Journal of the Korea Industrial Information Systems Research Vol.26 No.6, Dec. 2021 :61-80
http://dx.doi.org/10.9723/jksiis.2021.26.6.061 ISSN:1229-3741

The Role of Operational Absorptive Capacity on Supply Chain Risk+

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Abstract As the business environment becomes more rapid and unpredictable change, greater diversity, increased complexity, and intensified competitive pressures, supply chain risk management has been growing attention over the past several decades. However, little of known about how absorptive capacity can mitigate supply chain risk for improving operational performance despite its important role in responding to supply chain risk. Therefore, we aim to examine the role of organizational-level absorptive capacity on operational performance, and further identify how the interplay of individual-level and organizational-level absorptive capacity results in operational performance. Our results represent not only direct but also indirect effects of supply chain risk on operational performance, mediated by organizational-level absorptive capacity. Furthermore, this study reveals that individual-level absorptive capacity enhances the effect of organizational-level absorptive capacity on operational performance.

Keywords: Supply chain risk, operational absorptive capacity, manufacturing flexibility

1. Introduction

As the industrial environment has changed radically over the last two decades, with technology, market conditions, shorter product life-cycles and customer needs changing at an unprecedented speed and in directions that have been difficult to foresee, global firms in supply chain faced uncertainty associated with rivalry among existing firms and potential entrants into the industry(Jeong and Yoo, 2021; Lee and Lee, 2021).

Against the supply chain risk caused by the competitive and technological environments, the ability of a firm to respond quickly and flexibly to the risk source is critical issues (Bessant et al., 2003). Given increasing cross-functional efforts to broadly increase flexibility, a focus to scan the market condition and acquire external knowledge might be crucial to deal with more the supply chain risk such as to apply more productive manufacturing processes (Upton, 1994), and as a result to gain sustainable competitive advantage (Vokurka and O'Leary-Kelly, 2000).

To develop a firm's performance through quick and flexible response to the supply chain risk, numerous scholars have sought to

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+ This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (NRF-2019S1A5A2A03054143)
Manuscript received November 07, 2021 / revised November 23, 2021 / accepted November 28, 2021
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identify supply chain risk management to mitigate the negative impacts of supply chain risk by adopting various perspectives such as the fit of risk source, strategy and organizational structure (Lenz, 1980; Miller and Friesen, 1983; Venkatraman and Prescott, 1990), collaboration with partners (Ismail and Sharifi, 2006; McCullen and Towill, 2001), and their capabilities (Teece et al., 1997), with relatively a few on examining the relationship between a firm's absorptive capacity and its manufacturing flexibility.

In particular, a firm needs to develop the absorptive capacity as a supply chain risk capability to mitigate supply chain risks. Because the supply chain risk leads to greater restrictions creation of competitive advantages due to rapid, complex, and uncertain changes in today's environment, a firm pursues new knowledge to aggressively create innovation and sustain competitive advantage to constantly lookout for new opportunities in this uncertain environment (Zahra, 1991). In other words, the unpredictable changes in terms of rivalry and technology in market conditions facilitate a firm to develop better innovation capabilities in its exchange relationships to stay ahead of the competition (Jean et al., 2012). Absorptive capacity is organizational capability to acquire, assimilate, transform, and exploit knowledge (Zahra and George, 2002), which leads to enhancing capabilities required for confronting with unpredictable shifts and changes (Gilbert and Cordey-Hayes, 1996). As a result, absorptive capacity can allow a firm to mitigate supply chain risk.

To date, however, little of known about how absorptive capacity can mitigate supply chain risk for improving operational performance despite the popularity of using the absorptive capacity concept in operations field (Tu et al., 2006). Although several studies focused on the role of absorptive capacity on operational performance, the studies on absorptive capacity have largely overlooked the role of individuals in developing, deploying, and maintaining a firm's absorptive capacity (Rojo et al., 2017; Vokurka and O'Leary-Kelly, 2000). In other words, it has remained unclear how the individual-level and organizational-level absorptive capacity interplay in improving operational performance.

Given these apparent drawbacks in the extant studies, we investigate how the operational absorptive capacity can mitigate supply chain risk and further lead to operational performance in the manufacturing area of South Korea. Specifically, we aimed to examine the role of organizational-level absorptive capacity on operational performance, and further identify how the interplay of individual-level and organizational-level absorptive capacity results in operational performance.

The rest of the paper is organized as follows. Section 2 describes the theoretical background of research by reviewing the literature on supply chain risk and operational absorptive capacity in two dimensions, individual-level and organizational-level absorptive capacity, relevant to manufacturing flexibility in terms of internally-driven and externally-driven flexibility. Then, in Section 3, we introduce a research model of the causal relationships among the research constructs and relevant hypotheses. Section 4 describes the details of survey design, item development, and data collection. Section 5 presents the statistical analysis and hypothesis test results from the structural equation models (SEM) analysis. Finally, Section 6 addresses our findings to provide theoretical contributions and practical implications along with limitations and future research directions.

