the firm detected a vulnerable supplier that might be easily affected by the hazardous event. Based on the assessment of the collected information, the firm can proceed to ask this supplier to build a safety stock to be able to withstand disruptive events. Thus, implementing a bridging strategy through SCRM's risk identification practices is instrumental in developing robustness in a proactive manner to face SC disruptions.

Further, the time necessary to react to a disruptive event is a significant factor in reducing its impact on the supply chain (Craighead *et al.*, 2007). Adopting a buffering strategy through the implementation of risk mitigation techniques endows the firm with the ability to promptly redesign and adapt its supply chain in the case of a disruption to create "shock absorbers." Previous studies have stressed the importance of considering the creation of redundancy and slack in the supply chain to mitigate supply chain disruptions (Sheffi and Rice, 2005; Sarathy, 2006). For example, after identifying a distribution-center as weather-sensitive, the firm can build a dual distribution-center that can be utilized in response to disruption. Therefore, by implementing this mitigation technique, the firm will be able to promptly reroute its distribution strategy and recover quickly. From an OIPT perspective, the buffering strategy creates slack resources to mitigate risks by absorbing the uncertainty created by the disruptive event and allowing the firm to recover rapidly from a disruption. Based on these arguments, we suggest the following hypotheses:

H_{3a}: Supply chain risk management practices are positively related to robustness
H_{3b}: Supply chain risk management practices are positively related to agility

3. RESEARCH DESIGN

To empirically test our research model about enhancers of supply chain resiliency, we collected data through an online-based survey of 283 supply chain managers and executives from France and the United States. We collected our data from two countries and across various industries. According to (*Allianz Risk Barometer 2020*, 2020) report, 48% of respondents in France ranked supply chain disruptions as significant risk threatening the company's business performance; the same figure is reported to be 37% in the United States. All the measurement instruments used in our questionnaire were adopted from past validated studies. Following a key informant approach in our study, we decided to collect data from top managers and executives working in supply chain management activities such as operations, purchasing, and supply chain management. These individuals are knowledgeable about their organizations' activities and can readily access sensitive information (Liu *et al.*, 2016; Montabon, Daugherty and Chen, 2018). Following the key informant approach, we carefully screened the responses and eliminated those whose titles did not reflect a supply chain-related activity or did not have the required experience inside the company. For the US data, 40% of respondents are supply chain directors and VPs, and 17.8% occupy a Manager or VP position in Supply chain related activities (Materials handling and purchasing). Also, 65.8% are highly experienced professionals in supply chain activities. For the French sample, 58% of the respondents work as Supply Chain Directors and VP's, and 12.7% work in supply chain-related activity either as managers or VP's. Furthermore, in the US sample, 65.8% of the respondents have at least nine years of experience in the supply chain field. This figure is about 48.5% in the French sample.

To collect data from France, we collaborated with “Association Française pour la Supply Chain et la Logistique" (ASLOG), the largest association of supply chain management professionals in the country. An email that contains the web-link to the questionnaire was sent to the 1200 members of the organization of supply chain management professionals. After two waves of emails and reminders through the association's social networks, we received 133 usable responses, corresponding to an 11.25% response rate. To collect data in the US, we have commissioned Qualtrics, a third-party online survey administration company, to collect data from US supply chain managers and executives. Qualtrics Panels has been employed in previous studies and is identified as a reliable instrument to collect data (Courtright *et al.*, 2016; Hazen *et* *al.*, 2017). Qualtrics Panel services sent an email containing the online survey link to a pool of 842 participants. 152 completed questionnaires were recorded, corresponding to a response rate of 18.05%.

