An examination of the effect of supply chain disruption risk drivers on organizational performance: evidence from Chinese supply chains

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An Examination of the Effect of Supply Chain Disruption Risk Drivers on Organizational Performance: Evidence from Chinese Supply Chains

Purpose. This paper examines the relationship of supply chain disruption risk drivers to supply chain performance and firm performance outcomes.

Design/methodology/approach. Four disruption risk drivers for a supply chain are identified: demand disruption risk, supply disruption risk, process disruption risk, and environment disruption risk. A cross-sectional survey was developed, and data was collected from 315 Chinese firms to determine the relationship of supply chain disruption risks to supply chain performance and firm performance.

Findings. Our empirical findings show that supply disruption risks and process disruption risks have a significant impact on supply chain performance. In addition, we show that supply disruptions, demand disruptions, and process disruptions are significantly related to firm performance. We show that supply chain disruption risks have different effects on supply chain performance and firm performance. Managers should be aware that disruption risk drivers can have an impact on firm performance that is different from their impact on supply chain performance. An important finding of the study is that the magnitude of the impact of disruption risks on supply chain performance is greater on the upstream side of the supply chain than on the downstream side of the supply chain.

Originality/value. This is one of the early studies to examine the effect of supply chain disruption risk drivers on both firm performance and supply chain performance. An important finding of the study is that the magnitude of the impact of disruption risks on supply chain performance is greater on the upstream side of the supply chain than on the downstream side of the supply chain.

Keywords: Supply Chain Risk Management; Supply Risk; Demand Risk; Process Risk; Environmental Risk; COVID-19.

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1. Introduction

The business environment is facing high levels of uncertainty and complexity that make organizations vulnerable to supply chain disruptions (Knemeyer et al., 2009; Ambulkar et al., 2015; Fan et al., 2016). High-profile events such as natural disasters, political turmoil, diseases, and terrorism have severely disrupted the normal daily operations of firms (Chen et al., 2013; Sodhi and Tang, 2012; Sawik, 2013; Tukamuhabwa et al., 2015; Sawik; 2018). Recently, the outbreak of COVID-19 showed that events with unprecedented uncertainty had impacted normal supply and demand patterns, leading to large losses in sales and disruptions in logistics and supply chain systems. Over 400 companies have suffered with the large impact of COVID-19 on their first quarter earnings in 2020, and the leading economies have entered into recession after a decade of expansion (Bermingham and Tan, 2020; Cecere; 2020; Klebnikov, 2020). Thus, understanding how firms can manage disruptions and develop contingency plans to respond to supply chain disruptions has become a key area of research in supply chain management (Behzadi et al., 2018; Azadegan et al., 2020; Parast, 2020).

A supply chain disruption is defined as an event that disrupts the flow of goods or services in a supply chain system (Revilla and Saenz, 2017; Truong and Hara, 2018). It can have severe negative consequences on firm performance at multiple levels as well as on customers and suppliers (Hendricks and Singhal, 2003; Wagner and Bode, 2008; Bode and Macdonald, 2017). Firms have begun to address the importance of investment in supply chain disruption management to mitigate the impact of disruptions (Jüttner and Maklan, 2011; Melnyk et al., 2010; Wieland and Wallenburg, 2013; Dubey et al., 2019).

While the literature discusses how disruptions affect organizational performance (Hendricks and Singhal, 2003), many firms do not invest in disruption mitigation strategies and do not develop dynamic capabilities to make their supply chain robust and resilient. There are two main reasons for this. First, it would be challenging to quantify the long-term benefit of investment in the capabilities of a supply chain to mitigate disruptions from low-probability high-impact events, so from a cost-benefit perspective, managers are reluctant to commit to such investment. (Tang, 2006; Chopra and Sodhi, 2014). Second, managers need to know the relative importance of different disruption risk drivers and their impact on organizational performance. This is

important because it helps firms to orient their investment in supply chain capabilities to be more responsive to disruptions. Surprisingly, with the exception of a few studies (Wagner and Bode, 2008; Chen et al., 2013; Parast, 2020), there is limited research on the impact of different disruption risk drivers on firm performance and supply chain performance outcomes.

This study aims to address this gap in the literature by an examination of the impact of supply chain risks on firm performance and supply chain performance in the context of a Chinese supply chain. China is among 25 economies posing 'extreme' supply chain risks (CFO Innovation Asia, 2016), so it provides a suitable context to study supply chain disruptions. The other important contribution of this study is to determine the magnitude of the effect of different sources of supply chain disruptions on firm performance and supply chain performance. Although supply chain disruptions are expected to have a negative effect on organizational performance, it is important to know the magnitude of such effects. From a more practical, managerial aspect, it is important to develop organizational capabilities to mitigate the disruptions that have the most negative impact on organizational performance. Thus, understanding the relative magnitude of the impact on organizational performance of each disruption risk driver in a supply chain system has important practical and managerial implications.

The purpose of this paper is twofold: First, we develop a survey instrument for supply chain disruptions that includes several dimensions of supply chain disruptions, in order to provide a reliable and valid survey instrument that can be used for future research in supply chain risk management. Second, we assess the impact of different dimensions of supply chain disruptions on both supply chain performance and firm performance, using the empirical evidence from China.

2. Theoretical Perspectives on Supply Chain Disruptions

We define a supply chain risk as "the potential deviation from the expected value of a certain supply chain performance measure" (Wagner and Bode, 2008; Kumar et al., 2010; Chen et al., 2013; Parast, 2020). This definition of supply chain risk is centered on the variance-based view of risk (Miller, 1992), where risk is defined as the "variation in the distribution of possible outcomes, their likelihoods, and their subjective values" (March and Shapira, 1987, p. 1404). In this view, increases in the deviation from the expected value of a performance outcome lead to increased variation and a consequent increase in the level of risk (Yates and Stone, 1992; Shapira, 1995). Thus, we view risk management in a supply chain as an effort to identify the sources of disruption and then develop mitigation strategies to minimize the impact of disruptions on supply

chain performance and firm performance. The sources of variation in a supply chain include all disruptions that affect performance at the supply chain level and firm level by affecting the flow of information, products, and services across the supply chain (Jüttner et al., 2003). Thus, a variance-based view of supply chain risk management suggests that disruptions would have a negative effect on organizational performance.

