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## Article

# Supply chain integration and firm performance: the moderating role of demand uncertainty

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*Suggested Citation:* Hendijani, Rosa; Saei, Reza Saeidi (2020) : Supply chain integration and firm performance: the moderating role of demand uncertainty, Cogent Business & Management, ISSN 2331-1975, Taylor & Francis, Abingdon, Vol. 7, Iss. 1, pp. 1-21, <https://doi.org/10.1080/23311975.2020.1760477>

This Version is available at:

<https://hdl.handle.net/10419/244845>

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To cite this article: Rosa Hendijani & Reza Saeidi Saei | (2020) Supply chain integration and firm performance: the moderating role of demand uncertainty, Cogent Business & Management, 7:1, 1760477, DOI: [10.1080/23311975.2020.1760477](https://doi.org/10.1080/23311975.2020.1760477)

To link to this article: <https://doi.org/10.1080/23311975.2020.1760477>



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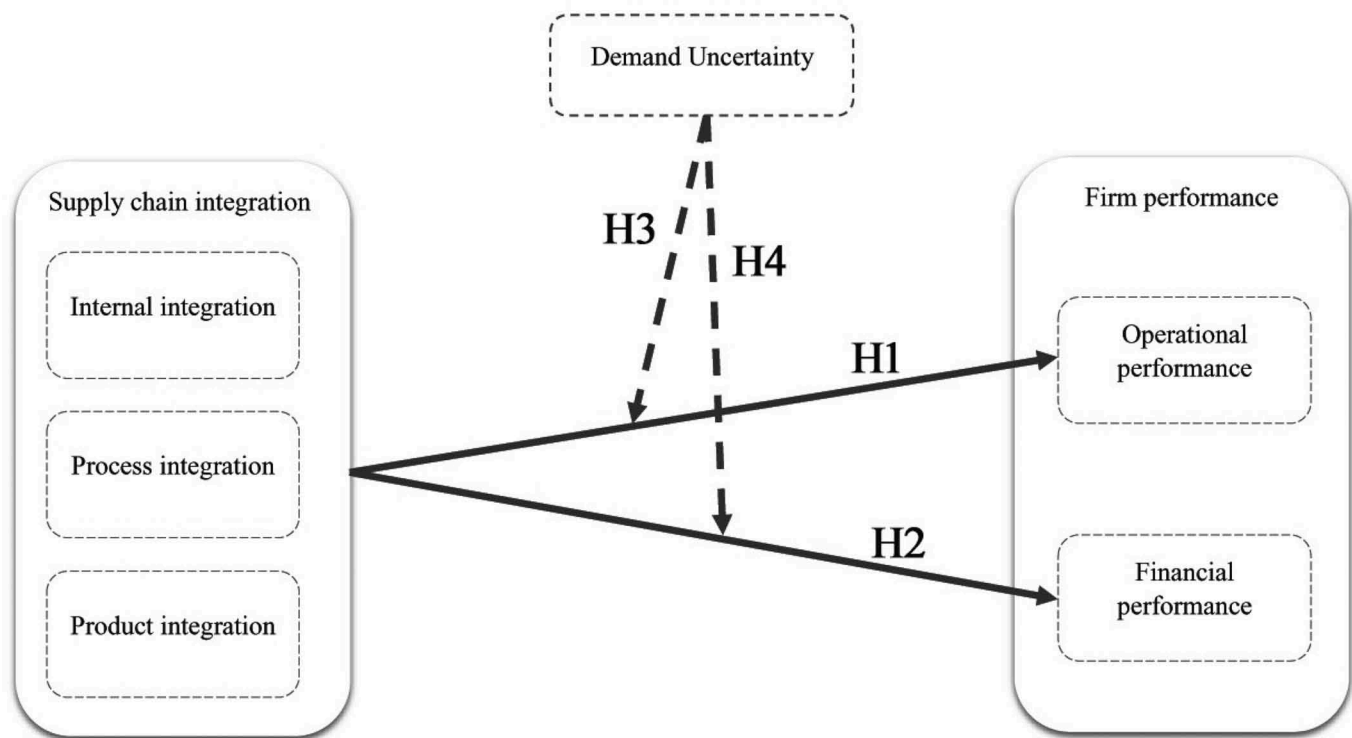
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*Cogent Business & Management* (2020), 7: 1760477



Received: 01 November 2019  
Accepted: 19 April 2020

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Reviewing editor:  
Alok Choudhary, Loughborough  
University, Loughborough, UK

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## OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

# Supply chain integration and firm performance: the moderating role of demand uncertainty

Rosa Hendijani<sup>1\*</sup> and Reza Saeidi Saei<sup>1</sup>

**Abstract:** Supply chain integration (SCI) has become increasingly important among firms. Several studies have addressed SCI's effect on firm performance. However, many moderating factors such as demand uncertainty can influence its effect. In this study, we empirically examined the moderating effect of demand uncertainty on the relationship between SCI and firm performance. We developed a series of hypotheses to address these relationships. SCI was categorized into internal and external integration, with external integration divided into product and process integration. Rather than categorizing external integration into integration with suppliers and customers which was commonly used in previous studies, we used product and process integration as the categories for external integration. This allows us to have an integrated approach to all parties in the supply chain instead of separating the relationship with suppliers from that with customers. Study sample consists of firms active in automotive parts and steel industries in Iran. In total, 84 firms completed the survey. Hierarchical regression analysis was used to test research hypotheses. Industry type was considered as a control variable. Research findings showed that internal and process dimensions of integration had a positive effect on operational performance. In addition, internal and process dimensions

### ABOUT THE AUTHOR

Dr. Rosa Hendijani is a professor in the area of operations and supply chain management. She has done extensive research and teaching for the past ten years in several business schools around the world, including Canada, US, and Iran. One of her key areas of research is to examine and better understand the factors influencing firm and supply chain performance under different conditions. In this line, she is conducting a series of international studies to examine and compare the effect of different moderating factors, such as demand uncertainty that can influence the relationship between supply chain integration and firm performance across different industries and in different countries. She hopes that her research can shed more light on the impact of supply chain integration from a global perspective and the factors that can affect its relationship with performance.