We surveyed the existing literature to identify validated and reliable measures for our study. All measurement scales used in our questionnaire were adopted from existing literature (Malhotra and Grover, 1998). For *supply chain robustness, we adopted* a scale from (Brandon-Jones *et al.*, 2014). This scale measures the firm's ability to keep performing its operations normally in case a disruption occurs. It assesses the extent to which the firm will be able to meet customer demand and achieve the expected level of performance despite the disruption. *Supply chain agility* was measured using a scale adopted from (Wieland and Wallenburg, 2012). It examines the speed at which the firm can modify its operations in case of unexpected changes. It estimates the firm's ability to rapidly adapt activities such as manufacturing lead-times or delivery reliability to face changes. To measure *supply chain risk practices,* we adopted a scale from (Wiengarten *et al.*, 2016). It evaluates the effort level devoted to implementing programs to identify and mitigate risks, such as vendor monitoring and rating programs and early warning systems and contingency programs (Manuj and Mentzer, 2008; Blome and Schoenherr, 2011). Finally, *Supply chain Integration:* we measured SCI through its supplier and customer dimension using scales adopted from (Frohlich and Westbrook, 2001; Flynn, Huo and Zhao, 2010). The items used, measured the level of coordination with key suppliers and customers of the flow of information and planning decisions.

Control Variables: To enhance our results' robustness, we included relevant variables as control variables to our research model. We controlled firm size by measuring the total number of employees since small-sized companies are less exposed to disruptions (Wagner and Neshat, 2012). Second, the level of SCRM and SCI practices implementation may differ across industrial sectors in terms of exposure to disruptions (Min and Galle, 2001). Thus, we decided to level out the effect of the industry on the results. Third, we included the country as a dummy variable to account for possible differences between the two countries (US and France). Finally, the relationship duration between the firm and its upstream and downstream partners may affect the results since long-established firms enjoy more information sharing routines and procedures to improve their performance to withstand disruptive events (Kotabe, Martin and Domoto, 2003).

4. PRELIMINARY RESULTS

The confirmatory factor analysis's CFA's results (see Table 1) indicates that the data effectively fit the model: ($\boldsymbol{\mathcal{X}^2 = 401.58\ (df = 178, \mathcal{X}^2/df = 2.256)}$; $\boldsymbol{CFI = .94}$; $\boldsymbol{TLI = .93}$; $\boldsymbol{RSMEA = .06}$), thus ensuring strong model fit. Additionally, we assessed the convergent validity of the constructs by analyzing the factors loading, average variance extracted (AVE), and composite reliability (CR). The analysis results show that all factor loadings are greater than 0.5 and significant at ($p < .001$) (Hair *et al.*, 2010). Thus we can establish high convergence of our measurement instruments. The CR values of all constructs used in our model were greater than 0.7 (Hair *et al.*, 2010), thus ensuring internal consistency and convergent validity. Also, the AVE for each measure was greater than 0.5; hence convergent validity is supported. Furthermore, the AVE results exceeded the squared correlations of the remaining measures (Hair *et al.*, 2010), indicating the support of the discriminant validity. Since all our scales exceed the recommended thresholds for each of the tests, it is safe to say that all our measurements have good reliability, convergent, and discriminant validity.

Robustness and agility are two closely related concepts that form the supply chain resiliency concept (Wieland and Wallenburg, 2012, 2013). Thus, error terms in the regression equations may correlate. To overcome this issue, we deem the use of Seemingly Unrelated Regression (SUR) as a suitable method to test the hypotheses of our research model. SUR is adapted to our regression equations because it accounts for the correlations among the error terms (Habermann, Blackhurst and Metcalf, 2015). Indeed, the SUR equation modeling is suitable to generate robust regression estimates when a set of equations includes identical independent variables (Habermann, Blackhurst and Metcalf, 2015). We used these set of equations below:

$$Robustness = \beta_0 + \beta_1 SCRM_{ct} + \beta_2 SI_{ct} + \beta_3 CI_{ct} + Controls \quad (1)$$
$$Agility = \beta_0 + \beta_1 SCRM_{ct} + \beta_2 SI_{ct} + \beta_3 CI_{ct} + Controls \quad (2)$$