Alternatively, the *Theory of Swift, Even Flow* can be used to address how supply chain disruptions impact organizational performance (Schmenner and Swink, 1998; Chen et al., 2013; Schmenner, 2014). Schmenner and Swink (1998) argue that improving the flow of material through the process enhances productivity and process performance. Swift, even flow involves two factors: 1) reducing variation, which can be assessed in terms of changes in quality, quantity, and timing; and 2) reducing process time, which is the time it takes to produce a product or deliver a service (Schmenner, 2014). Variability of the incoming material flow in terms of quality, quantity, or timing would have a negative impact on productivity (Schmenner, 2004). This suggests an inverse relationship between variability of the process and its associated performance outcome (Devaraj et al., 2013). Thus, from the perspective of swift, even flow in a supply chain, where an organization is facing different types of variation (e.g., demand, supply, and environment), there is a negative relationship between supply chain disruptions and organizational performance.

Complementary to the above discussion, *systemic risk theory* and *normal accident theory* explain how disruptions and firm performance are related (Scheibe and Blackhurst, 2018). Systemic risk theory explains how failures in a subset of a system can create chain reactions in the entire system (Ray, 2010). According to normal accident theory, failures in one part of a system can disrupt the activities and operations of other segments of the system (Perrow, 1999). While both theories emphasize the effect of failures and disruptions in the normal operations of the system, they do not discuss how such failures in a system (e.g., a supply chain) can impact organizational performance outcomes, and whether the impact of different supply chain disruption drivers (e.g., supply, demand, or environment) on organizational performance would be different. We aim to address these gaps in this study.

2.1. Previous studies in supply chain disruptions

Although the relationship between supply chain disruptions and organizational performance has been studied from several perspectives, most of those studies do not differentiate among different

types of disruptions. There are also studies that examine the impact of enhancing resilience to mitigate the negative effect of supply chain disruption risk drivers on organizational performance (e.g., Parast, 2020). Our focus in this paper is to review studies that examine the effect of different types of disruption risks on firm performance and supply chain performance. A literature review suggests that there are two empirical studies that examine the relationship between different supply chain disruption risk drivers and organizational performance. Here we provide an overview of the findings of those two studies.

Wagner and Bode (2008) examined the effect of different supply chain disruption risk drivers on supply chain performance in the context of Germany. The study defined supply chain disruption risk drivers such as demand risk; supply risk; regulatory, legal, and bureaucratic risk; infrastructure risk; and catastrophic risk. Their results showed that demand disruptions and supply disruptions have significant (negative) impacts on supply chain performance.

Chen et al. (2013) developed a supply chain risk management framework composed of demand risk, supply risk, and process risk in manufacturing firms in the Australian context. Their findings suggest that demand risk and process risk each have a significant impact on supply chain performance, but the effect of process risk is more than twice the effect of demand risk. Their findings also showed that collaboration (internal collaboration, supplier collaboration, and customer collaboration) is regarded as a mitigation strategy that decreases disruption risks in a firm's supply chain.

Table 1. Empirical Studies in Supply Chain Disruption Risks

Study	Types of supply chain disruptions	Performance measure	Context	Methodology	Major findings
Wagner and Bode (2008)	demand, supply, regulatory, legal and bureaucratic risk, infrastructure risk, and catastrophic risk	Supply chain performance	Germany	Ordinary least squares (OLS) regression model	Demand and supply disruptions have a significant (negative) impact on supply chain performance.
Chen et al. (2013)	Demand, supply, and process risks	Supply chain performance	Australia	Structural equation modeling	Demand risk and process risk have a significant impact on supply chain performance
Our study	Demand, supply, process, and environmental disruption risk	Supply chain performance Firm performance	China	Structural equation modeling	The effect of supply chain disruptions on firm performance is different from the effect on supply chain performance.

As shown in Table 1, previous studies emphasize the need to study the relationship between disruption risk drivers and supply chain performance in different contexts. However, we still have limited understanding about the impact of different types of disruption risks on supply chain performance and firm performance. We also need better understanding of the magnitude of the influence of such disruptions on different types of organizational performance outcomes. While both previous studies show that demand disruption risks have a significant impact on supply chain performance, they provide mixed results on the effect of supply disruption risks on supply chain performance. Most studies related these differences to factors such as the national culture (Jia and Rutherford, 2010; Revilla and Sáenz, 2014) and geographical traits (Durach and Wiengarten, 2017), along with differences in operationalizing supply chain disruption risks.

Thus, further scholarly work in supply chain disruption risk in different regions stresses the importance of understanding the relationship between disruption risks and organizational performance outcomes, which will ultimately advance our theoretical understanding and practical insight into supply chain disruption risk management. We aim to address this gap in the literature by examining the relationship of different types of supply chain disruption risk drivers to both firm performance and supply chain performance, thereby providing a more nuanced assessment of the impact of supply chain disruptions on different types of performance outcomes. In our study, we also examine the effect of disruption durability, disruption familiarity, and disruption frequency on the relationship between different types of supply chain disruptions and organizational performance. Capturing the duration, familiarity, and frequency of the disruption in our study allows us to assess different types of disruptions with respect to these contextual factors that may vary across firms. In addition, we explore the relationship between supply chain disruption risk and organizational performance in the context of Chinese supply chains. Using China as a context for our study enables us to advance the literature in supply chain disruptions. In addition, our study uses one of the widely established frameworks in supply chain management, which is discussed in the following section.

3. Conceptual Development and Hypotheses

Christopher and Peck (2004) proposed a typology for conceptualizing disruptions from a supply chain perspective.[1] In this framework, there are five supply chain disruption risks sorted into three

[1] We realize that there are many other conceptual frameworks for supply chain disruption (e.g., Wagner and Bode, 2008; Thun and Hoenig, 2011; Chen et al., 2013; Talluri et al., 2013; Lu et al., 2017). The conceptual framework

categories: disruption risks internal to the firm (process and control), disruption risks external to the firm but internal to the supply chain (demand and supply), and disruption risks external to the supply chain (environmental). Figure 1 presents the disruption risks used in this study and their relationships. In this study we focus on four types of disruption risks (supply, process, demand, and environmental).