2. Theoretical background

2.1 Supply chain risk

In some studies on supply chain risk, researchers have considered “environmental uncertainty” as one of the risk sources of their research (e.g. Chong and Zhou, 2014; Iyer et al., 2004; Wang et al., 2006; Wang et al., 2013). Researchers have classified the “environmental uncertainty” into various risk sources. For example, Wong et al. (2011) categorized into demand/market, supply, competitive/technological, and organizational risks, while Rao and Goldsby’s (2009) typology of supply chain risks that range from the organization itself to the environment concerning the entire supply chain: organizational, industrial, and environmental risks.

In particular, as the business environment becomes more rapid and unpredictable change, greater diversity, increased complexity, and intensified competitive pressures, it is evident that successful firms not only have to perform better than their competitors, but also have to constantly be flexible to competitive and technological risks. Zhu et al. (2016) represents one of the main risk sources is uncertainty associated with rivalry among existing firms and potential entrants into the industry. The supply chain risk renders existing technology obsolete, which can facilitate a firm to develop innovation capabilities in its exchange relationships to stay ahead of the competition (Jean et al., 2012).

With regard to the literature on supply chain risk management, scholars have sought to identify the underlying management to mitigate risks of the supply chain by adopting various perspectives(Baz and Ruel, 2021; Pournader et al., 2020). One influence perspective has substantiated the need for various strategies, such as redundancy (Sheffi, 2005), dual sourcing (Trkman and McCormack, 2009), and postponement (Yang and Yang, 2010), to mitigate the negative impacts of supply chain risk. However, Rosenbusch et al. (2013) have warned of the wrong strategic decision in environmental changes because it can undermine the potential for long-term competitiveness.

Another line of research has paid attention to collaboration, such as supply chain integration, with partners to cope with supply chain risk (Zhu et al., 2016). Researchers have identified various benefits of collaboration or coordination with partners such as increased flexibility, responsiveness to customer requirements, reduced uncertainty (Carr and Pearson, 1999; Chen et al., 2004; Ellram and Edis, 1996; Jorde and Teece, 1989; Lamming, 1993; Li et al., 2006; Robb et al., 2008; Lee, 2019). However, it is evident to select the right partners, develop a suitable alliance design, adapt the relationship as required, and manage the end game appropriately (Reuer, 1999). In addition, it is necessary to precisely specify certain contractual aspects to achieve mutual consent in the emerging challenges (Lee et al., 2009).

Another primary perspective has drawn upon supply chain risk capability as an important role in responding to uncertainty and complexity by coordinating its human and other resources effectively (Grant, 1991; Ireland et al., 2002; Lengnick-Hall and Beck, 2005). A firm with high capabilities to respond to unpredictable changes in the business environment can shorten the time for processing information, and implementing strategies (Melville et al., 2004). For example, the agility refers to a firm's ability to respond and adapt quickly to uncertainty in the business environment (Liu et al., 2013), while flexibility represents the ability to respond to uncertainty in market conditions in a cost-, time-, and effort-efficient manner (Upton, 1995). To my best knowledge, however, little of known about how absorptive capacity can mitigate supply chain risks. Taken together, those research streams suggest that investment of supply chain risk capability is essential for better mitigating to supply chain risk. Thus, we propose that the supply chain risk capability improved by the firm has the potential to impact the firm's ability to be flexible in competitive and technological environments.

2.2 Operational absorptive capacity

Absorptive capacity can be defined as the ability of a firm to obtain, assimilate, and utilize external knowledge for its goals (Cohen and Levinthal, 1990), which allows a firm to create value, and to gain and sustain a competitive advantage through organization's prior and external knowledge (Cohen and Levinthal, 1990; Zahra and George, 2002). The concept of absorptive capacity has been studied across a wide spectrum of research, including investment and development in research (Cohen and Levinthal, 1990, 1994; Joglekar et al., 1997), research productivity in pharmaceutical firms (Cockburn and Henderson, 1998), innovation in banking services (Buzzacchi et al., 1995), information technology use (Boynton et al., 1994), inward technology licensing (Atuahene-Gima, 1992), strategic alliances (Koza and Lewin, 1998; Kumar and Nti, 1998; Lane and Lubatkin, 1998; Luo, 1997; Mowery et al., 1996; Shenkar and Li, 1999), knowledge transfer (Szulanski, 1996), and organizational learning(Lane and Lubatkin, 1998; Kim, 1998; Shenkar and Li, 1999). However, a few studies have explained absorptive capacity in the operations management literature despite the growing popularity of using the absorptive capacity and the importance of effectively absorbing and utilizing external knowledge in manufacturing fields (Cohen and Levinthal, 1990; terWal et al., 2011).

The operational absorptive capacity is "the ability of firm's operational units can acquire, assimilate, and transform external information" (Patel et al., 2012). It is an important learning capability that can effectively and efficiently obtains external knowledge and information, and then quickly increases the range and mobility of components of manufacturing flexibility such as machines, labor, and materials (Munir et al., 2020; Patel et al., 2012). Therefore, a firm with high operational absorptive capacity is more likely to proactively respond to uncertainty in the competitive market by rapidly modifying the product design, adjusting the level of output, and introducing new products (Patel et al., 2012). As a result, the operational absorptive capacity enables a firm to be able to be flexible to today's environment by developing manufacturing flexibility.

