

The Effect of Supply Chain Integration on Supply Chain Risk Management Capability and Firm Performance in the Ppuri Industry^{*}

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ABSTRACT

The Ppuri industry continues to stagnate as it is interlocked with other industries and lacks the ability to respond to environmental changes. Structural equation model is adopted to analyze the effect of supply chain integration on supply chain risk management capability and firm performance. Results demonstrate that external integration might not have a direct effect on firm performance, whereas internal integration can directly help improve financial performance. Although integration with suppliers does not turn out to directly affect firm performance, it can help improve supply chain risk management capability, which in turn positively affects firm performance.

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INTRODUCTION

The Ppuri industry refers to an industry that operates a business using process technologies such as casting, molding, plastic working, welding, surface treatment, and heat treatment, or manufactures equipment used in such technologies (Korea National Ppuri Industry Center 2014). The Ppuri industry directly affects the quality of the product as it is in charge of starting production, and it has a great impact on the Korean economy due to the large ripple effect on the upstream and downstream industries (Kim 2015). The Ministry of Trade, Industry and Energy has announced an action plan to promote the Ppuri industry in 2021, and challenges for fostering the Ppuri industry are being discussed at the national level. The six technologies of the Ppuri industry and their descriptions according to the Ministry of Trade, Industry and Energy are summarized in table 1.

Table 1. Ppuri Technologies

Technology		Description
Product improvement manufacturing process	Casting	A technology for making a certain type of metal product by melting solid metal materials into a liquid state and injecting and cooling them into a mold.
	Molding	A technology for manufacturing a frame made of a metal material to mass-produce products of the same shape and size.
	Plastic working	A technique for processing raw materials into a certain type of product by applying an external force to the material and causing permanent deformation.
	Welding	A technology for combining materials using heat or pressure.

Technology		Description
<i>Special functioning process on the material</i>	<i>Heat treatment</i>	<i>A technology for improving physical properties by controlling the metal structure by repeatedly applying heating and cooling processes to metal materials.</i>
	<i>Surface treatment</i>	<i>A technology for improving aesthetics or durability and imparting surface functionality by physically and chemically attaching a metal (or non-metal) to the surface of a material.</i>

Despite its high industrial importance, the Ppuri industry continues to stagnate as it is interlocked with other industries and lacks the ability to respond to environmental changes (Korea National Ppuri Industry Center 2014). This is because most companies in the Ppuri industry have structural characteristics that are mainly located as subcontractors of large companies in the supply chain (Hong and Kim 2017), and experience difficulties in recruiting human resources as the industry is perceived as 3D (difficult, dirty, and dangerous) industry (Kim, Kim, and Choi 2014). Since the Ppuri industry usually performs simple manufacturing and processing work in response to requests from demanding companies rather than performing its own R&D activities, it is more difficult to achieve its competitiveness than other industries and is greatly affected by changes in the external environment. The crisis in the Ppuri industry caused by the South Korea-Japan trade dispute in July 2019 revealed the reality of the industry, which is vulnerable to changes in the external environment.

Although studies have been actively conducted to diagnose the current status of the Ppuri industry and devise methods to strengthen its competitiveness (Hong and Kim 2017; June, Ahn, and Kim 2013; Kim, Kim, and Choi 2014; Lee et al. 2021), strategies that Ppuri companies could utilize in terms of supply chain management have not been sufficiently suggested. Therefore, this study aims to analyze the effect of the integration of the supply chain in the Ppuri industry on supply chain risk management capability and firm performance from the perspective of the supply chain. To this end, this study collected data by conducting a survey on the managers at Ppuri

companies, and adopted structural equation model. It is expected to suggest ways for Ppuri companies to achieve competitiveness and improve performance, and this study could also be used as the basis for the government's policy-making to promote the Ppuri industry.

This study consists as follows. Section 2 establishes hypotheses based on the literature on the Ppuri industry along with previous studies on the supply chain integration and supply chain risk management capability, and Section 3 describes the research methods used in this study. Section 4 presents the results, and finally, Section 5 suggests the implications, limitations, and directions for the future research.

THEORETICAL BACKGROUND & HYPOTHESES DEVELOPMENT

Studies on the Ppuri Industry

Research has been actively conducted to examine the current status of the Ppuri industry and to propose tasks for the industry's growth. Studies identified the current status, characteristics, and trends in the industry and discussed the direction of industrial development based on industrial problems such as small firm size, lack of funds and human resources, and difficulties in conducting R&D (Hong and Kim 2017; Kim, Kim, and Choi 2014).