### PUBLIC INTEREST STATEMENT

Supply chain integration (SCI) has become increasingly critical among firms. SCI refers to the strategic collaboration between manufacturers and their supply chain partners to leverage internal and external resources across the whole supply chain. Firms have realized that they need to increase their collaboration with other supply chain members to improve their performance. This study examined the effect of SCI dimensions, including internal, product, and process integration on firm performance under different levels of demand uncertainty. Our results indicate that internal and process integration have positive effects on operational performance. In addition, internal, product, and process integration have positive effects on financial performance. Furthermore, the results indicate that in the face of high demand uncertainty, process integration is more important in improving financial performance. Therefore, firms are advised to reinforce process integration when faced with demand uncertainty to improve their financial performance.

had a positive effect on financial performance. In the face of high demand uncertainty, process integration improved financial performance. Moreover, industry type did not affect the results.

**Subjects:** Business, Management and Accounting; Production, Operations & Information Management; Industry & Industrial Studies

**Keywords:** supply chain integration; demand uncertainty; performance

## 1. Introduction

Supply chain integration (SCI) has become increasingly critical for organizational success in the long run (Huo et al., 2014). In order to survive, firms need to integrate with their suppliers and customers and have extensive collaboration with them. SCI refers to the strategic collaboration between manufacturers and their supply chain partners in order to leverage internal and external resources and capabilities across the whole supply chain (Flynn et al., 2010). Members of the supply chain work together and collaborate to improve performance, resulting in more profitability while meeting customer demand (Kumar et al., 2017). SCI has been commonly recognized as an important factor that positively influences firms' competitive advantage (Devaraj et al., 2007). It has proved to have a significant positive impact on firm's operational and financial performance (Mohammadi et al., 2014).

Today, many activities such as the procurement of raw materials, inventory control and goods distribution are no longer performed within the boundaries of the organizations and have moved to the supply chain level. Firms have accepted that they cannot operate on their own and require the participation and collaboration of other members of their supply chain, including their suppliers and customers (Bavarsad et al., 2017). Experts have recognized the advantages of SCI and coordination among supply chain members (Flynn et al., 2010). In fact, SCI is identified as one of the important factors influencing firm performance (Van der Vaart & van Donk, 2008).

SCI can affect firm performance in both direct and indirect ways. Directly, the close collaboration between the companies within the supply chain results in improved performance (Flynn et al., 2010; Huo et al., 2014; Kim, 2009; Kumar et al., 2017; Rosenzweig et al., 2003). Indirectly, SCI can help firms identify and eliminate the activities that do not add value to the whole supply chain. This can enhance product quality and decrease cost of production, resulting in better value creation and higher customer satisfaction (Rosenzweig et al., 2003).

There are two perspectives on the relationship between SCI and firm performance, including the universal and contingency perspectives (Huo et al., 2014). Universal perspective focuses on different dimensions of SCI and their effect on performance (Frohlich & Westbrook, 2001; Huo & Zhao, 2012). For example, some studies have shown that internal integration can have a stronger effect on operational performance compared to external integration (Flynn et al., 2010; Li, 2015). Contingency perspective, on the other hand, focuses on the contextual factors such as environmental characteristics or company strategies. This perspective suggests that these contingencies can affect the relationship between SCI and firm performance (Flynn et al., 2010; Huo et al., 2014; Iyer et al., 2009; Jayaram, 2011; Wong et al., 2011a).

Nevertheless, there is inconsistency in the literature regarding the effect of SCI on firm performance (Flynn et al., 2010; Huo & Zhao, 2012; Zhao et al., 2013). According to contingency stream, the reason for such inconsistency can be the lack of consideration of contingency variables (Ketokivi & Schroeder, 2004a, 2004b). As some of these contingency factors, technological uncertainty (Boon-itt & Pongpanarat, 2011), demand uncertainty (Boon-itt & Pongpanarat, 2011; Iyer et al., 2009), IT competence (Li, 2015) and product type and complexity (Wong et al., 2011b) can be mentioned (For a comprehensive review of different contingency factors and their effect on SCI-performance relationship, please refer to: Tarifa-Fernandez & De Burgos-Jiménez, 2017).