To assess multicollinearity, we used traditional OLS regression to estimate the variance inflation factors (VIF) for regression coefficients among our independent variables (Habermann, Blackhurst and Metcalf, 2015). The VIF values vary from 1.38 to 2.38, indicating that our results are below the recommended cut-offs for multicollinearity problems (Hair *et al.*, 2006).
The results of the seemingly unrelated regression are presented in table 2a and table 2b. The first group of hypotheses proposed a positive direct effect of supplier integration (H1a) and customer integration (H1b) on robustness and a similar positive direct effect between supplier integration (H2a) and customer integration (H2b) on agility. The SUR results provided full support for this set of hypotheses H1a, H1b, H2a and H2b, thus demonstrating that SCI positively and significantly enhance supply chain resiliency in its robustness and agility dimension. The second group of hypotheses suggested that SCRM is positively related to robustness (H3a) and agility (H3b). The results indicate that SCRM is positively and significantly related to robustness and agility. Hence both our hypotheses are supported.

Hypotheses 1 proposed a positive relationship between SCI and robustness. The relationship was positive and significant for the supplier integration $(\boldsymbol{\beta} = \mathbf{.14},\ \boldsymbol{\rho} < \mathbf{.01})$, and customer integration $(\boldsymbol{\beta} = \mathbf{.18},\ \boldsymbol{\rho} < \mathbf{.00})$, hence providing full support for hypotheses H1a and H1b. Also, our results supported the hypotheses 2, where we suggested that SCI has a positive and significant effect on agility both for supplier integration hypothesis H2a $(\boldsymbol{\beta} = \mathbf{.12},\ \boldsymbol{\rho} < \mathbf{.05})$ and customer integration Hypothesis H2b $(\boldsymbol{\beta} = \mathbf{.18},\ \boldsymbol{\rho} < \mathbf{.00})$. Finally, the results confirm the hypotheses H3a and H3b and suggest that SCRM is positively and significantly enhancing robustness H3a $(\boldsymbol{\beta} = \mathbf{.33},\ \boldsymbol{\rho} < \mathbf{.00})$ and agility $(\boldsymbol{\beta} = \mathbf{.26},\ \boldsymbol{\rho} < \mathbf{.00})$.

Table 1- Confirmatory Factor Analysis

Construct[a]	Loading
Robustness (α = .89; CR = .90; AVE = .66)	
To what extent do these statements apply to your supply chain should disruptions of operations occur (1= Not at all; 7= To a very great extent):	
ROB1 Operations would be able to continue	,780
ROB2 We would still be able to meet customer demand	,836
ROB3 performance would not deviate significantly from targets	,829
ROB4 The supply chain would still be able to carry out its regular functions	,820
Agility (α = .85; CR = .86; AVE = .62)	
Please indicate the speed of reaction with which your company can engage in the following activities should changes occur (1= Slow; 7= Fast):	
AGI1 Adapt manufacturing lead-times	,692
AGI2 Adapt level of customer service	,804
AGI3 Adapt delivery reliability	,762
AGI4 Adapt responsiveness to changing market needs	,854
Supply chain risk management practices (α = .89; CR = .89; AVE = .66)	
What level of effort did your company invest in action programs within the previous 3 years (1= None, 7 = High):	
SCRM1 Rethinking and restructuring supply strategy and the organization and management of supplier portfolio	,811
SCRM2 Implementing supplier development and vendor rating programs	,820
SCRM3 Rethinking and restructuring distribution strategy in order to change the level of intermediation	,839
SCRM4 Implementing practices including early warning system, effective contingency programs for possible supply chain disruptions	,785
Supplier Integration (α = .91; CR = .91; AVE = .68)	
Please indicate the extent of integration or information sharing between your organization and your major supplier in the following areas (1 = Not at all; 7 = Extensive):	
SI1 Our major supplier shares their production schedule with us	,840
SI2 Our major supplier shares their production capacity with us	,897
SI3 Our major supplier shares available inventory with us	,809
SI4 We share our production plans with our major supplier	,804
SI5 We share our inventory levels with our major supplier	,735
Customer Integration (α = .84; CR = .84; AVE = .57)	
Please indicate the extent of integration or information sharing between your organization and your major customer in the following areas (1 = Not at all; 7 = Extensive):	
CI1 Our major customer shares Point of Sales (POS) information with us	,756
CI2 Our major customer shares demand forecast with us	,771
CI3 We share our available inventory with our major customer	,686
CI4 We share our production plan with our major customer	,716