Studies also identified the current status of the Ppuri industry based on a specific region, and they examined the problems and suggested policies for the promotion of the industry. Such literature focused on the Ppuri industry in Gyeongnam (Song 2011), Busan (Kim 2014), Daejeon (Lim and Ji 2017), and Jeonbuk (Yang 2019).

Others have drawn policy implications by comparing the current status of domestic Ppuri industries with overseas industries. First, Park, Ko, and Kim (2010) presented the gap by comparing domestic companies' technology level with advanced countries in terms of the six major technology fields of the Ppuri industry. Lee et al. (2021) compared the competitiveness of domestic and overseas Ppuri industries, and emphasized that the domestic Ppuri industry needs to prepare for improvement of competitiveness, profitability, and training. Studies highlighted the importance of the Ppuri industry by pointing out that it is highly interlocked with other industries

(June, Ahn, and Kim 2013; Kim, Han, and Jeong 2019; Kim, Kim, and Kim 2017), and recently, literature also proposed software and system for building smart factories in the Ppuri industry (Song et al. 2020).

The previous studies on the Ppuri industry are meaningful in that they drew problems based on the current status of the industry and proposed tasks to solve them. Despite high linkage between supply chain partners, however, studies have limitations that the competitiveness of the Ppuri industry has not been empirically analyzed from the perspective of the supply chain.

Supply Chain Integration and Firm Performance

Supply chain integration refers to the degree of strategic cooperation in processes within and between organizations (Flynn, Huo, and Zhao 2010; Narasimhan and Jayaram 1998). Therefore, many studies measure the integration of the supply chain based on internal and external integration, and external integration can also be divided into supplier integration and buyer integration (Huo 2012; Huo et al. 2016; Wong, Boon-Itt, and Wong 2011; Xian, Sambasivan, and Abdullah 2018). Such integration with suppliers and buyers, as well as internal integration, is considered as a key resource and capability of companies from a resource-based view, drawing attention as a source of improvement in corporate performance (Combs and Ketchen 1999; Cousins and Spekman 2003).

Supplier integration is defined as an organization's ability to develop, manage, and maintain long-term relationships with suppliers, and buyer integration is defined as a practice for improving customer satisfaction and managing customer relationships (Ayoub, Abdallah, and Suifan 2017). Such external integration enables benefits such as cost reduction, productivity and agility improvement, and ease of obtaining resources (Amoako-Gyampah et al. 2020; Jajja, Chatha, and Farooq 2018). It also has a positive effect on operational performance such as cost, quality, delivery, and flexibility (Wong, Boon-Itt, and Wong 2011), eventually increasing firm performance (Errassafi, Abbar, and Benabbou 2019).

Internal integration is defined as an organizational practice to achieve knowledge sharing across departmental boundaries, support external integration, and achieve organizational goals

(Ayoub, Abdallah, and Suifan 2017; Kim 2013). Internal integration enables cooperation and information sharing between departments, reducing conflicts between departments and contributing to stabilization (Jun, Qiuzhen, and Qingguo 2011). Furthermore, such cooperation and information sharing can ensure consistency in goal and improve corporate performance (Jun, Qiuzhen, and Qingguo 2011; Schoenherr and Swink 2012).

Under the difficulties in obtaining human resources (Kim, Kim, and Choi 2014), the achievement of internal integration is expected to have a positive impact on the formation of competitiveness in the Ppuri industry. In addition, considering the characteristics of the Ppuri industry, which is difficult to achieve its own competitiveness and is highly dependent on other industries (Hong and Kim 2017), establishing long-term and cooperative relationships with suppliers and buyers is expected to have a positive impact on the competitiveness of the Ppuri industry. Accordingly, the following hypotheses are established.

H1a: Supplier integration has a positive effect on firm performance.

H1b: Buyer integration has a positive effect on firm performance.

H1c: Internal integration has a positive effect on firm performance.

Supply Chain Integration and Supply Chain Risk Management Capability

Supply chain risk is defined as an event that negatively affects the operation of the supply chain (Tummala and Schoenherr 2011). It includes buyer-related risks such as distortion of demand information or volatility in demand, supplier-related risks such as poor raw material quality or supplier bankruptcy, and internal processes such as high production costs (Tummala and Schoenherr 2011). Thus, it requires supply chain risk management (SCRM) capability that identifies potential risks through a coordinated approach between supply chain partners and implements appropriate strategies to reduce vulnerability in the supply chain (Christopher et al. 2003; Colicchia and Strozzi 2012).