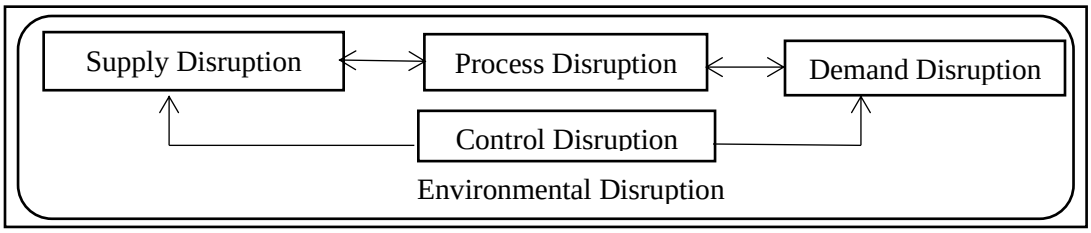

Figure 1. Supply Chain Disruption Risk Drivers (Christopher and Peck, 2004)

3.1 Supply disruption

Supply side disruptions take place in the upstream side of a firm's supply chain (Christopher and Bode, 2008; Samvedi et al., 2013). The literature on quality management has acknowledged the importance of supplier quality in improving firm performance (Kaynak, 2003). By improving supplier product quality and eliminating uncertainties, firms would be able to minimize supplier risk (Giunipero and Eltantawy, 2004). A supplier's financial stability and its ability to have a strong market position, both technologically and financially, have also been recognized as important factors in managing supply risk (Wagner and Johnson, 2004).

Supply disruption can also occur as a result of operational inefficiency in the supplier, deviations in product quality and quantity, logistics and transportation delays, or poor coordination between a supplier and the firm (Kumar et al., 2010; Chen et al., 2013; Sarker et al., 2016). Product quality and service quality can significantly contribute to reducing supply disruption, especially when they extend across the entire supply chain (Tse and Tan, 2012). In addition, suppliers should have the capability to adapt to changes in market demand (such as customer preferences) and the capability to remain competitive through new product development (Zsidisin and Ellram, 2003; He et al., 2020). Moreover, a recent study suggested that the negative effects of the COVID-19 pandemic lockdown on global supply disruption came from having a complex supply network that was subject to many human errors and safety concerns (Gunessee and Subramanian, 2020). In

presented here provides the most comprehensive assessment of supply chain disruption risks in terms of capturing different types of risks in a supply chain.

addition to the negative impact of supply disruptions on firm performance, supply disruptions can affect outbound logistics and consequently deteriorate supply chain performance in terms of delivery time (Chen et al., 2013). Thus, we have these hypotheses:

H_{1a}: There is a negative relationship between supply disruption and supply chain performance.

H_{1b}: There is a negative relationship between supply disruption and firm performance.

3.2 Demand disruption

Firms are exposed to demand disruption as a result of disruption in the downstream side of the supply chain (Jüttner, 2005). Demand disruption can arise from incidents such as disruptions in the distribution of products to customers due to transportation delays or other logistical inefficiencies, or from unstable and unpredictable customer demand (Nagurney et al., 2005; McKinnon, 2006). Demand variations such as changes in order quantity, shorter product life cycle, and the introduction of new products pose significant risks to the firm (Ho et al., 2005; Manuj and Mentzer, 2008). COVID-19 showed that customers who engage in panic buying and social distancing cause volatility in demand with a ripple effect in supply chains (Gunessee and Subramanian, 2020)

A fundamental activity in a supply chain is to properly match demand and supply. Demand disruption also occurs when a firm is not able to properly match supply and demand, as a result of either forecast inaccuracy, a ripple effect, or from inefficient coordination in the supply chain (Chen et al., 2013). A classic example of a mismatch between supply and demand happens due to the bullwhip effect, when demand fluctuation is further amplified across the upstream of the supply chain; this fluctuation affects forecast accuracy, capacity utilization, and production planning, which all lead to operational inefficiency (Lee et al., 1997; Lee, 2002). In addition, the supply chain of a firm will be negatively affected as a result of fluctuations in demand. Based on the above, we have these hypotheses:

H_{2a}: There is a negative relationship between demand disruption and supply chain performance.

H_{2b}: There is a negative relationship between demand disruption and firm performance.

3.3 Process disruption

Process disruption occurs as a result of disruption in a firm's internal operations; examples are capacity limitation, machine failure, quality problems, and inefficient IT infrastructure (Chopra

and Sodhi, 2004; Talluri et al., 2013; Gunessee and Subramanian, 2020). As firms increasingly rely on their IT infrastructure to maintain supply chain function, they become more vulnerable to IT-related problems such as cyber attacks or hardware failure (Chopra and Sodhi, 2004).

According to Hopp and Spearman (2000), process variability is increased by variations in process selection, production design, and management decisions. One of the key aspects of organizational processes is their adaptability to respond to changes in the internal and external environment (Valença et al., 2013). Organizations can minimize process variability by implementing cross-functional teams, improving communication systems between departments, and making effective use of knowledge sharing procedures (Flynn et al., 1995; Chen et al., 2013). In fact, the implementation of management programs such as total quality management was popularized due to their ability to minimize process variability (Schmenner and Swink, 1998). Based on these considerations, we have these hypotheses:

H_{3a}: There is a negative relationship between process disruption and supply chain performance.

H_{3b}: There is a negative relationship between process disruption and firm performance.

3.4 Environmental disruption

Incidents such as pandemics, epidemics, natural disasters (such as earthquakes), socio-political instability, economic downturns, and terrorist attacks are examples of environmental disruption (Parast, 2020; Gunessee and Subramanian, 2020). These events are exogenous to the firm and its supply chain, they happen infrequently, and their impact on a firm's supply chain can be significant. The negative impact of environmental disruptions on supply chains can be substantial, since production facilities, logistics, and transportation systems are vulnerable to natural disasters or terrorism attacks (Kamalahmadi and Parast, 2016; Kamalahmadi and Parast, 2017). Taking these aspects into account, we have these hypotheses:

H_{4a}: There is a negative relationship between environmental disruption and supply chain performance.