The first item in each scale was fixed to a loading of 1.0 in the initial run to set the construct's scale. Observed CFA fit statistics were: X2(401) = 178.25; TLI = .933; incremental fit index = .944; comparative fit index = .943; root mean square error of approximation = .06

Table 2a: SUR Results for Robustness

Seemingly Unrelated Regression: DV1 Robustness

	Control Model		*Full model*	
Variables	*B*	S.E	*B*	S.E
Controls				
Firm Size	-.03	(.05)	-.08*	(.04)
Supplier relationship duration	.15*	(.07)	.11*	(.06)
Country dummy	.86***	(.18)	.19	(.16)
Customer relationship duration	.01	(.07)	.02	(.06)
Industry-type dummy variables[a]				
Main effects				
Supply chain risk management			.33***	(.05)
Supplier Integration			.14**	(.05)
Customer Integration			.18***	(.05)
Model Summary				
R^2	.20		.48	
ΔR^2			.28	

Sample size for all models, N = 283.
[a]Industry type was included as a dummy variable, but it was not included in the table for the sake of brevity.
Results are presented as coefficients and standard errors in (parentheses).
* $p < .05$,
** $p < .01$,
*** $p < .000$.

Table 2b: SUR Results for Agility

Seemingly Unrelated Regression: DV2 Agility

	Control Model		*Full model*	
Variables	**B**	**S.E**	**B**	**S.E**
Controls				
Firm Size	-.10*	(.05)	-.14***	(.04)
Supplier relationship duration	.14*	(.07)	.10	(.05)
Country (dummy variable)	.55*	(.17)	-.04	(.16)
Customer relationship duration	-.06	(.06)	-.05	(.05)
Industry-type dummy variables[a]				
Main effects				
Supply chain risk management			.26***	(.05)
Supplier Integration			.12*	(.05)
Customer Integration			.18***	(.05)
Model Summary				
R^2		.17		.41
ΔR^2				.24

[a]Industry type was included as a dummy variable, but for the sake of brevity, it was not included in the table.
Results are presented as coefficients and standard errors in (parentheses).
* $p < .05$,
** $p < .01$,
*** $p < .000$.

5. IMPLICATIONS AND RESEARCH AVENUES

By studying supply chain resiliency from an information-based view, we suggest that firms can mobilize buffering and bridging to enhance their resiliency by balancing their information needs and capacity. As a result, we complement the existing findings regarding enhancers of resiliency (Pettit, Fiksel and Croxton, 2010; Scholten, Sharkey, Scott and Fynes, 2014) by nuancing the supply chain practices that company can build on to improve its robustness and agility. Hence, by opting for bridging or buffering strategies, managers can vary the levels of information capacity and information needs according to the set of resources they have to enhance the resiliency of their supply chain. Our findings identify supply chain integration and supply chain risk management practices as two crucial factors that contribute to enhancing the firm's robustness and agility.