Supply chain integration can have a positive effect on SCRM

capability. Supplier and buyer integration enables timely acquisition of reliable information (Kauppi et al. 2016; Schoenherr and Swink 2012) and improves the ability to identify, prevent, and respond to potential risks (Munir et al. 2020). Accordingly, external integration with supply chain partners enables appropriate responses to risks, such as rapid response to environmental changes and exploration of new business opportunities (Amoako-Gyampah et al. 2020).

Cooperation and information sharing between departments based on internal integration can increase the agility of the supply chain and enable faster and more effective responses to environmental changes (Braunscheidel and Suresh 2009; Williams et al. 2013). In addition, internal integration affects the improvement of the ability to identify risks in the supply chain, which contributes to overcoming risks and improving performance (Riley et al. 2016).

Considering that the Ppuri industry is vulnerable to external risks as it is interlocked with other industries and lacks ability to respond to environmental changes (Korea National Ppuri Industry Center 2019), supply chain integration is expected to have a positive impact on achieving and improving SCRM capability. Accordingly, the following hypotheses are established.

H2a: Supplier integration has a positive effect on SCRM capability.

H2b: Buyer integration has a positive effect on SCRM capability.

H2c: Internal integration has a positive effect on SCRM capability.

In addition, the improvement of SCRM capability could have a positive impact on corporate performance (Ali and Shukran 2016; Hu et al. 2019; Manhart, Summers, and Blackhurst 2020; Saglam, Çankaya, and Sezen 2020; Shou et al. 2018; Singh and Hong 2020), and the following hypothesis is established.

H3: SCRM capability has a positive effect on firm performance.

RESEARCH METHODS

Research Model and Data

Based on the hypotheses, the research model is established as figure 1.

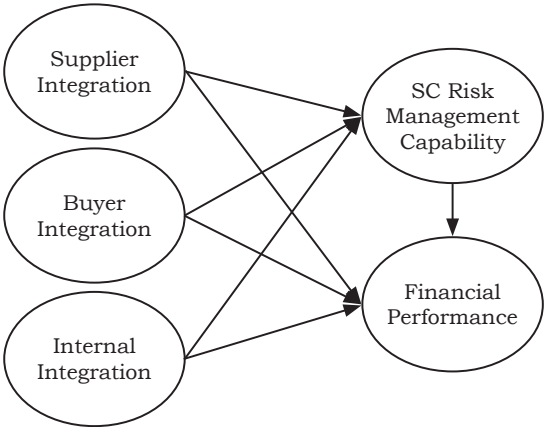


Figure 1. Research Model

Survey questions for the supply chain integration, SCRM capability, and firm performance are extracted based on a review of previous studies (Cao and Zhang 2011; Flynn, Huo, and Zhao 2010; Kwak, Seo, and Mason 2018; Narasimhan and Kim 2002; Wong, Boon-Itt, and Wong 2011), and the questionnaire is finalized through interviews with managers at firms belonging to the Ppuri industry. The list of Ppuri companies which is provided by the Korea National Ppuri Industry Center is utilized, and managers at each Ppuri companies are asked to answer survey questions through face-to-face and e-mail from September 24th to October 12th. 75 responses are secured out of 928 Ppuri companies (8.08% response rate), of which 74 samples are used for analysis after excluding one sample with missing values. The characteristics of the Ppuri technology field of the corporate sample used in this study are shown in table 2.

Table 2. The Characteristics of the Sample

	<i>Frequency</i>	<i>Percentage</i>
<i>Casting</i>	9	12.2
<i>Molding</i>	7	9.5
<i>Plastic working</i>	21	28.4
<i>Welding</i>	23	31.1
<i>Heat treatment</i>	3	4.1
<i>Surface treatment</i>	11	14.9
	74	100.0

Measurement

Following to the research model, supply chain integration is set as an exogenous variable, which is divided into three categories: supplier integration, buyer integration, and internal integration. SCRM capability is set as a mediating variable, and corporate performance is set as an endogenous variable. Structural equation model is adopted, and confirmatory factor analysis for exogenous variables and the same analysis for mediating and endogenous variables are performed, respectively.