Demand uncertainty is one of the contingency factors that has proved to substantially influence firm performance (Duncan, 1972; Flynn et al., 2016). Thus, it can significantly influence the effect of SCI on firm performance. This study investigates the moderating effect of demand uncertainty on the relationship between SCI and firm performance. Following previous studies, we categorized integration into internal and external integration (Droge et al., 2004; Stank et al., 2001). External integration was then divided into product and process integration (Huo et al., 2014; Li, 2015). While some studies had used supplier/customer integration as the categories of external integration, we used product/process integration categorization instead. This categorization allowed us to have an aggregate view to suppliers and customers as the main partners of the organization (e.g., Flynn et al., 2010; Kim, 2009; Kumar et al., 2017; Oghazi, 2009; Zailani & Rajagopal, 2005). Thus, this study is innovative and aims to enrich the literature on SCI and performance by providing empirical evidence on the effect of demand uncertainty as one of the main contingency factors that affect the relationship between SCI and firm performance.

The following sections are organized as follows. In the first section, the theoretical foundations of SCI, demand uncertainty, and their effect on firm performance are discussed. Next, our research hypotheses are explained and research model is developed based on the literature. Then, the research methodology is described. Finally, study results are presented and conclusions are drawn based on them.

## 2. Literature review

### 2.1. Supply chain integration

A supply chain includes all parties involved in realizing customer demand. In addition to the manufacturer and suppliers, supply chain includes distributors, wholesalers, retailers, and the end customers. Inside the organization, supply chain includes the functions related to receiving and fulfilling customer order. Some of these functions are operations, new product development, marketing, finance, distribution, and customer service (Chopra & Meindl, 2007).

SCI refers to the level of strategic collaboration and management of inter- and intra-organizational processes in the supply chain (Flynn et al., 2010). Most previous studies have considered SCI as an approach to integrate information among suppliers, manufacturers, distributors, and customers (Pagell, 2004). While some definitions of SCI emphasize material flows and components, others focus on information, resources, and cash flows. (Flynn et al., 2010). SCI has many benefits for the firm, including improvement in financial performance (Flynn et al., 2010; Kim, 2009; Oghazi, 2009; Rosenzweig et al., 2003; Vickery et al., 2003), increase in customer satisfaction (Kim & Chai, 2016; Oghazi, 2009; Zailani & Rajagopal, 2005), and rise in the market share (Kim, 2009; Oghazi, 2009).

In general, SCI is divided into internal and external integration (Droge et al., 2004; Li, 2015). Internal integration refers to the level at which the manufacturer organizes its internal activities, processes, and strategies to meet the needs of its customers (Kahn & Mentzer, 1996). It involves collaboration and coordination across organizational functions through information sharing in order to better understand and address the needs of its customers (Flynn et al., 2016). External integration refers to collaboration and coordination between the firm and its external supply chain partners (Zhao et al., 2013). Previous studies have taken different approaches to categorizing external integration. One approach divides external integration into supplier and customer integration, which refers to coordinated and cohesive links between a firm and its suppliers or customers (e.g., Boon-itt & Pongpanarat, 2011; Fazli & Amin Afshar, 2016; Flynn et al., 2010, 2016; Hosseini & Sheikhi, 2013; Kim, 2009; Oghazi, 2009). Another approach categorizes external SCI into product and process dimensions (Fabbe-Costes & Jahre, 2008; Huo et al., 2014). Product integration refers to the participation of suppliers and customers in the development of new products (Huo et al., 2014; Khazanchi et al., 2007; Wagner, 2008). It aims to support the product development activities through close interaction between the firm and its key suppliers and

customers. Process integration refers to the cooperative and coordinated design and implementation of supply chain processes with suppliers and customers. The aim is to eliminate non-value added activities and improve the speed and flow of information, material, and cash flow across the supply chain (Huo et al., 2014; Kim et al., 2012; Wagner, 2008).

In this study, we used the second approach for categorizing external dimensions of SCI. Thus, we classify integration into internal, product, and process integration. This classification has several advantages. First, it helps us to address the impact of SCI on firm performance from an angle that has been less studied before. Previous studies have mainly focused on integration with suppliers and customers as the dimensions of external integration. The use of product and process integration in this study allows us to have a unified approach towards integration with the main partners in supply chain (i.e., suppliers and customers) and examine the effect of external integration across the whole supply chain instead of examining the separate effects of integration with suppliers and customers. Furthermore, combining the relationship with suppliers and customers assists in developing integrated strategies across the whole supply chain. This enables firms to use their limited resources more effectively and improve their performance. Table 1 shows different SCI classifications used in previous studies.

There are other studies that have addressed supply chain integration from different perspectives and using different research methods (For deep reviews of these studies, please refer to the following references: Awasthi & Omrani, 2019; Duan et al., 2018; Dubey et al., 2015; A. Gharaei et al., 2019a, 2019b, 2019c, 2019d; Giri & Bardhan, 2014; Giri & Masanta, 2018; Hao et al., 2018; Hoseini Shekarabi et al., 2019; Kazemi et al., 2018; Rabbani et al., 2019, 2020; Sarkar & Giri, 2018; Sayyadi & Awasthi, 2018a, 2018b; Shah et al., 2018; Tsao, 2015; Yin et al., 2016).

## 2.2. Uncertainty

Uncertainty is the changes in environmental status and the inability to predict the effects of such changes and their expected consequences on firms (Milliken, 1987). Previous research has pointed to measuring uncertainty based on variables such as demand, supply of raw materials, competition, technology and external environment (Dean & Snell, 1996; Kotha & Orne, 1989; Wernerfelt & Karnani, 1987). Another group of researchers used the perceptual criterion to measure environmental uncertainty, stating that managers make decisions based on their perceptions of environmental uncertainty. (Bourgeois, 1985; Duncan, 1972; Swamidass & Newell, 1987).