Fundamentally, a firm's absorptive capacity depends on the ability of its members to recognize valuable external knowledge, align it with existing knowledge, and facilitate its utilization within the organization (terWal et al., 2011). However, previous research has considerably neglected the role of individuals in growing, disposing, and sustaining a firm's absorptive capacity and its impact on operational performance. Instead, the studies on absorptive capacity have focused mainly on the organizational-level absorptive capacity, even often using crude measures to approximate it (Argyris and Schon, 1989; Kim, 1998). For example, Volberda et al. (2010) conclude that individual absorptive capacity is relatively neglected in the literature, although it is essential to build a block of absorptive capacity in the organization research (Lane et al., 2006; terWal et al., 2011). In this regard, it may still be more significant to clarify the interplay between individual and organizational absorptive capacity and their effects on facilitating the development of a firm's performance through manufacturing flexibility.

2.3 Manufacturing flexibility

Since Hayes and Wheelwright (1985) first emphasized the importance of manufacturing flexibility, it is widely recognized as a critical component to building a competitive advantage in an increasingly competitive market place (D'Souza and Williams, 2000; Gerwin, 1993; Hill, 1995; Kathuria and Partovi, 1999; Koste and Malhotra, 1999). Manufacturing flexibility can be described as the ability of the manufacturing function to react to shifts and changes with little penalty in time, effort, or performance (D'Souza and Williams, 2000; Upton, 1994), and respond to changing business environment (Gerwin, 1987; Gupta and Gupta, 1991).

There is general agreement among researchers that manufacturing flexibility is a multidimensional concept. Sethi and Sethi (1990) suggest 11 dimensions of manufacturing flexibility, Gupta and Somers (1996) identify nine, whereas Gerwin's (1993) taxonomy consists of seven dimensions which could include volume flexibility, material handling flexibility, mix flexibility, modification flexibility, changeover flexibility, rerouting flexibility, and flexibility responsiveness. D'Souza and Williams (2000) focus on four dimensions (volume flexibility, variety flexibility, process flexibility, and materials handling flexibility) based on the manufacturing function of the organization, called the factory, plant, or production function of the firm. Furthermore, they also note two of these dimensions (process flexibility and material handling flexibility) are "internally-driven," toward operational activities of the manufacturing function. The other two dimensions (volume flexibility and variety flexibility) are "externally-driven," toward meeting the market needs of the firm. Internally-driven flexibility including process flexibility and material handling flexibility tends to be more tactical, while externally-driven flexibility including volume flexibility and variety flexibility tends to be more strategic. Furthermore, those studies offered the nature of hierarchal relationships between flexibility dimensions (Koste and Malhotra, 1999). To date, however, previous studies on manufacturing flexibility have not tested empirically.

3. Research model and hypotheses

We introduce a research model with hypotheses to examine based on the literature review, as in Fig.1. Our study investigates the influence of operational absorptive capacity on a firm's performance through manufacturing flexibility in supply chain risk. More specifically, we broadly examine four types of relationships: (1) between supply chain risk and manufacturing flexibility (internally-driven and externally-driven flexibility), (2) mediated by organizational absorptive capacity, and (3) between internally-driven and externally-driven flexibility. Furthermore, we investigate the relationship between supply chain risk and organizational absorptive capacity, (4) moderated by individual absorptive capacity. The subsequent subsections represent the basis for each association in detail.

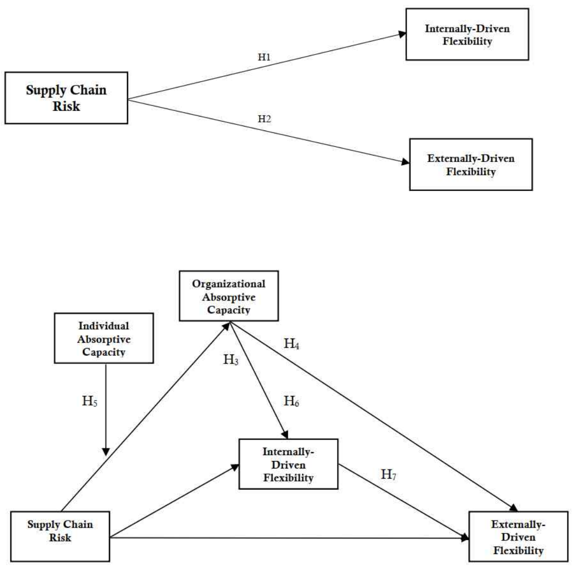

Fig. 1 Research model

3.1 Supply chain risk and its relationship with manufacturing flexibility

It has been argued that the nature of the business environment influences the level of flexibility required from operations. A firm must be more flexible when operating in highly uncertain environments (Martínez Sánchez and Pérez, 2005; terWal et al., 2011). D'Souza and Williams (2000) noted that there are external and internal drivers of flexibility. The external drivers represent the market conditions such as environmental uncertainty, perceived uncertainty, dynamism, unpredictability and market differentiation, while the internal drivers indicate operating characteristics such as process similarity. Further, Patel et al. (2012) found the direct effect of environmental uncertainty on manufacturing flexibility. As a result, the risk sources enforce a firm to pursue high manufacturing flexibility to develop a firm's performance due to its restrictions creation of competitive advantages.