The findings of this study offer a threefold contribution to supply chain management and OIPT literature. First, past studies on SCI focused on investigating its effects on various forms of firm performance such as operational performance (Swink, Narasimhan and Wang, 2007; Flynn, Huo and Zhao, 2010), financial performance (Vickery *et al.*, 2003; Chang *et al.*, 2016), and business performance (Flynn, Huo and Zhao, 2010; Cao and Zhang, 2011). Nevertheless, the study of other types of SCI benefits is still scarce. This paper's results demonstrate the role SCI plays in enhancing supply chain resiliency in its two dimensions (robustness and agility). We considered SCI as an information exchange relationship that involves repeated interactions between the firm and its supply chain partners to collect and interpret data. Per OIPT principles (Galbraith, 1977), we consider SCI as a bridging strategy that enables the firm to cope with high uncertainty, which allows the firm to endure and recover from a disruptive event. By creating bridges with supply chain partners, SCI acts as a mechanism to increase the firm's information processing capacity. By tightly integrating with suppliers and customers, the firm can enhance its visibility of the supply chain to prepare beforehand for disruptive events. Moreover, SCI allows the firm to leverage the established routines and procedures to quickly make sense of collected information and react quickly to disruptive events.

Second, we differentiate between risk identification practices as a bridging strategy that increases the firm's information processing capacity. In contrast, the risk mitigation practices are viewed as buffering practices aiming to reduce the firm's need to process information. Consistent with OIPT principles, we explained that the practices of SCRM allow the firm to bridge with supply chain partners to identify sources of risk proactively and buffer against disruptive events by building the necessary redundancy in the supply chain to absorb the possible shocks of disruptive events. Thanks to bridging practices aiming to identify sources of risks, the firm can detect and position more effectively the buffers' ex-ante to disruptions. While buffering options through mitigation practices will allow the firm to react promptly to disruptions by capitalizing on the created slacks (safety stock, dual sourcing, etc.).

Third, by viewing the enhancement of supply chain resiliency as an information-based process, we deemed suitable to apply the OIPT to explain how the combination of bridging and buffering strategies through SCI and SCRM practices can allow the firm to cope with the high uncertainty involved in building robustness and agility to deal with SC disruptions. By studying these two factors, we answer researchers' calls to investigate the enhancers of supply chain resiliency (Blackhurst, Dunn and Craighead, 2011). Consistent with OIPT principles, we suggest that managers can cope with the uncertainty implied by disruptive events either by increasing their information processing capacity through bridging alternatives via SCI and risk identification practices of SCRM or by decreasing their needs for information processing through buffering alternatives via the implementation of mitigation practices of SCRM practices that seeks to build redundancy in the supply chain. Therefore, we contribute to OIPT by offering two mechanisms that can be used to manage or lessen the uncertainty to improve supply chain resiliency.

Our study extends and clarifies prior research on supply chain resiliency by investigating two mechanisms through which the firm can enhance its robustness and agility. Specifically, we study how supply chain integration and supply chain risk management practices enhance the resiliency of the firm to disruptive events. By applying OIPT principles, we identified buffering and bridging as two mechanisms through which the firm can cope with uncertainty. Our results demonstrate that bridging strategy allows the firm to increase its information processing capacity by leveraging the lateral benefits relations with suppliers and customers. Also, it can confer to the firm the possibility of identifying risks effectively to implement adequate solutions that will enhance supply chain resiliency. Finally, implementing a buffering strategy enables the firm to create the required redundancy to reduce its information processing needs.

Future research can attempt to replicate our study to add on its validation or use longitudinal data to analyze SCI and SCRM practices on agility and robustness over time. Second, we limited our model to two possible enhancers of supply chain resiliency, but other unexplored factors might contribute to supply chain resiliency. We invite future research to explore other factors that may improve robustness and agility. Finally, in our preliminary study we did limit the external integration scale to a fraction of the original items used by Flynn et.al (2010) to study SCI construct. In future studies, we should include the three dimensions of SCI (external and internal) and mobilize the full set of items to capture the different aspects of SCI.