Flynn et al. (2016) classified the uncertainty in supply chains into micro-, meso- and macro-levels. The micro-level uncertainty occurs in processes repeating in firms and found in environments with lower complexity (Flynn et al., 2016). Variability of material and information flows in value and time results in uncertainty (Sivadasan et al., 2002). Micro-level uncertainty is concerned with data predicting through distribution, such as variability of customer demand (Flynn et al., 2016).

The meso-level of supply chain uncertainty refers to the deviation between the information required by a supply chain member and the available information (Galbraith, 1977). As the supply chain complexity increases, the need for information increases (Leuschner et al., 2013). Convenient

**Table 1. SCI classifications**

SCI classification	Author(s)
Internal integration and external integration	Li (2015), Droge et al. (2004)
Internal integration, supplier integration and customer integration	Boon-itt and Pongpanarat (2011), Fazli and Amin Afshar (2016), Flynn et al. (2010), Flynn et al. (2016), Hosseini and Sheikhi (2013), Kim (2009), Oghazi (2009), Zhao (2015)
Internal integration, product integration, and process integration	Fabbe-Costes and Jahre (2008), Huo et al. (2014)



and accurate information facilitates inventory reduction, and prevents from overproduction as well as lost profit (Stevenson & Spring, 2007).

The macro-level supply chain uncertainty is related with a complex and dynamic environment in which there are ambiguous and unstructured circumstances (Flynn et al., 2016), such as facing natural disasters or unexpected shifts in customer demand. Other examples of macro-level uncertainty are accidents, wars and terrorist attacks (Kauppi, 2013). Changes in economic conditions, market turmoil, competition intensity and turmoil in industry and technology are major sources of uncertainty in macro-level (Germain et al., 2008).

Boonyathan and Power (2007) argue that it is possible to mitigate uncertainty by close coordination with both suppliers and customers. On the customer side, firm customers such as wholesalers and retailers are closer to the end customers in the supply chain. Integration with them leads to better demand forecasting through receiving more accurate information regarding the demand of end customers. In the face of demand uncertainty, access to a more accurate information on demand fluctuations becomes even more critical and helps in mitigating bullwhip effect and its harmful consequences on firm performance. On the supply side, the early involvement of suppliers in the production of new products is highly critical and can reduce costs associated with uncertainties in new product development, resulting in positive impact on operational and financial performance.

While the effect of environmental uncertainty on firm performance appears to be negative, it can have positive effects in practice. According to previous studies, environmental uncertainty can result in higher levels of manufacturing flexibility (Patel et al., 2012), which, in turn, improves firm performance (Ebrahimpour Azbari et al., 2018). Uncertainties in demand and technology dimensions reinforce the positive relationship between customer participation and process flexibility (Feng et al., 2010).

### **2.3. Demand uncertainty**

Demand uncertainty (DU) is one type of micro-level uncertainty which can have a significant impact on firm performance (Flynn et al., 2016). It refers to the extent to which the needs of customers change over time (Chang et al., 2002). DU is one of the external factors that firms face in the supply chain (O'Leary-Kelly & Flores, 2002). Geary et al. (2002) argue that demand uncertainty can be seen as the difference between actual market demand and projected customer orders in an organization. In fact, DU refers to the difficulty level in predicting future demand characteristics of the firm's customers (Bernstein & Federgruen, 2005).

### **2.4. Organizational performance**

Various factors have been used as a basis for evaluating organizational performance in previous research, including operational performance (Devaraj et al., 2007), financial performance (Vickery et al., 2003), customer satisfaction (Homburg & Stock, 2004), innovation in product (Koufteros et al., 2007), competitive abilities (Rosenzweig et al., 2003), and level of customer service (Vickery et al., 2003). Following Huo et al. (2014), we used financial performance (FP) and operational performance (OP) as benchmarks for assessing firm performance.

## **3. Hypotheses development**

### **3.1. Relationship between SCI and organizational performance**

SCI can have a positive effect on firm performance (Li, 2015; Tarifa-Fernandez & De Burgos-Jiménez, 2017). According to information processing theory, SCI can improve communication between the firm's employees and external partners, resulting in higher quality and more informed decision making. In addition, SCI allows firms to attain required information related to demand, technology, and strategy in a timely manner. This can help in better aligning and coordinating activities among supply chain partners, decreasing waste, and providing products at a higher



speed and lower cost to customers (Li, 2015). Internal integration can improve internal processes and prevent the occurrence of non-value added and duplicated activities within the firm. This results in the production of higher quality products at lower costs (Flynn et al., 2010). External integration can help in acquiring information regarding supply chain including information about suppliers' activities and customer demand in a timely manner, which helps in higher coordination and collaboration among supply chain members, and avoiding inefficiencies across the whole supply chain (Swink et al., 2007).

Previous empirical studies have supported the positive effect of SCI in the form of internal and external integration on firm's operational and financial performance (Flynn et al., 2016; Kumar et al., 2017; Rosenzweig et al., 2003; Vickery et al., 2003). In one study, Kumar et al. (2017) found that SCI had a positive effect on supply chain performance, including operational performance, production flexibility, inventory turnover, order fulfilment rate, and total logistics costs. In another study, Othman et al. (2016) found that SCI had a positive effect on the logistics performance. Li (2015) found that internal and product integration had a positive effect on operational performance among companies active in transportation, electronics, and machinery industries. The study was conducted internationally and several countries such as Germany, Finland, Taiwan, and Italy were included. In another study, researchers found that SCI, including internal integration and external integration with suppliers and customers had positive effects on financial performance. In addition, internal integration had a positive effect on operational performance (Zailani & Rajagopal, 2005).