Zahra (1991, 1996) has showed that firms competing in dynamic and growing competitive environments put a greater emphasis on product and process innovations compared to firms competing in stable and non-rivalrous environments. Barney (1991) suggests that A firm has a bunch of resources and capabilities that describe its competitive position and long-term performance. According to dynamic capability perspective, absorptive capacity refers to "the firm´s potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions and to change its resource base" (Barreto, 2010; Zahra and George, 2002). Since the knowledge obtained from the external environment via organizational absorptive capacity enables a firm to improve a deep understanding of market demands and to reorganize internal resources to respond it (Dobrzykowski et al., 2015; Rojo et al., 2018). As a result, supply chain risk enforces efforts that enable a firm to more improve efficiency in product line (Hambrick, 1983; Miller, 1991; Ward et al., 1996) and to more effectively serve markets through innovative adaptations to product and process lines. Therefore, we propose to test:

H1. Supply chain risk is positively associated with internally-driven flexibility.

H2. Supply chain risk is positively associated with externally-driven flexibility.

H3. Organizational absorptive capacity mediates the relation between supply chain risk and internally-driven flexibility.

H4. Organizational absorptive capacity mediates the relation between supply chain risk and externally-driven flexibility.

3.2 Individual- and organizational operational absorptive capacity

Individuals who proactively explore the external environment are more likely to induce innovations than those who execute lower levels of effort to seek externally. The alertness of individuals to opportunities is a critical part of their ability to generate new business concepts and products (Ardichvili et al., 2003; Gaglio and Katz, 2001; Kirzner, 1973). Alert individuals aggressively look for useful ideas, often in unusual places. They monitor developments across a broad range of sources, as they are often looking for ideas that differ from the conventional logic of their industry or organization (Kaish and Gilad, 1991). They may further be exploring constructive ideas to produce together new ideas with extant knowledge. Thus, we can expect individuals with high absorptive capacity facilitate organizations to more effectively acquire, transform, and share knowledge among internal departments, which in turn leads to high operational performance. Therefore, we propose to test:

H5. Individual operational absorptive capacity moderates the relation between supply chain risk and organizational operational absorptive capacity.

3.3 Internally-driven and externally-driven flexibility

A hierarchy built on such relationships between flexibility dimensions has been developed in prior literature (Browne et al., 1984; Hyun and Ahn, 1992; Sethi and Sethi, 1990). Sánchez and Pérez (2005) introduced the hierarchal relation of supply chain flexibility dimensions based on the earlier framework of Sethi and Sethi (1990). Furthermore, researchers generally appear to support the idea of viewing operational flexibility as an output of a system including both its vertical and horizontal dimensions (Stevenson, 2007; Zhang et al., 2008). Koste and Malhotra (1999) propose that the flexibility dimensions that tend to be more tactical serve as building blocks for the flexibility dimensions that tend to be more strategic. Therefore, we propose to test:

H6. Internally-driven flexibility mediates the relation between organizational absorptive capacity and externally-driven flexibility.

H7. Internally-driven flexibility is positively associated with externally-driven flexibility.

4. Servey design and data collection

4.1 Survey design and measures

Most of the survey items were selected based on the existing literature, as shown in Table 1.

Dependent variable. Manufacturing flexibilities were divided into internally-driven flexibility and externally-driven flexibility and based on a scale adapted from D'Souza and Williams (2000). Internally-driven flexibility is composed of process flexibility and materials handing flexibility, while externally-driven flexibility consists of volume flexibility and variety flexibility. Internally-driven flexibility was adapted in four items tapping into volume flexibility and variety flexibility toward “operational activities of the manufacturing function”. Externally-driven flexibility was measured using four items tapping into volume flexibility and variety flexibility toward “meeting the market needs of the firm”.

Independent variables. We defined supply chain risk as uncertainty associated with rivalry among existing firms and potential entrants into the industry. This study used three items adapted from Zhu et al. (2016) tapping into the intense competition and a relative lack of exploitable opportunities.

Mediator variables. We defined organizational operational absorptive capacity as organizational abilities of operational units to acquire, assimilate, and transform external information. The organizational operational absorptive capacity was measured with three items from Cohen and Levinthal (1994) and Zahra and George (2002) on organizational ability to undertake to acquire, assimilate, transform, and exploit knowledge from operations environment.

Moderator variables. We defined individual operational absorptive capacity as individual abilities of operational units to acquire, assimilate, and transform external information. Individual operational absorptive capacity was measured with four items from Patel et al. (2012) on the individual’s ability to undertake to acquire, assimilate, transform, and exploit knowledge from operations environment.