H_{4b}: There is a negative relationship between environmental disruption and firm performance.

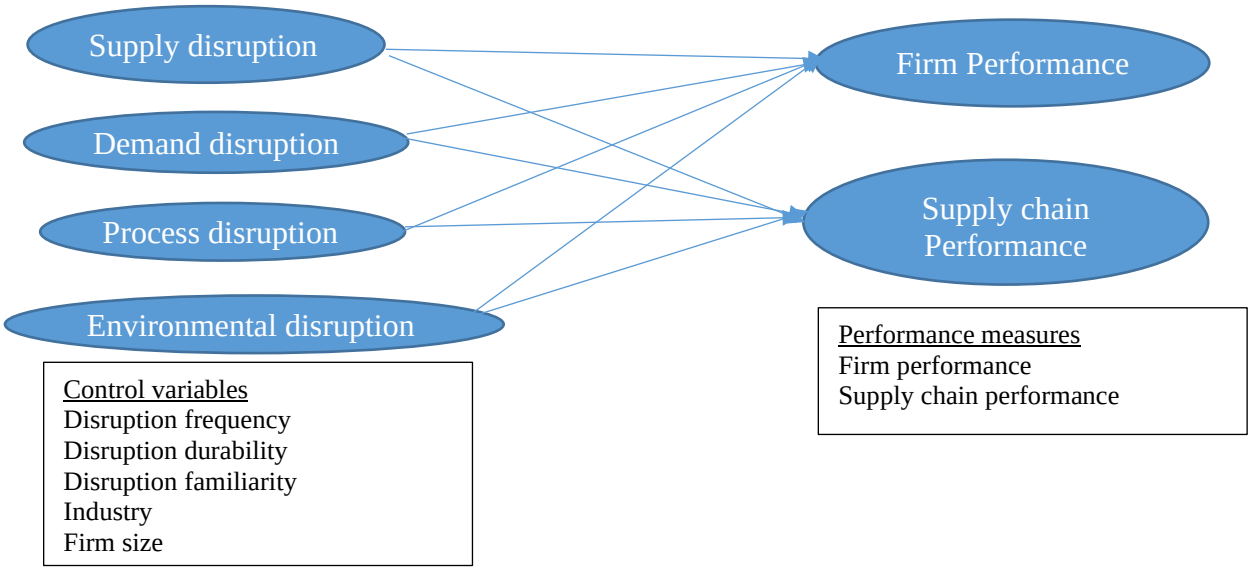

Figure 2. Conceptual Model for Supply Chain Disruption Risks

4. Methodology

4.1. Survey development

We derived standard scales from the literature to measure all the constructs in our research model, shown in Figure 2. A copy of the survey is provided in the Appendix.

Since our context is China, we used the recommended double-translation method to translate our survey instrument. The original version of the questionnaire was in English. We used the back-translation method to ensure consistency, accuracy, and appropriateness of translation. There were two teams, with each team composed of two bilingual academics with Ph.D. degrees. Of the two members in each team, one member was an academic with an operations management background, and the other was an academic from the Centre for English Language Education. The two teams did back translations simultaneously; then we exchanged the translations to sort out the issues (if any) in terms of accuracy and appropriateness.

We piloted our survey instrument with four manufacturing firms in the eastern province of China. We focused on three major industrial clusters in the eastern province: Shanghai, Guangzhou, and Hangzhou. Each of these centers was contributing ten percent to the GDP and to the growth of the national economy (Subramanian et al., 2015). In addition, the companies located in these clusters were advanced, and many had ties with multi-national corporations.

To administer the survey, we used an intermediary to conduct the survey and collect the data. The intermediary circulated the online link to individuals in the firms within our sample and announced a luck draw to win a smartphone for those who completed the survey. In addition, the intermediary also sent reminders on a weekly basis. The total time taken to complete the survey (60 minutes maximum) was taken as a proxy for an honest response. Moreover, when the intermediary got consent, they requested that the respondent include an email address and contact number if the respondent wished to get the report of the study. Later, one of the author's research associates randomly contacted companies to verify the authenticity of the company's response.

4.2. Data collection

We used a systematic stratified random sampling method to select Chinese firms for our study. We generated our initial sample by randomly including 135 firms in each province that are registered with the provincial government, using a Chinese trade directory for 22 provinces. This enabled us to include firms from all major provinces of China. Our sample includes the views of multiple respondents at focal firms in manufacturing and service industries, including transportation, information technology, manufacturing, and services. Our total sample had 487 valid responses out of 2970 approached firms, with a response rate of 16.6%. We eliminated surveys that had missing values; therefore, the final sample size was 315. Table 2 provides the characteristics of the final sample.

Table 2. Characteristics of the Final Sample

Industry Type	Frequency	Percent
Transportation/Logistics	10	3.17
Information Technology	24	7.62
Manufacturing	257	81.59
Services	24	7.62
Total	315	100
Sales (in 10 thousand USD)	Frequency	Percent
Up to 100	48	15.24
101-500	57	18.10
501-1000	65	20.63
1001-5000	70	22.22
5001-10000	22	6.98
Over 10000	53	16.83
Total	315	100
Number of Employees	Frequency	Percent
Up to 100	88	27.94
101-500	136	43.17
501-1000	42	13.33
1001-1500	21	6.67
1501-2000	12	3.80

Over 2000	16	5.00
Total	315	100.0
Job Categories	Frequency	Percent
Vice President (or higher)	29	9.21
Manager (General/Project/Plant)	161	51.11
Manager (Supply Chain / Purchasing/Commodity)	89	28.25
Senior Engineer/ Engineer	32	10.16
Others	04	1.27
Total	315	100.0