Beheshti et al.'s (2014) study on Swedish manufacturing companies showed that all SCI dimensions, including internal integration and external integration with suppliers and customers were beneficial to organizations' financial performance. In other words, firms with higher levels of SCI had higher levels of financial performance. Flynn et al. (2010) found a positive relationship between external integration with customers and suppliers and operational performance. Fazli and Amin Afshar (2016) found that SCI had a positive effect on operational and financial performance of the organizations. Other research has shown that internal integration improves external integration and that internal and external integration both directly and indirectly improve firm performance (Huo & Zhao, 2012; Nazemi & Kharidar, 2012). Given the background of the above research, hypotheses one and two are as follows.

**H1.** Different dimensions of supply chain integration improve operational performance.

**H1a.** Internal integration improves operational performance.

**H1b.** Product integration improves operational performance.

**H1 c.** Process integration improves operational performance.

**H2.** Different dimensions of supply chain integration improve financial performance.

**H2a.** Internal integration improves financial performance.

**H2b.** Product integration improves financial performance.

**H2 c.** Process integration improves financial performance.

### **3.2. Moderating effect of demand uncertainty**

The relationship between SCI and organizational performance is affected by different environmental factors. Demand uncertainty is one of the important environmental factors that can moderate this relationship. According to the literature, the effect of SCI on organizational

performance varies depending on the level of demand uncertainty (Liao et al., 2010). In the following, we will explain the literature and formulate our hypotheses for internal and external integration, separately.

### *3.2.1. Moderating effect of demand uncertainty on internal integration*

In the face of high demand uncertainty, firms resort to greater coordination and collaboration between their internal units (Ganbold & Matsui, 2017). They utilize specialized teams, working groups, and joint committees to coordinate their operational activities (Thompson, 2017). Increasing such coordination and inter-organizational activities may decrease operational performance and increase costs. Accordingly, demand uncertainty is predicted to moderate the relationship between internal integration and firm's operational and financial performance. The results of empirical research conducted by Boon-Itt and Yew Wong (2010) supported this prediction, indicating that demand uncertainty can have a negative moderating effect on the relationship between internal integration and firm performance. Therefore, we have the following hypotheses:

**H3a.** Demand uncertainty moderates the effect of internal integration on operational performance.

**H4a.** Demand uncertainty moderates the effect of internal integration on financial performance.

### *3.2.2. Moderating effect of demand uncertainty on external integration*

Demand uncertainty can moderate the effect of external integration in the form of product and process integration and firm performance. Process integration helps in removing the constraints in the supply chain. It facilitates information, material, financial, and resource flows. Effective information sharing allows firms to reduce the negative effects of demand uncertainty (e.g., bullwhip effect) and to enhance the ability to reduce its related costs (Naylor et al., 1999). Accordingly, the integration of the processes by providing a smooth flow of information can improve firm's operational and financial performance.

Likewise, product integration reduces production costs by involving suppliers in the early stages of new product development (Handfield et al., 1999). Therefore, product integration can provide an effective role in improving firms' financial performance by providing collaboration with suppliers, when faced with demand uncertainty. Given the above, it can be predicted that demand uncertainty can moderate the relationship between external integration, including product and process integration and firm's operational and financial performance.

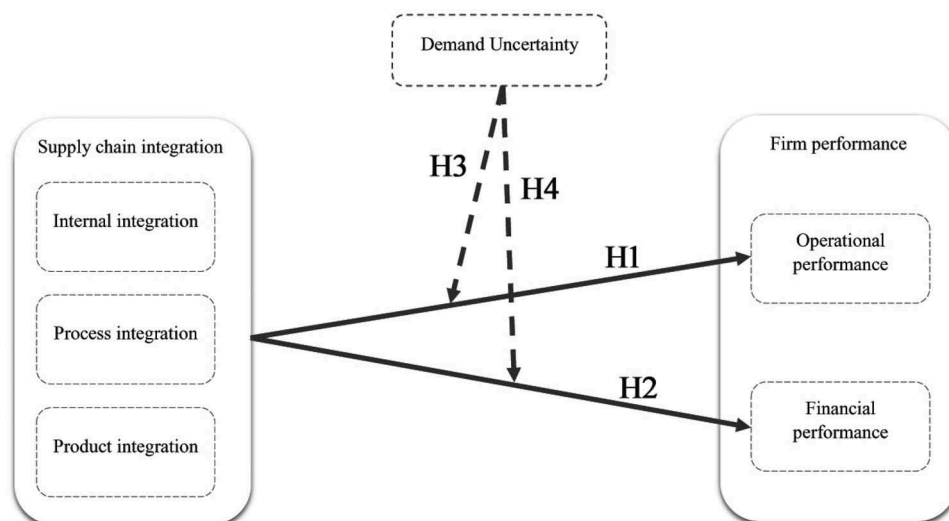
Empirical studies have supported these predictions. In one study in the Thai automotive industry, Boon-Itt and Yew Wong (2010) found that demand uncertainty moderated the relationship between external integration with suppliers and customer delivery performance. In another study conducted in auto parts manufacturing industry in Thailand, Wong et al. (2011a) found that the relationship between external integration with suppliers and customers and firm's operational performance was strengthened in high uncertainty environments. In another empirical study in China's automotive supply chain, Ding et al. (2017) found that demand uncertainty had a positive effect on the relationship between external integration with customers and firm's operational performance. Therefore, we have the following hypotheses:

**H3b.** Demand uncertainty moderates the effect of process integration on operational performance.

**H3 c.** Demand uncertainty moderates the effect of product integration on operational performance.

**H4b.** Demand uncertainty moderates the effect of process integration on financial performance.

**Figure 1. The effect of supply chain integration and demand uncertainty on firm performance.**



**H4 c.** Demand uncertainty moderates the effect of product integration on financial performance.

Figure 1 presents the schematic diagram related to our research hypotheses. Independent variable is SCI with three dimensions of internal, process, and product integration. Demand uncertainty is the moderating variable. The dependent variables are firm's operational and financial performance.

#### 4. Research methodology

This research is a descriptive study with practical purposes. In this study, the statistical population included firms active in the steel and automotive parts industries. Data were collected from the managers and experts of the above-mentioned firms with related task functions. Due to small statistical population of the above industries, and the probability that some of them may not cooperate, the census method was used and all members of the community were considered as research samples (Salant & Dillman, 1994).

The survey consisted of 48 questions with a 7-point Likert scale to measure demand uncertainty, SCI, and firm performance. Demand uncertainty questions were selected from Flynn et al.'s study (Flynn et al., 2016). There were four questions related to demand uncertainty which we used in our study. Flynn et al.'s (2016) questionnaire has been used in many studies, which demonstrates its high reliability and validity (Ding et al., 2017; Huo et al., 2014; Laari, 2016; Marin-Garcia et al., 2013; Vieira et al., 2013; Ziaullah et al., 2017).

SCI and firm performance constructs were measured using questions selected from the questionnaire used in Huo et al.'s study (Huo et al., 2014). There were 18 questions related to SCI dimensions of internal, product, and process, and 16 questions related to financial and operational dimensions of firm performance. Considering the extensive literature search and use of face-to-face interviews in the development of Huo et al.'s questionnaire, it is among the high-quality questionnaires used in the literature (Huo et al., 2014).

Since the questionnaires were extensively used in previous studies, their validity was implicitly confirmed. Face validity of the questionnaires was evaluated by professors with relevant expertise and some minor changes were made. The original questionnaires were translated into Persian and presented to two professors in the field of supply chain for review. Then, the final questionnaire

was translated again into English by another translator and compared with the original questionnaires. Considering the similarity of the reverse-translated questionnaire with the original questionnaires, it can be concluded that the Persian-translated questionnaire has the reliability and validity for measuring the variables and the subject under study (Mohammadbeigi et al., 2015).

Convergent validity and differentiation validity are used to examine construct validity. Convergent validity deals with the relationship between variables and factors and seeks to find a strong correlation between the factor and its constituent variables (Mohammadbeigi et al., 2015). The principle of grouping the variables is that if the correlation coefficient of the correlation matrix is less than  $\pm 0.3$ ,  $\pm 0.4$  indicates the importance of the variable and  $\pm 0.5$  indicates the fundamental importance of the variable in the domain (Hair et al., 2013). The correlation between each factor and its constituent variables was greater than 0.5 in all cases and it was between 0.6 and 0.9 in most cases, indicating the crucial importance between the variables and the factor. The validity of the distinction deals with the correlation between the variables of each factor and the other factors. This correlation is expected to be weak. The correlation coefficient of the question with other factors should be weaker than the correlation coefficient of the question with its own factor (Mohammadbeigi et al., 2015). The correlation coefficients of each factor with other factors were lower than their correlation coefficients with each factor and they were less than 0.3 in all cases.

Cronbach's alphas were calculated for each variable. All alpha coefficients were above 70%. Thus, study variables have acceptable reliability (Mohammadbeigi et al., 2015).

The questionnaire used in this study consisted of three parts. The first part included description of the questionnaire and the guidance to complete it for the respondents. The second part consisted of 44 questions for measuring internal integration, product integration, process integration, financial performance, and operational performance. Internal integration questions deal with issues such as data integration between enterprise internal units, integrated warehouse management, and regular inter-agency meetings (Huo et al., 2014). Collaborating with suppliers to improve inter-organizational processes, striving to increase trust between firms and customers, and sharing information with customers are measured by process integration questions. Product integrity questions dealt with the collaboration with both suppliers and customers when designing and manufacturing new products (Huo et al., 2014). Demand uncertainty was measured by factors such as steady demand for products, orders received to generate demand, and demand forecasting (Flynn et al., 2016). Operational performance was measured by factors such as flexibility in product diversification, delivery speed, production capacity change and support services are compared to the main competitors, and financial performance was measured by factors such as return on investment and market share (Huo et al., 2014). The third section consisted of six questions about the organizational position (optional), age, gender, level of education, years of respondent service, and organization life. A web-based version of the questionnaire was also prepared and the URL was sent to the participants.