<Table 1> Measurements

Construct	Item	Measurements
Supply Chain Risk	SCR1	Our industry to which our firm belongs is very competitive in the domestic market
	SCR2	Our industry to which our firm belongs is very competitive in foreign markets
	SCR3	Our industry to which our firm belongs is likely to have new brand products or suppliers.
	SCR4	The technology of our industry is changing rapidly
Organizational Absorptive Capacity	OAC1	Employees (production departments) work together to solve problems that arise in business processes.
	OAC2	Employees (production departments) share their business knowledge and know-how.
	OAC3	Employees (production departments) strive to learn a wide range of knowledge and know-how from other departments and other firms.
Individual Absorptive Capacity	IAC1	Evaluate the level of knowledge or skill associated with your employees' work (production departments)
	IAC2	Evaluate the level of proficiency associated with your employees' work (production departments)
	IAC3	Evaluate the level of problem-solving skills associated with your employees' work (production departments)
	IAC4	Evaluate your employees' abilities in a comprehensive manner (production departments)
Internally Driven Flexibility	IDF1	Our company strives for small lot operation.
	IDF2	Our company strives to shorten preparation time (mold, tool, etc.).
	IDF3	Our company strive to shorten the cycle of a definite production plan (production plan that cannot be changed or modified)
	IDF4	Our company can continue production by adjusting the order of operations when production facilities are out of order.
Externally Driven Flexibility	EDF1	Our firm can produce various products
	EDF2	Our company can respond smoothly to changing orders.
	EDF3	Our company can respond to rapid changes in production volume.
	EDF4	Our company can respond smoothly to model changes.

4.2 Data collection, sample characteristics and common method bias

This data focuses on the ability of an individual and its organization to respond to the hypercompetitive market and its intended manufacturing flexibility. A random sample of 435 manufacturing firms in shipbuilding, automotive and general machinery industries from the 2013 survey was drawn from the Korea Productivity Center. Therefore, this study taps into the manufacturing company’s perceptions in a wide range of representative Korea manufacturing industries. Table 2 shows the descriptive statistics. Content validity can be determined by the extent to which the items of each construct in the survey instrument properly represent the research domain of investigation (Nunnally, 1954). This data drawn from the Korea Productivity Center is designed based on most of the scales form the extant literature to secure the content validity of the research constructs and the survey instrument (Churchill, 1979).

Despite the possible problem of common method bias, we have employed data from single respondents due to the high cost of gaining participation and consensus from several individuals from a large number of organizations (Miller and Roth, 1994). Thus we tried to minimize the extent of common method variance by applying ex ante remedy, as controlling common method bias should be started at the research design phase (Guide and Ketokivi, 2015). In data collection, we intentionally asked managers or people of higher rank to respond to the survey, as "high ranking informants tend to be more reliable sources of information than their lower counterparts" indicated by Philips (1981). As an ex post analysis, we conducted Harman's single factor test (Podsakoff et al., 2003) as well, finding that common method bias is not of significant concern.

<Table 2> Profiles of the sample firms and survey respondents (n = 435).

Characteristic		Frequency	Proportion (%)
Industry	Automobile parts	147	33.8
	Machinery	123	28.3
	Shipbuilding	84	19.3
	Communication device	81	18.6
Tiers in supply chain	First-tier supplier (Direct delivery to final manufacturers)	308	70.8
	Second-tier supplier (Delivery to first-tier suppliers)	127	29.2
Size	Large	33	7.6
	Middle-Standing	43	9.9
	Middle-Standing (Delaying)	4	0.9
	Small and Medium	355	81.6
Annual sales ($)	< 500,000	0	0.0
	500,000–1,000,000	1	2.0
	1,000,000–5,000,000	30	6.9
	5,000,000 –10,000,000	48	11.0
	>10,000,000	356	81.8

4.3 Convergent validity and discriminant validity of measurements

We adopted the conventional two-stage analysis approach for structure equation modeling (SEM) to accurately represent indicators by avoiding unnecessary interactions between measurement and structural models (Anderson and Gerbing, 1988). So we first applied a series of factor analyses to establish the measurement model in order to secure convergent validity and discriminant validity of the constructs. Then we used the finalized measurement model to determine the path coefficients of the structural model.

To evaluate convergent validity, we examined composite reliability and the average variance extracted (AVE) from the indicators (Hair et al., 1998). As shown in Table 3, composite reliability ranged from 0.773 to 0.933, exceeding the recommended value of 0.6 (Bagozzi and Yi, 1988). The AVE for each construct ranged from 0.483 to 0.914, satisfying the acceptable level of 0.5 (Fornell and Larcker, 1981). As the construct of supply chain risk includes comprehensive concepts of the unpredictable changes representing rivalry and technology in market conditions, the AVE for supply chain risk construct is relatively low. Thus, this sustains convergent validity of the measurement model.