REFERENCES:

El Abdellaoui, M. and Pache, G. (2019) ‘Effects of disruptive events within the supply chain on perceived logistics performance’, *Economics Bulletin*, 39(1), pp. 41–54.
Allianz Risk Barometer 2020 (2020), Available at: https://www.agcs.allianz.com/news-and-insights/reports/allianz-risk-barometer.html.
Ataseven, C. and Nair, A. (2017) ‘Assessment of supply chain integration and performance relationships: A meta-analytic investigation of the literature’, *International Journal of Production Economics*. Elsevier, 185, pp. 252–265.
Barratt, M. and Oke, A. (2007) ‘Antecedents of supply chain visibility in retail supply chains: a resource-based theory perspective’, *Journal of Operations Management*, 25(6), pp. 1217–1233.
Blackhurst, J., Dunn, K. S. and Craighead, C. W. (2011) ‘An Empirically Derived Framework of Global Supply Resiliency’, *Journal of Business Logistics*, 32(4), pp. 374–391.
Blome, C. and Schoenherr, T. (2011) ‘Supply chain risk management in financial crises - A multiple case-study approach’, *International Journal of Production Economics*. Elsevier, 134(1), pp. 43–57.
Bode, C. *et al.* (2011) ‘Understanding Repsonses to Supply Chain Disruptions: Insights From Information Processing and Resource Dependence Perspectives’, *Academy of Management Journal*, 54(4), pp. 833–856.
Brandon-Jones, E. *et al.* (2014) ‘A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness’, *Journal of Supply Chain Management*, 50(3), pp. 55–73.
Cao, M. and Zhang, Q. (2011) ‘Supply chain collaboration: Impact on collaborative advantage and firm performance’, *Journal of Operations Management*. 29(3), pp. 163–180.
Chang, W. *et al.* (2016) ‘Supply chain integration and firm financial performance: A meta-analysis of positional advantage mediation and moderating factors’, *European Management Journal*. Elsevier Ltd, 34(3), pp. 282–295.
Chen, D. Q., Preston, D. S. and Xia, W. (2013) ‘Enhancing hospital supply chain performance: A relational view and empirical test’, *Journal of Operations Management*. Elsevier B.V., 31(6), pp. 391–408.
Chen, I. J. and Paulraj, A. (2004) ‘Towards a theory of supply chain management: The constructs and measurements’, *Journal of Operations Management*, 22(2), pp. 119–150.
Chopra, S. and Sodhi, M. S. (2004) ‘Managing risk to avoid supply-chain breakdown’, *MIT Sloan management review*, 46(1), pp. 53–62.
Chowdhury, M. M. H. and Quaddus, M. (2017) ‘Supply chain resilience: Conceptualization and scale development using dynamic capability theory’, *International Journal of Production Economics*. Elsevier B.V., 188(September 2015), pp. 185–204.
Christopher, M. and Lee, H. (2004) ‘Mitigating supply chain risk through improved confidence’, *International Journal of Physical Distribution & Logistics Management*, 34(5), pp. 388–396.
Christopher, M. and Peck, H. (2004) ‘Building the Resilient Supply Chain’, *The International Journal of Logistics Management*, 15(2), pp. 1–14.
Courtright, S. H. *et al.* (2016) ‘My Family Made Me Do It: a Cross-Domain, Self-Regulatory Perspective on Antecedents to Abusive supervision’, *Academy of Management Journal*, 59(5), pp. 1630–1652.
Craighead, C. W. *et al.* (2007) ‘The Severity of Supply Chain Disruptions : Design Characteristics and Mitigation Capabilities’, *Decision Sciences*, 38(1), pp. 131–156.
Daft, R. L. and Lengel, R. H. (1986) ‘Organizational Information Requirements, Media Richness and Structural Design’, *Management Science*, 32(5), pp. 554–571.
Fennell, M. L. and Alexander, J. A. (1987) ‘Organizational Boundary Spanning in Institutionalized Environments.’, *Academy of Management Journal*, 30(3), pp. 456–476.
Flynn, B. B., Huo, B. and Zhao, X. (2010) ‘The impact of supply chain integration on performance: A contingency and configuration approach’, *Journal of Operations Management*, 28(1), pp. 58–71.
Frohlich, M. T. and Westbrook, R. (2001) ‘Arcs of integration: An international study of supply chain strategies’, *Journal of Operations Management*, 19(2), pp. 185–200.
Galbraith, J. R. (1973) *Designing Complex Organizations.* Reading, MA.: Addison-Wesley.
Galbraith, J. R. (1974) ‘Organization design: An information processing view’, *Interfaces*, 4(3), pp. 28–36.
Galbraith, J. R. (1977) *Organization design.* Reading, MA.: Addison-Wesley.
Habermann, M., Blackhurst, J. and Metcalf, A. Y. (2015) ‘Keep Your Friends Close? Supply Chain Design and Disruption Risk’, *Decision Sciences*, 46(3), pp. 491–526.
Hair, J. F. *et al.* (2006) *Multivariate data analysis*. Englewood Cliffs, NJ: Prentice-Hall.
Hair, J. F. *et al.* (2010) *Multivariate data analysis*. 7th ed. Upper Saddle River, NJ: Prentice-Hall.
Hazen, B. T. *et al.* (2017) ‘Enterprise architecture: A competence-based approach to achieving agility and firm performance’, *International Journal of Production Economics*. Elsevier Ltd, 193(July), pp. 566–577.
Hendricks, K. B. and Singhal, V. R. (2005a) ‘An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm.’, *Production & Operations Management*, 14(1), pp. 35–52.