## 5. Data analysis

### 5.1. Descriptive statistics

The survey was designed online and sent to 305 firms consisting of 64 firms in the steel industry and 241 firms in the auto part industry. The survey was filled by operations and supply chain professionals in each company. In total, 92 companies participated in the survey. Eight company responses were removed due to incomplete or invalid answers. Thus, we had complete responses from 84 companies. Most companies returned one completed response file. Some companies returned more than one response file. In this case, we calculated the average of the responses for respondents in the related company and used that as a measure for the related company. Participation rate in the steel industry and auto parts industry was 25.0% and 28.4%, respectively. The average response rate was 27.5%, in total. It should be noted that such a response rate is typical in organizational studies where respondents should hold executive positions in firms (Gu

et al., 2017). An examination of published papers in this area indicates that the response rate of 27.5% is comparable with previous studies with similar samples and contexts (e.g., Beheshti et al., 2014; Flynn et al., 2010; Huo et al., 2014; Mora-Monge et al., 2019; Van der Vaart & van Donk, 2008). The highest frequency of firms' experience (i.e., 34.2%) was 6–10 years of experience. The average age of the participants was 35.2 years. Twenty-three respondents were female and 61 were male. 53.9% of the respondents had undergraduate degree. Most of the participants (i.e., 42.1%) had 6–10 years of work experience.

Considering the number of variables in the model (including four independent variables and one control variable), the sample size of 84 is sufficient to perform hierarchical regression analysis to test the research hypotheses (Heir et al., 2014).

The reliability of the variables and constructs of the research was calculated by SPSS software using Cronbach's alpha coefficient. Descriptive statistics of the research variables along with the corresponding Cronbach's alpha coefficients are presented in Table 2. Since all obtained coefficients are above 0.7, the variables have acceptable reliability (Mohammadbeigi et al., 2015).

Chi-square test was used to determine the homogeneity of the respondents compared to the statistical population of the participating industries to ensure that there was no bias related to non-respondents in the participating industries (Malhotra & Grover, 1998). Table 3 shows the results of the chi-square test. The results of chi-square test ( $\chi^2$ ) showed no significant difference between the distribution of respondents and the distribution of the overall population ( $\chi^2 = 0.262$ ,  $df = 1$ ,  $p = 0.609$ ) (Atif et al., 2012; Huo et al., 2014; Mora-Monge et al., 2019). The insignificant result indicates that our sample is not biased towards any specific industries (Greenwood & Nikulin, 1996; Huo et al., 2014).

In addition, we examined non-response bias among early and late respondents by means of wave analysis. We conducted a chi-square test ( $\chi^2$ ) to examine the difference regarding years of personal experience and education level among individual respondents and the firms' experience in the industry between early and late respondents (Atif et al., 2012; Huo et al., 2014; Mora-Monge et al., 2019). Difference in early respondents as wave 1 and late respondents as wave 2 was analyzed. Following previous studies guidelines, late respondents were used as a substitute for non-respondents (Mora-Monge et al., 2019). Results indicated no significant difference between them. These results suggest that there was no significant bias in terms of individual respondent characteristic and organizational characteristics in our sample. Considering the results of these analyses along with sample size comparison with previous studies, it can be inferred that non-response is not a major problem in our sample and does not have a serious impact on the generalizability of our results.

**Table 2. Cronbach's alpha coefficients**

Construct	Variable	Mean	Variance	Cronbach's alpha
Supply chain integration	Internal integration	4.54	1.26	0.80
	Process integration	4.76	0.94	0.89
	Product integration	3.94	1.46	0.75
Demand uncertainty	Demand uncertainty	4.75	1.30	0.71
Firm performance	Operational performance	4.85	0.78	0.87
	Financial performance	5.26	0.78	0.91

**Table 3. Chi-square test for industry distribution of respondents and total population**

Variable	Industries	Groups		df	Value	Significance
		Respondents (%)	Population (%)			
Industry	Auto parts	19.0	21.0	1	0.262	0.609
	Steel	81.0	79.0			
Total		100	100			

## 5.2. Multiple regression analysis

In order to investigate the study hypotheses, two sets of hierarchical regression models were run. The first set examined the moderating role of demand uncertainty on the relationship between SCI and firm's operational performance and the second set examined the moderating role of demand uncertainty on the relationship between SCI and firm's financial performance. In each set, first, industry type was entered into the model as a control variable. Second, the components of SCI constructs were entered as independent variables. In the third step, demand uncertainty was entered into the model as another independent variable. In the fourth step, the interaction of the SCI dimensions and demand uncertainty, a total of three interactive relationships, were entered into the model. We mean centered independent variables to reduce multicollinearity effect before performing the interaction tests between the dimensions of SCI and demand uncertainty (Iacobucci et al., 2016). To do this, the mean values of the answers to each question were first calculated. Then, the value of each variable was subtracted from the mean value to calculate the mean center value for each variable (Iacobucci et al., 2016). The order of entry of the predictor variables in the hierarchical regression model is based on a theoretical or empirical framework considered by the researcher. Variables or sets of variables are entered in steps (blocks). Each variable is added to the regression model to help predict the criterion variable after controlling for previous variables (Pallant, 2010; Sarmad et al., 1998). In order to facilitate the presentation of results, only the variables that were statistically significant are reported. In the following section, we will present the results related to operational and financial performance, consecutively.

### 5.2.1. Results for hypotheses related to operational performance

Table 4 shows the results of hierarchical regression models with operational performance as the dependent variable. The order of entry of variables into the model was as follows: industry as a control variable (Model I), SCI dimensions (Model II), demand uncertainty (Model III), and the interaction of SCI dimensions and demand uncertainty (Model IV).