Both Cronbach's α and construct reliability (CR) values of the variables are above 0.7; convergent validity is secured. Also, the average variance extracted (AVE) values of all variables are above 0.5, and the square root values of AVE are greater than those of the correlation coefficient. Also, the two-standard error interval estimation does not include 1; thereby, discriminant validity is secured. The results of factor analysis and correlation matrix are presented in tables 3 and 4, respectively.

Table 3. Results of Factor Analysis

Supplier integration				
Measurement item	Factor loading	AVE	CR	Cronbach's α
Have strategic partnership with major suppliers.	0.842	0.660	0.782	0.849
Planning with major suppliers to achieve a rapid ordering process.	0.797			
Maintain collaborative relationships with major suppliers.	0.797			
Buyer integration				
Measurement item	Factor loading	AVE	CR	Cronbach's α
Secure demand visibility through high-level joint planning and prediction with major customers.	0.833	0.649	0.736	0.816
Major customers provide information to us in the process of procurement and production.	0.961			
Major customers are involved in our product development process.	0.573			
Internal integration				
Measurement item	Factor loading	AVE	CR	Cronbach's α
High level of responsiveness in the factory to meet the needs of various functional departments.	0.809	0.754	0.868	0.894
Functional departments communicate and interact with each other frequently.	0.982			
Each department cooperates to solve problems in the event of conflict between functional departments.	0.802			
χ ² /df=1.408, RMR=0.091, GFI=0.914, CFI=0.975, TLI=0.963, NFI=0.921, IFI=0.976, RMSEA=0.075				

Table 3. (continued)**Supply chain risk management (SCRM) capability**

Measurement item	Factor loading	AVE	CR	Cronbach's α
Possible to redesign the logistics process quickly to adapt to the disruption situation.	0.922	0.847	0.931	0.956
Possible to respond quickly and appropriately to risks.	0.958			
Possible to recover quickly to the previous level of performance or above when risk arises.	0.915			
Possible to reduce the negative effects of risk by responding quickly.	0.885			

Firm performance

Measurement item	Factor loading	AVE	CR	Cronbach's α
Return-on-assets (ROA) is high	0.860	0.774	0.860	0.906
Profit growth is high	0.990			
Net profit is high	0.777			

$\chi^2/df=1.514$, RMR=0.077, GFI=0.932, CFI=0.987, TLI=0.978, NFI=0.962, IFI=0.987, RMSEA=0.084

Table 4. Correlation Matrix

	Ave.	St.d.	1	2	3	4	5
1. Supplier integration	4.86	1.33	(.74)				
2. Buyer integration	4.50	1.33	.66 *	(.70)			
3. Internal integration	4.98	1.21	.37 *	.55 *	(.83)		
4. SCRM capability	4.35	1.30	.42 *	.40 *	.39 *	(.88)	
5. Firm performance	3.78	1.34	.02	.13	.33 *	.39 *	(.82)

* The values in parentheses are the square root values of AVE.

* $p < .05$

RESULTS

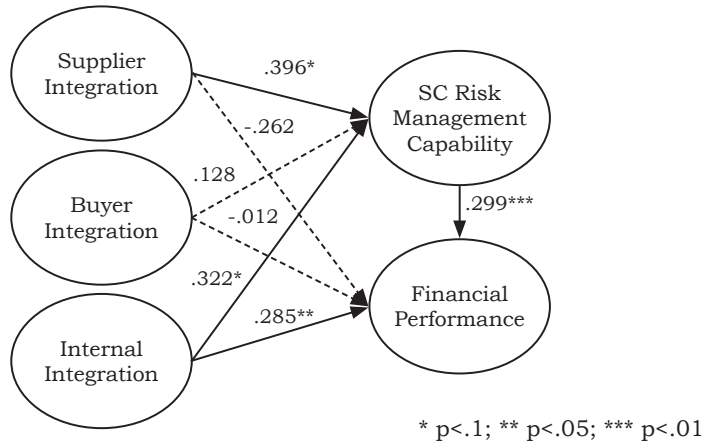


Figure 2. Hypotheses Test Results

The results are shown in figure 2. Regarding the effect of supply chain integration on firm performance, the effect of supplier integration on financial performance ($\gamma = -.262$, $p = .16$) and the effect of buyer integration on financial performance ($\gamma = -.012$, $p = .95$) is not verified (H1a, H1b not supported). On the other hand, it is verified that internal integration has a positive effect on financial performance ($\gamma = .285$, $p = .05$; H1c supported).