4.3 Measurements

A survey instrument developed by Wagner and Bode (2008) was used in this study. We made modifications to the survey to fit our conceptualization of supply chain disruption risk management used in this study. With respect to the indicators (items) for the risk drivers, we initially reviewed and followed the survey instrument developed by Wagner and Bode (2008). In the process, we added new items to the survey to improve its reliability and validity. For example, demand disruption in Wagner and Bode (2008) has only three indicators. While that is acceptable from a measurement aspect, we were concerned about the risk of losing one of the indicators in the analysis due to low factor loading. Thus, we decided to enhance the original survey developed by Wagner and Bode (2008) to improve its robustness in terms of increasing reliability and validity. For regulatory, legal, and bureaucratic risks, Wagner and Bode (2008) had included only two items. Having only two items is a concern regarding the validity and reliability of the constructs. In addition, Wagner and Bode (2008) defined another disruption risk driver called catastrophic risks, which aims to measure natural disasters, terrorist attacks, and political instability. While they did not provide an explanation for separating regulatory, legal, and bureaucratic risks and catastrophic risks, we were able to merge these under the environmental risk based on the framework proposed by Christopher and Peck (2004). In summary, our study was developed based on the framework proposed by Christopher and Peck (2004), where we used the survey instrument developed by Wagner and Bode (2008). We made certain modifications to the survey to make it compatible with the supply chain resilience model proposed by Christopher and Peck (2004). A copy of the survey items is provided in the Appendix.

Independent variables. Firm-level response to supply chain disruptions was used as the unit of analysis (Parast, 2020). We identified four dimensions of supply chain disruption: supply disruption, demand disruption, process disruption, and environmental disruption.

Dependent variables. We defined two response variables: 1) firm-level performance, and 2) supply-chain-level performance. We measured *Firm Performance* and *Supply Chain Performance* using a 7-point Likert scale by asking respondents about the negative impact on firm performance and supply chain performance due to the four dimensions of disruption risks in a supply chain (Wagner and Bode, 2008; O'Neil et al., 2016; Maestrin et al., 2017). Table 3 provides the list of constructs, their descriptions, and their sources.

Table 3. Constructs, Their Descriptions, and Their Sources

Construct	Description	Source
Supply disruption	Measured using four items as a result of operations on the upstream side of the firm's supply chain, involving activities such as purchasing, supplier relationship, supplier quality, and supply network	Wagner and Bode (2008)
Demand disruption	Measured using four items that evaluate disruption risks related to changes in demand, such as loss of major accounts, volatility of demand, concentration of customer base, short life cycles, and innovative competitors	Wagner and Bode (2008)
Process disruption	Measured using four items that evaluate internal risks of the firm, such as manufacturing yield variability, lengthy set-up times and inflexible processes, equipment unreliability, bottlenecks or limited capacity, and outsourcing of key business processes	Wagner and Bode (2008)
Environmental disruption	Measured using four items that evaluate disruption risks such as natural disasters, terrorism and war, regulatory changes, and strikes	Wagner and Bode (2008)
Firm performance	Measured by return on assets, product quality, customer service level, market share, average selling price, and competitive position	Narasimhan et al. (2008)
Supply chain performance	Measured by order-fill capacity, delivery speed, delivery dependability, and customer satisfaction	Wagner and Bode (2008)

It is important to note that firm performance is different from supply chain performance. Frohlich and Westbrook (2001) discuss the challenges associated with understanding the relationship between financial performance of a firm and its supply chain performance. Thus, we examined the relationship between supply chain disruption risk drivers and both performance outcomes simultaneously. A study by Johnson and Templar (2011) alludes to the relationship between supply chain performance and firm performance. While these measures are expected to be correlated, they are different; this is examined in the following sections.

Control variables. We used three sets of control variables that are expected to be related to the response variable. To control for firm characteristics, we used Firm Size. It is argued that larger firms have more resources to respond to disruptions (Saint-Germain, 2005). The second level of control variables capture industry segments. We identified four categories of industry segments to group the observations. The third category of control variables are related to the frequency, durability, and familiarity of the disruption.

4.4 Analysis

We present the descriptive statistics in Table 4. We examined the normality of the data by evaluating the measures of skewness and kurtosis. By reviewing correlations, we find a significant correlation between *Firm Performance* and *Supply Chain Performance* (ρ=.603, $p<.05$), which supports the argument that firm performance is related to supply chain performance.

Table 4. Variables and Their Correlations

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1. Firm Size *(Control)*	604	1021	1.00									
2. Disruption Durability *(Control)*	4.03	1.73	-.019	1.00								
3. Disruption Familiarity (*Control*)	4.07	1.72	-.052	.735**	1.00							
4. Disruption Frequency (*Control*)	3.47	1.76	-.074	.680**	.602**	1.00						
5. Supply Disruptions	4.63	1.23	.043	.397**	.375**	.391**	1.00					
6. Demand Disruptions	4.80	1.22	.027	.323**	.294**	.302**	.717**	1.00				
7. Process Disruptions	4.23	1.47	.073	.382**	.336**	.427**	.725**	..601**	1.00			
8. Environmental Disruptions	3.89	1.67	.036	.272**	.231**	.319**	.604**	.477**	.711**	1.00		
9. Firm Performance	4.08	1.44	.016	.358**	.391**	.413**	.406**	.313**	.385**	.344**	1.00	
10. Supply Chain Performance	4.54	1.42	.020	.450**	.403**	.475**	.574**	.395**	.528**	.396**	.603**	1.00

** p<.05 * p <.10

Measurement model. Statistics for factor loadings, average variance extracted (AVE), and construct reliabilities are presented in Table 5. Reliability assessment was conducted using Cronbach's Alpha (Nunnally and Bernstein, 1994; Malhotra, 2004); all the reliability values are larger than 0.70. We used AMOS 25.0 to assess the validity of the measurement model (Hair et al., 2013). Assessment of the model fit provided satisfactory model fit: $\chi 2/df = 2.6$, RMSEA = (.70, .79) (Hu and Bentler, 1999; Iacobucci, 2010). Assessment of convergent validity was conducted using factor loadings, reliability, and AVE measures. Convergence validity was checked by reviewing the factor loadings; all were above .50. In addition, a review of composite reliability found that they are all greater than 0.7, providing additional support for convergent

validity (Hair et al., 2010). Finally, AVE numbers are all greater than or equal to 0.5, providing support for discriminant validity.