<Table 3> Results of factor analysis

	Construct	Item	α	CR	AVE	Loading
Independent variables	Supply Chain Risk	SCR1	0.821	0.773	0.483	0.811
		SCR2				0.788
		SCR3				0.785
		SCR4				0.836
Mediator Variables	Organizational Absorptive Capacity	OAC1	0.903	0.892	0.734	0.878
		OAC2				0.901
		OAC3				0.890
Moderator variables	Individual Absorptive Capacity	IAC1	0.930	0.932	0.914	0.861
		IAC2				0.900
		IAC3				0.906
		IAC4				0.942
Dependent variables	Internally Driven Flexibility	IDF1	0.873	0.850	0.788	0.765
		IDF2				0.846
		IDF3				0.838
		IDF4				0.774
	Externally Driven Flexibility	EDF1	0.918	0.896	0.865	0.838
		EDF2				0.883
		EDF3				0.848
		EDF4				0.892

α = Cronbach's α; CR = Composite reliability; AVE = Average variance extracted.

To assess discriminant validity that each construct shares the greater variance with its own measurements than with those of other constructs, we compared the square root of AVE and the corresponding factor correlations (Fornell and Larcker, 1981). As shown in Table 4, the square root in AVE (diagonal elements) for each construct was larger than the corresponding inter construct correlations (factor correlations in the same column or the same row). Therefore, this confirms the presence of discriminant validity in the measurement model.

<Table 4> Correlations and discriminant validity

	SCR	OAC	IAC	IDF	EDF
Supply Chain Risk (SCR)	0.695				
Organizational Absorptive Capacity (OAC)	0.140**	0.857			
Individual Absorptive Capacity (IAC)	0.064	0.182***	0.956		
Internally Driven Flexibility (IDF)	0.149***	0.442***	0.188***	0.888	
Externally Driven Flexibility (EDF)	0.130**	0.248***	0.157***	0.539***	0.930

* $p< 0.1$; ** $p< 0.05$; *** $p< 0.01$; n = 435; Shaded numbers on the diagonal = square root AVE.

As shown in Table 5, we evaluated the goodness of fit of the measurement model, using various fits indices. The results, i.e., goodness-of-fit index (GFI = 0.980), root mean square error of approximation (RMSEA = 0.042), normed fit index (NFI = 0.956), and comparative fit index (CFI = 0.980), indicate that all the fit indices satisfy the recommended cutoff values. Therefore, the measurement model is judged reliable for the proposed research model, meriting further analysis.

<Table 5> Test results of the structural model.

Comparison Criteria	Recommended Criteria	Confirmatory Model	Structural Model
Absolute Fit Measure			
Chi-square test statistic (χ^2)		251.293	235.017
Degrees of freedom		142	84
p-value	< 0.050	0.000	0.000
Goodness-of fit index (GFI)	> 0.900	0.980	0.932
Root mean square error of approximation (RMSEA)	< 0.080	0.042	0.063
Incremental Fit Measure			
Normed fit index (NFI)	> 0.900	0.956	0.944
Comparative fit index (CFI)	> 0.900	0.980	0.963
Parsimonious Fit Measure			
Normed chi-square	1.000 ~ 3.000	1.770	2.798

We conducted multi-group analysis to investigate measurement invariance. The first group is estimated with path determined distinctly for each group. Then a second group is calculated where the path calculation of affair is restrained from being equal within the groups. According to a chi-square difference test, the model fit diminished statistically if the estimates were restrained from being equal within the groups. Based on a statistically significant difference between models, we can estimate the effect of moderation exists. The results are presented in Table 6. The table exhibits the fit indices for a constrained, unconstrained, and chi-square difference test. The chi-square difference test represents statistical significance across two groups. First, the unconstrained model was tested and resulted in = 312.98, df = 168. Second, constrained model was tested which resulted in = 340.07, df = 185. The difference test was significant (p = 0.057) at 10% level. Table 6 represents test results of multi-group analysis. This indicates that moderation exists and the two groups under consideration do affect the relationship between supply chain risk and organizational absorptive capacity differently. This implies that a firm with high individual absorptive capacity can facilitate to respond to supply chain risk by connecting acquired knowledge to internal knowledge within organizations, and facilitating its utilization.

<Table 6> Test results of multi-group analysis.

Comparison Criteria	Unconstrained Model	Constrained Model	Model Differences ($\Delta\chi^2$)
Absolute Fit Measure			
Chi-square test statistic (χ^2)	312.98	340.07	27.10*
Degrees of freedom	168	185	
Comparative fit index (CFI)	0.95	0.95	
Root mean square error of approximation (RMSEA)	0.05	0.05	

* $p< 0.1$; ** $p< 0.05$; *** $p< 0.01$

4.4 Analysis and results

To test the research hypotheses in section, we developed a structural model for operations performance. This model examines the hypothesized relations among the supply chain risk, the operational absorptive capacity, and the operations performance.