Hendricks, K. B. and Singhal, V. R. (2005b) 'Association between Supply Chain Glitches and Operating Performance', *Management Science*, 51(5), pp. 695–711.
Kitano, H. (2004) 'Biological robustness', *Nature Reviews Genetics*, 5(11), pp. 826–837.
Kotabe, M., Martin, X. and Domoto, H. (2003) 'Gaining from vertical partnerships: Knowledge transfer, relationship duration, and supplier performance improvement in the U.S. and Japanese automotive industries', *Strategic Management Journal*, 24(4), pp. 293–316.
Koufteros, X. (2014) 'The Effect Of Performance Measurement Systems On Firm Performance: A Cross-Sectional And A Longitudinal Study', *Journal of Operations Management*. Elsevier B.V, pp. 313-336.
Lavastre, O., Gunasekaran, A. and Spalanzani, A. (2012) 'Supply chain risk management in French companies', *Decision Support Systems*. Elsevier B.V., 52(4), pp. 828–838.
Liang, W. and Huang, C. (2006) 'Agent-based demand forecast in multi-echelon supply chain', *Decision Support Systems*, 42(1), pp. 390–407.
Liu, H. *et al.* (2016) 'The configuration between supply chain integration and information technology competency: A resource orchestration perspective', *Journal of Operations Management*. Elsevier Ltd, 44, pp. 13–29.
Malhotra, M. K. and Grover, V. (1998) 'An assessment of survey research in POM: from constructs to theory', *Journal of Operations Management*, 16(4), pp. 407–425.
Manuj, I. and Mentzer, J. T. (2008) 'Global Supply Chain Risk Management', *Journal of Business Logistics*, 29(1), pp.133–155.
Mayer, R. C., Davis, J. H. and Schoorman, F. D. (1995) 'An Integrative Model Of Organizational Trust', *Academy of Management Review*, 20(3), pp. 709–734.
Meznar, M. B. and Nigh, D. (1995) 'Buffer or Bridge? Environmental and Organizational Determinants of Public Affairs Activities in American Firms', *Academy of Management Journal*, 38(4), pp. 975–996.
Min, H. and Galle, W. P. (2001) 'Green purchasing practices of US firms', *International Journal of Operations & Production Management*, 21(9), pp. 1222–1238.
Montabon, F. L., Daugherty, P. J. and Chen, H. (2018) 'Setting Standards for Single Respondent Survey Design', *Journal of Supply Chain Management*, 54, pp. 35–41.
Pettit, T. J., Croxton, K. L. and Fiksel, J. (2013) 'Ensuring supply chain resilience: Development and implementation of an assessment tool', *Journal of Business Logistics*, 34(1), pp. 46–76.
Pettit, T. J., Fiksel, J. and Croxton, K. L. (2010) 'Ensuring Supply Chain Resilience: Development of a Conceptual Framework', *Journal of Business Logistics*, 31(1), pp. 1–21.
Rothaermel, F. T. and Deeds, D. L. (2006) 'Alliance type, alliance experience, and alliance management capability in high-technology ventures', *Journal of Business Venturing*, 21(4), pp. 429–460.
Sambasivan, M. and Yen, C. N. (2010) 'Strategic alliances in a manufacturing supply chain: Influence of organizational culture from the manufacturer's perspective', *International Journal of Physical Distribution & Logistics Management*, 40(6), pp. 456–474.