Table 5. Reliabilities

Scale	Indicators	Loadings	Reliability	Composite reliability	Average Variance Extracted
Supply Disruption	SR_1	.75	.87	.91	.55
	SR_2	.77			
	SR_3	.66			
	SR_4	.77			
	SR_5	.77			
Demand Disruption	DR_1	.69	.81	.87	.50
	DR_2	.74			
	DR_3	.73			
	DR_4	.67			
Process Disruption	PR_1	.78	.84	.93	.64
	PR_2	.82			
	PR_3	.79			
	PR_4	.81			
Environmental Disruption	ER_1	.87	.91	.93	.61
	ER_2	.86			
	ER_3	.85			
	ER_4	.77			
	ER_5	.70			
	ER_6	.61			
Firm Performance	FP_1	.78	.92	.92	.64
	FP_2	.81			
	FP_3	.82			
	FP_4	.82			
	FP_5	.73			
	FP_6	.83			
Supply Chain Performance	SCP_1	.76	.89	.94	.67
	SCP_2	.84			
	SCP_3	.82			
	SCP_4	.85			

Assessment of common method bias and non-response. We tested for non-response through comparing characteristics of the sample that responded (sample of 315) with those that were contacted but did not reply (sample of 2930) in terms of industry (SIC code), function within the company, sales, and net profit. We did not find any significant differences.

To assess common method bias, all variables were entered to determine the number of factors that are necessary to account for the variance in the variables using Harman's one-factor test (Podsakoff et al., 2003; Steensma et al., 2005; Krishnan et al., 2006). Unrotated principal component factor analysis showed that about 65% of the variance was explained by four factors, where the largest factor accounted for 33% of the variance. Thus, we concluded that the results are not impacted by common method variance.

5. Results

Structural equation modeling using the maximum likelihood procedure was used to test the hypotheses. Since our objective was to evaluate the effects of various supply chain disruption risk drivers on performance outcomes, we used a set of control variables. The list is presented earlier in Table 4. The results are presented in Table 6 for both the controls and the predictors.

Table 6. Standardized Regression Coefficients

Variables	**Outcomes**	
Controls	Supply Chain Performance	Firm Performance
Firm Size	.023	.033
Disruption Durability	.144*	-.069
Disruption Familiarity	.023	.287**
Disruption Frequency	.243**	.169**
Transportation	.071	-.079
Information Technology	-.015	.008
Service	.002	.081
Predictors		
Supply Disruption	.380**	.106*
Demand Disruption	-.067	.112*
Process Disruption	.250**	.137**
Environmental Disruption	-.001	-.001
Measure of fit (R^2)	.36	.18

*p<.10, **p<.05

The results show that *Disruption Frequency* has a significant relationship with *Firm Performance* (ß=.169, p <.05) and with *Supply Chain Performance* (ß=.243, p<.05). We also find that *Disruption Durability* has a significant effect on *Supply Chain Performance* (ß=.144, p <.10). We find that *Supply Disruption* has a significant impact on both *Firm Performance* (ß=.106, p <.10) and *Supply Chain Performance* (ß=.380, p <.05). *Demand Disruption* has a significant impact on *Firm Performance* (ß=.112, p <.10). We did not find a significant relationship between *Demand Disruption* and *Supply Chain Performance* (ß=-.067, p >.10).

We find that *Process Disruption* has a significant impact on *Firm Performance* (ß=.137, p <.05), and *Supply Chain Performance* (ß=.250, p <.05). With respect to the relationship between environmental disruption and performance outcomes, we were not able to find a significant relationship between *Environmental Disruption* with either *Firm Performance* (ß=-.001, p >.10), or *Supply Chain Performance* (ß=-.001, p >.10).

5.1 Robustness Test

We explored the validity of alternative models. One potential alternative model that is suggested in the literature asserts that supply chain performance would have an impact on firm performance (Johnson and Templar, 2011). This alternative model provides the following model fit statistics: χ^2/df =3.40; RMSEA=.088; χ^2 = 1404.45 and *df*=412 (reduced model). The structural model proposed in this study has the following fit indices: χ^2/df = 3.40, RMSEA=.088; χ^2= 1404.46 and *df*=413 (base model). The alternative model does not provide much improvement over the base model (the χ^2 values are not much different). Thus, we conclude that the base model provides a better assessment of the relationship between disruption risk drivers and organizational performance outcomes.

6. Discussion

Our study provides important theoretical contributions to supply chain risk management literature, and the results help supply chain managers understand the relationship between supply chain disruption risk, firm performance, and supply chain performance. We discuss these findings in the following sections.

6.1 Theoretical contributions

The results of this study provide new knowledge and directions for organizations in managing supply chain disruptions. According to the results, supply disruptions and process disruptions have the most profound impact on supply chain performance; supply disruptions, process disruptions, and demand disruptions significantly affect firm performance. These findings support previous research regarding the relationship between supply disruption risk drivers and supply chain performance (Wagner and Bode, 2008). However, by measuring performance outcomes at two levels, we were able to provide a more nuanced explanation of the effect of supply chain disruption risks on supply chain performance and firm performance.

Our second contribution is concerned with providing empirical evidence on similarities and differences related to the impact of supply chain disruption risk drivers on organizational

performance outcomes. While supply disruption has a significant impact on supply chain performance (ß=.380, p <.05) and firm performance (ß=.106, p <.10), the impact is more pronounced on supply chain performance. Similarly, the impact of process disruption on supply chain performance is more pronounced (ß =.250, p <.05) than the impact of process disruption on firm performance (ß =.137, p <.05).

It should be noted that we were not able to find sufficient evidence to support a significant relationship between environmental disruptions and organizational performance outcomes (firm performance and supply chain performance). One possible explanation would be that environmental disruptions fall into the category of "low probability, high impact" events. We know that these incidents happen infrequently; thus, on average, organizations would not be able to properly capture their impact due to limited information. The current COVID-19 pandemic is a good example of such disruptions. While they happen rarely, such environmental disruptions have short-term and long-term impacts on global supply chains and disrupt economic activities across the globe. Due to the low probability of such disruptions, we would not be able to capture their effect properly. In particular, the effect of environmental risk has not been included in the theory of swift, systemic risk theory, and normal accident theory. When we collected the data, the respondents had not yet encountered pandemics such as COVID-19, and all they knew was the effect of natural disasters and epidemics. However, future risk theories need to include the moderating and mediating effects of environmental risks on both supply chain performance and organizational performance.