The overall fit statistics of the structural model for operations performance are reported in Table 5. The goodness-of-fit indices (absolute, incremental, and parsimonious fit measures) evaluate how precisely the research model fits the data (Bentler and Bonett, 1980; Hair et al., 1998). All the absolute fit indices (GFI = 0.932, RMSEA = 0.063), incremental fit indices (NFI = 0.944, CFI = 0.963), and parsimonious fit index (normed chi-square = 2.798) met the recommended criteria, thereby indicating an acceptable model fit (Browne and Cudeck, 1992; Segars and Grover, 1998). Fig. 2 provide all the path coefficients (β) and error variances for the hypothesized relations. Specially, Fig. 2 indicate that the supply chain risk showed a strong positive effect on internally-driven flexibility (β = 0.183, $p < 0.01$) and externally-driven flexibility (β = 0.155, $p < 0.01$), supporting hypothesis 1 and 2. Fig. 2. shows that the supply chain risk has a positive effect on organizational absorptive capacity. Also, the organizational absorptive capacity has a significant relation with the internally-driven flexibility (β = 0.445, $p < 0.01$), while he organizational absorptive capacity has an insignificant relation with the externally-driven flexibility (β = −0.002, $p < 0.05$). The internally-driven flexibility have a strongly positive relation with the externally-driven flexibility (β = 0.544, $p < 0.01$).

We further conducted Sobel test to verify the significance of the mediation effects, using Sobel test calculator (Soper, 2018). The results, summarized in Table 7, indicated that that supply chain risk demonstrated a significant impact on internally-driven flexibility through organizational absorptive capacity as a mediating effect ($p < 0.01$) whereas the mediation effect of the organizational absorptive capacity between supply chain risk and externally-driven flexibility was not statistically significant (p = 0.127), supporting only hypothesis 3. Therefore, the mediation paths of supply chain risk - organizational absorptive capacity - internally-driven flexibility was statistically supported.

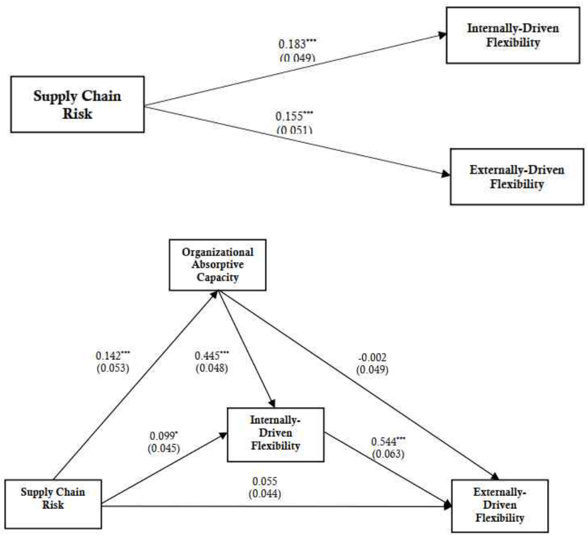

Fig. 2 The result of research model (Single-analysis)

<Table 7> Test results of multi-group analysis.

IV	MV	DV	IV→MV		MV→DV		*Sobel t-stat*	*p*	Support
			β	SE	*β*	SE			
SCR	OAC	IDF	0.142***	0.053	0.445***	0.048	2.574	0.010	YES
	OAC	EDF	0.142***	0.053	-0.002	0.049	-0.041	0.967	NO
OAC	IDF	EDF	0.445***	0.048	0.544***	0.063	6.319	0.000	YES

Legends: MV–Mediator Variable; IV–Independent Variable; DV–Dependent Variable; SE–Standard Error;β–Regression Coefficient; SCR–Supply Chain Risk; OAC–Organizational Absorptive Capacity; * $p< 0.1$; ** $p< 0.05$; *** $p< 0.01$.

The results, presented in Table 7, showed that a firm is required to improve organizational absorptive capacity be more effective responses to supply chain risk. However, it has remained unclear how the individual-level and the organizational-level absorptive capacity interplay, in turn drives manufacturing flexibility in supply chain risk. Thus, this study examines the role of individual absorptive capacity on organizational absorptive capacity in supply chain risk from the perspective of fit as moderation in strategy research (Venkatraman, 1989, 1990).

Figure 3 represents the result of multi-group analysis. Table 8 shows summary of analysis results.

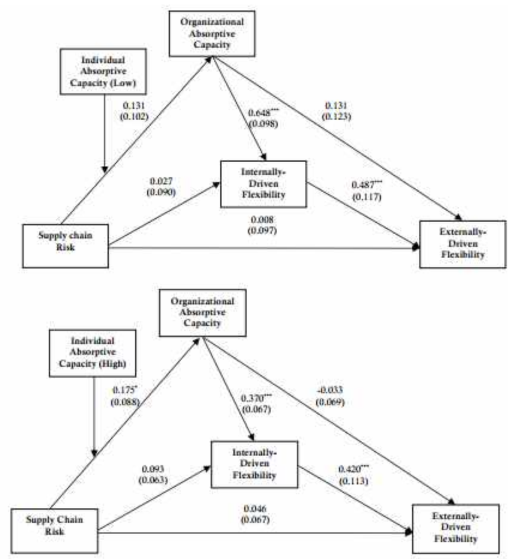

Fig. 3 The result of research model (Multi-analysis)

<Table 8> Summary of analysis results.