Sarathy, R. (2006) 'Security and the global supply chain', *Transportation Journal*, 45(4), pp. 28–51.
Schoenherr, T. and Swink, M. (2012) 'Revisiting the arcs of integration: Cross-validations and extensions', *Journal of Operations Management*. Elsevier B.V., 30(1–2), pp. 99–115.
Scholten, K., Sharkey, Scott, P. and Fynes, B. (2014) 'Mitigation processes – antecedents for building supply chain resilience .', *Supply Chain Management: An International Journal*, 19(2), pp. 211–228.
Sheffi, Y. and Rice, J. B. (2005) 'A Supply Chain View of the Resilient Enterprise Resilient', *MIT Sloan Management Review*, 47(1), pp. 41–48.
Srinivasan, R. and Swink, M. (2015) 'Leveraging Supply Chain Integration through Planning Comprehensiveness: An Organizational Information Processing Theory Perspective', *Decision Sciences*, 46(5), pp. 823–861.
Stank, T. P. and Keller, S. B. (2001) 'Supplychain Collaboration And Logistical service Performance', *Journal of Business Logistics*, 22(1), pp. 29–48.
Swink, M., Narasimhan, R. and Wang, C. (2007) 'Managing beyond the factory walls: Effects of four types of strategic integration on manufacturing plant performance', *Journal of Operations Management*, 25(1), pp. 148–164.
Tummala, R. and Schoenherr, T. (2011) 'Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP)', *Supply Chain Management: An International Journal*, 16(6), pp. 474–483.
Tushman, M. L. and Nadler, D. A. (1978) 'Information processing as an integrating concept in organizatonal design', *Academy of Management Review*, 3(3), pp. 613–624.
Vickery, S. K. *et al.* (2003) 'The effects of an integrative supply chain strategy on customer service and financial performance: An analysis of direct versus indirect relationships', *Journal of Operations Management*, 21(5), pp. 523–539.
Wagner, S. M. and Neshat, N. (2012) 'A comparison of supply chain vulnerability indices for different categories of firms', *International Journal of Production Research*, 50(11), pp. 2877–2891.
Wieland, A. and Wallenburg, C. M. (2012) 'Dealing with supply chain risks: Linking risk management practices and strategies to performance', *International Journal of Physical Distribution & Logistics Management*, 42(10), pp. 887–905.
Wieland, A. and Wallenburg, C. M. (2013) 'The influence of relational competencies on supply chain resilience: a

relational view', *International Journal of Physical Distribution & Logistics Management*, 43(4), pp. 300–320.
Wiengarten, F. *et al.* (2016) 'Risk, risk management practices, and the success of supply chain integration', *International Journal of Production Economics*. Elsevier, 171, pp. 361–370.
Wong, C. Y., Wong, C. W. and Boon-itt, S. (2015) 'Integrating environmental management into supply chains', *International Journal of Physical Distribution & Logistics Management*, 45(1/2), pp. 43–68.
Zhang, M. and Huo, B. (2013) 'The impact of dependence and trust on supply chain integration', *International Journal of Physical Distribution & Logistics Management*, 43(7), pp. 544–563.