We also found that supply chain disruption risks have a more pronounced impact on firm performance than on supply chain performance. Three of the four supply chain disruption risks (supply, demand, and process) have a significant impact on firm performance. Thus, from a practical standpoint, firms need to be aware of the impact of supply chain disruptions on their operations as well as the impact on supply chain performance outcomes. The fact that three of the four supply chain disruption risks have significant impacts on firm performance implies that supply chain risk management should address disruption risk sources at the firm level, in order to ensure that each member of the value chain is proactive to mitigate the negative impact of supply chain disruptions. These findings provide an important insight related to the relationship between supply chain disruptions and organizational performance. Firms need to evaluate investments in organizational capabilities with respect to their specific performance goals. Our empirical findings

show that supply chain disruption risks have different impacts on different measures of organizational performance. For example, demand disruptions have a significant impact on firm performance, but they do not have a significant impact on supply chain performance. Because a firm develops a variety of performance measures to determine its progress in achieving specific organizational objectives, mitigating supply chain disruptions should be addressed based on the organization's performance objectives.

Our study also provides important insights into the relative importance of supply disruption vs. demand disruption on organizational performance outcomes. Previous studies have reported mixed findings on the impact of supply disruptions and demand disruptions on supply chain performance (Wagner and Bode, 2008; Chen et al., 2013). We think the main reason for the mixed findings in previous studies is related to their model specification: their model has only one dependent variable (supply chain performance). By measuring organizational performance due to disruptions at both the firm level and the supply chain level, we showed that supply disruptions have a significant impact on both firm performance and supply chain performance, while demand disruptions have a significant impact on firm performance but not a significant impact on supply chain performance. Thus, viewed from a supply chain perspective, managing supply disruptions should be considered as the first priority of organizations. In that regard, our findings support the managers' perception regarding the more significant impact of supply risk compared to demand risk (Christopher et al., 2011). Furthermore, managing process disruption should be a priority as well, because process disruptions have a significant impact on both supply chain performance (ß =.250, p<.05) and firm performance (ß =.137, p<.05). From the perspective of both firm performance and supply chain performance outcomes, the effect of supply chain disruption risks on firm performance and supply chain performance increases as we move from the downstream (demand) side to the upstream (supply) side in the supply chain.

Finally, we realize that our study was conducted in the context of Chinese firms. Future studies can examine the relationship between supply chain disruptions and organizational performance in other regions in order to examine the validity of the findings. Our empirical findings regarding the impact of supply chain disruptions on two performance outcomes suggest that firms need to carefully balance supply-demand dynamics in order to minimize the effect of supply chain disruptions on their performance outcomes. Thus, effective supply-demand

coordination, which is the core of supply chain management (Wagner and Bode, 2008), can help firms minimize the impact of supply chain disruptions.

6.2 Implications for managers

Our study has several insights for supply chain managers that can help them address disruption risks in their supply chains. First, managers should be aware of the impact of supply chain disruption risks on different levels of organizational performance outcomes, as the impact of supply chain disruptions risk would be different on firm performance and supply chain performance. While from a practical standpoint, firms are motivated to improve their organizational performance (i.e., firm performance), effective risk management across the supply chain requires attention to both firm-level and supply-chain-level disruption risk, as well as determining the best way to examine the overall impact of disruptions on performance outcomes. To improve performance at both the firm level and the supply chain level, managers need to address supply disruptions and process disruptions. Operations and supply chain managers should realize that while managing supply chain partners is important, managers should also pay close attention to the internal processes of the firm (Chen et al., 2013).

The second managerial implication of our study is to inform operations and supply chain managers regarding the trade-off between investing in disruption mitigation capabilities at the supply chain level vs. at the firm level. One possible solution to address such a tradeoff would be to emphasize supply chain collaboration practices as an effective disruption mitigation strategy; this requires coordination between the firm and the supply chain entities to address improving supply chain disruption mitigation capabilities. Chen et al. (2013) showed that different forms of collaboration (internal collaboration, external collaboration, and customer collaboration) would decrease supply chain disruption risks. Empirical studies also show that supply chain collaboration has a positive effect on firm performance (Cao and Zhang, 2011; Liao and Kuo, 2014; Hill et al., 2018). Thus, investment in visibility and collaboration can be regarded as a supply chain disruption mitigation strategy that provides firms with resources, both internal and external, to address supply chain disruptions (Gunessee and Subramanian, 2020). Organizational preparedness and learning is limited, and organizations need to ensure resilience in their supply network through visibility and involvement of stakeholders. Because organizations are involved in collaborative activities with their suppliers and customers, they can view such efforts as a means to mitigate the negative

effects of supply chain disruptions that improves both firm performance and supply chain performance.

7. Future Research Directions

The study has several limitations. First, our data was collected by conducting a cross-sectional survey. Such research designs rely on respondents' perceptions, which are subjective in nature. While we were able to mitigate this limitation through capturing two measures of organizational performance, using objective measures of performance is recommended in future studies. We realize that obtaining objective measures for supply chain disruption risks would be a challenge. One way to mitigate this limitation would be to conduct longitudinal studies that examine the dynamics of disruptions in organizations over time. Finally, as described above, we conducted the study in China, with its specific cultural and economic system. Replication studies in other regions with different social and cultural norms are recommended, to enhance the external validity of the results. While the emergence of global supply chains has resulted in development of more efficient supply chains that work collaboratively, we need to be mindful of the potential impact on local or regional supply chains of factors such as the national culture (Gupta and Gupta, 2019). National culture has been shown to impact several operations management decision processes such as the number of suppliers, the type of relationship with suppliers, outsourcing decisions, and forecasting horizon (Pagell et al., 2005). Thus, one potential area of research in supply chain risk and disruption management would be to examine how the national culture could impact the relationship between supply chain disruption risks and organizational performance outcomes. In that regard, comparative assessment of supply chain disruption risk management across countries is a promising research area that warrants further attention.