Model		Hypothesis	Causal Path	Path Coefficients	*t*-value	Hypothesis Supported	
Single-analysis test		H1	SCR→IDF	0.183***	3.290	YES	Figure 2
		H2	SCR→EDF	0.132**	3.018	YES	
		H3	SCR→OAC→IDF	2.574***	-	YES	
		H4	SCR→OAC→EDF	-0.041	-	NO	
Multi-analysis test	Individual absorptive capacity (High)	H5	SCR→OAC			YES	Figure 3
	Individual absorptive capacity (Low)	H5	SCR→OAC			YES	
Single-analysis test		H6	OAC→IDF→EDF	6.319***	0.000	YES	Figure 2
		H7	IDF →EDF	0.544***	8.978	YES	

Legends: SCR–Suppl Chain Risk; OAC–Organizational Absorptive Capacity; IDF–Internally Driven Flexibility; EDF–Externally Driven Flexibility;* $p< 0.1$; ** $p< 0.05$; *** $p< 0.01$.

5. Discussion and implications

In this section, we discuss the findings on the effects of different absorptive capacities (individual and organizational absorptive capacity) in hostile market on operations performances (internally-driven and externally-driven flexibility). Then, we present significant theoretical contribution and managerial implications.

5.1 Theoretical and managerial implications

This study investigated the interplay of operational absorptive capacity in improving manufacturing flexibility in Korea manufacturing firms. Although operations management literature widely accepts that firms are open rational systems (Ketokivi and Schroeder, 2004), investigation of the interface between supply chain risk and operations department learning is limited. To our knowledge, this study is the first attempt to look into the interplay of individual and organizational absorptive capacity on manufacturing flexibility in supply chain risk. Our study exhibited several findings concerning the significance of supply chain risk and specific operational absorptive capacity for manufacturing flexibility, thereby enriching the body of knowledge on absorptive capacity, and its mechanism and role in supply chain risk. Our study contributes to literatures on supply chain risk, operational absorptive capacity, and manufacturing flexibility. First, we observed not only direct but also indirect effects of supply chain risk on internally-driven flexibility, mediated by organizational absorptive capacity, based on the mediation perspective in strategy research (Venkatraman, 1989). This indicates that it is necessary for a firm to investigate organizational absorptive capacity to be more effective responses to supply chain risk. In other words, a firm is required to invest organizational ability to acquire, assimilate, and transform external knowledge to facilitate more flexible response to supply chain risk.

Second, we focused on how the individual and organization absorptive capacity interplay, and in turn drive manufacturing flexibility in supply chain. To the best of our knowledge, previous researches on absorptive capacity have not examined it empirically yet. Our framework revels that individual absorptive capacity enhances the effect of organizational absorptive capacity on internally-driven flexibility and externally-driven flexibility. It may be that in such supply chain risk, once individual member identifies valuable external information and knowledge, and then pass external information to internal department, it is evident to require the effort of organization to connect the external knowledge to a format that is usable and exploitable by the individuals (Harada, 2003). Furthermore, a firm is required to transform additional knowledge from an organization to internal knowledge and discover how it may be reconnected with what it previously knows and can do. In other words, a firm is required to develop not only individual absorptive capacity to acquire, assimilate, and transform external knowledge but also organizational absorptive capacity to facilitate its effect to be more flexible response in a hostile environment. To do so, our study highlights the need for managers not only to develop the ability of its members but also to not only to seek frequent interactions and communication with other departments to facilitate to recognize valuable external knowledge, align it with existing organizational knowledge, and facilitate its utilization within the organization.

Third, we examined the relation between two flexibilities; internally-driven flexibility that tends to be more tactical and externally-driven flexibility that tends to be more strategic. To our knowledge, previous studies on manufacturing flexibility have not tested empirically although Koste & Malhotra (1999) offered empirically investigating the nature of hierarchal relationships between flexibility dimensions. Our finding provides evidence requested in recent reviews of manufacturing flexibility (Koste and Malhotra, 1999) to explore the relation between flexibility dimensions. Our study suggests that managers should seek a sufficient building block for the formation of high-level externally-driven flexibility (Koste and Malhotra, 1999). Within this context, managers are required to prioritize investments in internally-driven flexibility for externally-driven flexibility.

5.2 Limitations and future research directions

Despite its contributions, we also have several limitations. First, we collected the data in one country at one point in time. Thus, a generalization of the findings may require caution. Future research should incorporate longitudinal data to examine the causal relationships and/or co-evolution of the learning capability and manufacturing flexibility across time.

Second, future studies may further investigate the interaction of organizational absorptive capacity and individual absorptive capacity in a different environment beyond a hostile environment to excavate environment-specific findings. This will deepen our understanding of how two absorptive capacities work together in developing performance, thereby contributing to the existing body of knowledge on absorptive capacity.

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