Regarding the effect of supply chain integration on SCRM capability, buyer integration has a positive effect on SCRM capability ($\gamma = .396$, $p = .09$; H2a supported), and internal integration also has a positive effect on SCRM capability ($\gamma = .322$, $p = .07$; H2c supported). On the other hand, the effect of buyer integration on the ability to respond to risk in the supply chain has not been significantly verified ($\gamma = .128$, $p = .64$; H2b not supported). Lastly, it is verified that SCRM capability has a positive effect on firm performance ($\gamma = .299$, $p = .00$; H3 supported).

The results prove that external integration might not have a significant direct effect on firm performance in the Ppuri industry,

but internal integration can directly help improve financial performance. Although integration with suppliers does not directly affect firm performance, it can help improve SCRM capability, which in turn positively affects firm performance. Thus, supplier integration is essential to improve the financial performance of companies in the Ppuri industry.

As the Ppuri industry experiences difficulties in recruiting human resources (Kim, Kim, and Choi 2014), managers at Ppuri companies mentioned during interviews that it is often difficult to cooperate and coordinate between departments within a company, which hinders business activities. Therefore, there is a possibility that internal integration rather than external integration is likely to have a direct positive impact on financial performance in the Ppuri industry.

Considering that buyer integration has a positive effect on corporate performance in previous studies (Amoako-Gyampah et al. 2020; Errassafi, Abbar, and Benabbou 2019; Wong, Boon-Itt, and Wong 2011), it is noteworthy that the relationship between buyer integration and firm performance is not verified. The reason may be due to the characteristics of the Ppuri industry. Firms in the Ppuri industry play a role as suppliers of large companies in the supply chain, and most of them perform simple manufacturing and processing tasks at the request of buying companies. Therefore, even if the level of buyer integration increases, firms in the Ppuri industry might not fully achieve the advantages of buyer integration, including cost reduction, productivity improvement, and ease of securing resources, due to the power imbalance between supply chain partners. However, it is difficult to identify the exact reason for the unverified relationship among buyer integration, SCRM capability and firm performance within the boundary of this study.

CONCLUSIONS

Many studies have diagnosed the current status of the Ppuri industry, and suggestions for strategies and policy have been made to improve firm performance. Considering the characteristics of the industry, however, the strategies to improve the performance of firms in the Ppuri industry should be discussed from the perspective of the supply chain. This study has its importance in that it is the first study to verify the relationship among supply chain integration,

SCRM capability, and firm performance in the Ppuri industry. Given that the Ppuri industry is not only interlocked with supply chain partners but also vulnerable to supply chain risks such as environmental changes, this study could be utilized as a criterion for measuring the competitiveness of the Ppuri industry.

This study can also have the following practical implications. First, this study can provide strategic suggestions to managers at firms belonging to the Ppuri industry to improve firm performance. Firms in the Ppuri industry may have focused on meeting the demands of large buying companies, as they play a role as large firms' subcontractors. However, this study suggests that supplier integration and internal integration could help improve SCRM capability and ultimately improve firm performance, so they could achieve a higher level of firm performance by achieving supplier and internal integration.

In addition, this study proposes supply chain integration as a strategy for Ppuri companies to cope with supply chain risks. Studies pointed out that the Ppuri industry suffers from internal and external risks such as lack of human resources, lack of capabilities, and vulnerability in environmental change. Based on the results of this study, managers at Ppuri companies could improve supply chain integration as a way to cope with the risks and improve firm performance.

Despite the above implications, the following limitations could be pointed out. First, the number of samples used in this study is not sufficient, so it may not be enough to infer the entire Ppuri industry. This is because many firms in the Ppuri industry did not continue their business as of the survey date, the response rate was low, and above all, it was difficult to actively conduct surveys under COVID-19 pandemic. Second, though the reason for the failure to support hypotheses on the overall relationship among buyer integration, SCRM capability, and firm performance was inferred, the exact reason could not be identified.

Therefore, future studies are expected to provide precious implications if sufficient samples belonging to the Ppuri industry are secured and the relationship between buyer integration and firm performance can be revealed. Since this study analyzes the Ppuri industry during the recession caused by COVID-19, it can also be a good study to verify the difference in the relationship among supply chain integration, SCRM capability, and firm performance depending on the changes in COVID-19 pandemic in the future. Such studies

are expected to provide fruitful implications for improving the competitiveness of the Ppuri industry and to suggest implications for government policy-makers.

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