We are also mindful of how we conceptualized supply chain disruption risks. From the environmental disruption perspective, our conceptualization of disruption risks is concerned with major disruptions to the firm's supply chain systems with respect to natural and manmade events. While our survey questions also capture the impact of diseases and epidemics on organizational performance outcomes, we should realize that existing global supply chains have not experienced a global pandemic similar to that of COVID-19 within the last century. Because of the unique challenges of COVID-19 and its impact on global supply chains, it would be valuable to assess the effect of COVID-19 on global supply chains and organizational performance using qualitative

studies. We feel that a qualitative study seems more appropriate because of the depth of the knowledge and the richness of the data that can be obtained through qualitative studies.

7. Conclusion

In this study, our goal was to examine how supply chain disruption risk drivers impact organizational performance outcomes. Our study extends prior research in disruption management in several ways. We assessed the impact of supply chain disruption risks on both firm performance outcomes and supply chain performance outcomes. More specifically, we showed that a supply chain disruption risk can have an impact on firm performance measures that is different from its impact on supply chain performance measures. The findings also contribute to the literature in supply chain risk management by validating a supply chain risk management measurement tool that can be used in future research.

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Appendix: Supply Chain Disruption Risk Management Survey

I. Sources of Risk

To what extent has your firm in the past 3 years experienced a negative impact in supply chain management due to the following sources of risk (1 strongly disagree – 7 strongly agree)

Demand Risk

	Strongly Disagree			Neither Agree Nor Disagree			Strongly Agree	Not Applicable
Unanticipated or very volatile demand.	1	2	3	4	5	6	7	X
Insufficient or distorted information from your customer about orders or demand quantities.	1	2	3	4	5	6	7	X
Unusual customer payment delays.	1	2	3	4	5	6	7	X
Request from the customer to expedite pending order (s).	1	2	3	4	5	6	7	X

Supply Risk

	Strongly Disagree			Neither Agree Nor Disagree			Strongly Agree	Not Applicable
Poor logistics performance of suppliers (e.g., delivery dependability, order fill capacity).	1	2	3	4	5	6	7	X
Supplier quality problems.	1	2	3	4	5	6	7	X
Sudden demise of a supplier (e.g., due to bankruptcy).	1	2	3	4	5	6	7	X
Poor logistics performance of logistics service providers.	1	2	3	4	5	6	7	X
Capacity fluctuations or shortages on the supply markets.	1	2	3	4	5	6	7	X

Process Risk

	Strongly Disagree			Neither Agree Nor Disagree			Strongly Agree	Not Applicable
Downtime or loss of own production capacity due to local disruptions (e.g., labor strike, fire, explosion, industrial accidents).	1	2	3	4	5	6	7	X
Perturbation or breakdown of internal IT infrastructure (e.g., caused by computer viruses, software bugs).	1	2	3	4	5	6	7	X
Loss of own production capacity due to technical reasons (e.g., machine deterioration).	1	2	3	4	5	6	7	X
Perturbation or breakdown of external IT infrastructure.	1	2	3	4	5	6	7	X

Environment Risk

	Strongly Disagree			Neither Agree Nor Disagree			Strongly Agree	Not Applicable
Political instability, war, civil unrest, or other socio-political crises.	1	2	3	4	5	6	7	X
International terror attacks (e.g., 2005 London, 2004 Madrid).	1	2	3	4	5	6	7	X
Disease or epidemics (e.g., SARS, foot and mouth disease, Ebola).	1	2	3	4	5	6	7	X
Natural disasters (e.g., earthquake, flooding, extreme climate, tsunami)	1	2	3	4	5	6	7	X
Changes in the political environment due to the introduction of new laws, stipulations, etc.	1	2	3	4	5	6	7	X
Administrative barriers for the setup or operation of supply chains (e.g., authorizations).	1	2	3	4	5	6	7	X

II. Performance Outcomes

To what extent has your firm in the past 3 years experienced a negative impact in performance as the result of the above sources of risks (1 strongly disagree – 7 strongly agree)

Supply Chain Performance

	Strongly Disagree			Neither Agree Nor Disagree			Strongly Agree	Not Applicable
Drop in order fill capacity: Provision of desired quantities on a consistent basis.	1	2	3	4	5	6	7	X
Drop in delivery dependability: Meeting quoted or anticipated delivery dates and quantities on a consistent basis.	1	2	3	4	5	6	7	X

Drop in customer satisfaction: Meeting customer satisfaction with supply chain performance on a consistent basis.	1 - 2 - 3 - 4 - 5 - 6 - 7	X
Drop in delivery speed: Time between order receipt and customer delivery.	1 - 2 - 3 - 4 - 5 - 6 - 7	X

Firm Performance

	Strongly Disagree	Neither Agree Nor Disagree	Strongly Agree	Not Applicable
Drop in return on assets.	1 - 2 - 3 - 4 - 5 - 6 - 7			X
Drop in overall product quality.	1 - 2 - 3 - 4 - 5 - 6 - 7			X
Drop in overall customer service levels.	1 - 2 - 3 - 4 - 5 - 6 - 7			X
Drop in market share.	1 - 2 - 3 - 4 - 5 - 6 - 7			X
Drop in average selling price (high performance means higher average price).	1 - 2 - 3 - 4 - 5 - 6 - 7			X
Drop in overall competitive position.	1 - 2 - 3 - 4 - 5 - 6 - 7			X

III. Miscellaneous Questions

Please answer the following questions about yourself and your company:

1. How many years have you worked in your current job? __ 0-2 yrs, __ 3-5 yrs, __ 6-10 years, __ 10+ years

2. Number of years your company has been in business: _____

3. Which of the following most accurately describes your position or title in your organization?

[ ] Vice President or higher
[ ] Project Manager
[ ] Senior Engineer
[ ] Engineer
[ ] Supply Chain Manager
[ ] Purchasing Manager
[ ] Plant Manager
[ ] General Manager
[ ] Commodity Manager or Senior Buyer
[ ] Other (please specify) _____

4. Please select your firm's business environment:

[ ] Transportation/Logistics
[ ] Finance/Insurance
[ ] Healthcare
[ ] Service industries
[ ] Utility
[ ] Telecommunication
[ ] Merchandiser/Retailer
[ ] Information Technology
[ ] Consulting
[ ] Manufacturing
[ ] Not-for-Profit
[ ] Wholesale/Distributor
[ ] Government/Military
[ ] Other (please specify):_____