Hierarchical regression results in Model I showed that industry type had no significant effect on firm performance in any of the models, indicating that industry type did not influence the results. Based on the results of linear regression in Models II and III, SCI dimensions of internal integration ( $p < 0.001$ ) and process integration ( $p < 0.05$ ) had significant positive effects on operational performance. Therefore, hypotheses H1a and H1b were supported and hypothesis H1 c was not supported.

Based on the results of linear regression in Model IV, the interaction between SCI dimensions and demand uncertainty was not significant. Interaction between demand uncertainty and internal integration ( $\beta = 0.008$ ,  $p = 0.803$ ), process integration ( $\beta = 0.089$ ,  $p = 0.105$ ) and product integration ( $\beta = -0.009$ ,  $p = 0.764$ ) was not significant. Therefore, hypotheses H3a, H3b and H3 c regarding the interactive effect of demand uncertainty and SCI were not supported.

### 5.2.2. Results for hypotheses related to financial performance

Table 5 shows the results of hierarchical regression models with financial performance as the dependent variable. The order of entry of variables into the model includes Industry as Control Variable (Model I), SCI dimensions (Model II), demand uncertainty (Model III) and interaction of supply chain dimensions with demand uncertainty (Model IV).

Based on the results of Model I, industry type had no effect on the results. Results of Model II showed that SCI dimensions of internal integration ( $p < 0.001$ ) and process integration ( $p < 0.01$ ) had significant positive effects on financial performance. Contrary to the hypothesis, product integration ( $p < 0.001$ ) had a negative effect on firm's financial performance. Therefore, hypotheses H2a and H2b regarding the effect of internal and process integration on financial performance were supported. Hypothesis H2 c, regarding the effect of product integration on financial performance, was not supported. The results of Model IV showed that when firms were faced with demand uncertainty, only process integration ( $p < 0.001$ ) had a significant positive effect on financial performance. Therefore, hypothesis H4b was supported and hypotheses H4a and H4 c were not supported.



Table 4. Results of hierarchical regression test, dependent variable: operational performance

	Model I		Model II		Model III		Model IV	
	Sig.	$\theta$	Sig.	$\theta$	Sig.	$\theta$	Sig.	$\theta$
Constant	0.000	4.803	0.000	4.765	0.000	4.747	0.000	4.670
Industry	0.457	0.170	0.309	0.134	0.166	0.172	0.530	0.082
Internal Integration (II)			0.000 ***	0.450	0.000 ***	0.302	0.000 ***	0.340
Process Integration (PI)			0.043 *	0.127	0.003 **	0.183	0.009 **	0.192
Product Integration (TI)			0.506	-0.025	0.889	-0.005	0.464	0.030
Demand Uncertainty (DU)					0.002 **	-0.195	0.001 ***	-0.213
II x DU							0.803	-0.008
PI x DU							0.105	0.089
TI x DU							0.764	-0.009
$R^2$	0.746		0.729		0.689		0.007	
Adjusted $R^2$	0.716		0.710		0.671		-0.006	
$\Delta R^2$	0.017		0.041		0.681		0.007	
Durbin-Watson							2.086	

\* $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ .

Table 5. Results of hierarchical regression test, dependent variable: financial performance

	Model I		Model II		Model III		Model IV	
	Sig.	$\theta$	Sig.	$\theta$	Sig.	$\theta$	Sig.	$\theta$
Constant	0.000	5.587	0.000	5.542	0.000	5.516	0.000	5,211
Industry	0.929	0.024	0.695	0.083	0.507	0.135	0.422	0.150
Internal Integration (II)			0.000 ***	0.230	0.783	0.026	0.282	0.102
Process Integration (PI)			0.002 **	0.322	0.000 ***	0.399	0.000 ***	0.405
Product Integration (TI)			0.000 ***	-0.320	0.000 ***	-0.301	0.005	-0.169
Demand Uncertainty (DU)					0.008 **	-0.268	0.000 ***	-0.352
II x DU							0.172	-0.063
PI x DU							0.004 **	0.232
TI x DU							0.728	0.014
$R^2$	0.612		0.457		0.400		0.000	
Adjusted $R^2$	0.566		0.418		0.366		-0.013	
$\Delta R^2$	0.155		0.057		0.400		0.000	
Durbin-Watson							1.771	

\* $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

## 6. Discussion

In this study, we examined the effect of SCI on firm's operational and financial performance, with demand uncertainty as the moderating variable. SCI was measured in two categories of internal and external integration with external integration divided into product and process integration. In the following sections, theoretical implications, managerial implications, future directions and conclusion are discussed.

### 6.1. Theoretical implications

Regarding operational performance, the results indicated that internal and process dimensions of SCI had a positive effect on operational performance. These results are consistent with the findings of previous studies (e.g., Flynn et al., 2016; Rosenzweig et al., 2003; Vickery et al., 2003). However, product integration did not have a significant effect on operational performance. This can be due to the fact that product integration creates more interaction between the firm and its customers. A more active presence of customers and higher levels of customer contact may slowdown the production process and result in reducing operational performance. Demand uncertainty did not have a significant moderating effect on the relationship between different types of SCI and operational performance.

Regarding financial performance, SCI in the three dimensions of internal, process, and product integration had positive effects on financial performance. This is consistent with previous research findings (Beheshti et al., 2014; Fazli & Amin Afshar, 2016). In addition, when firms were faced with demand uncertainty, the relationship between process integration and financial performance was strengthened. This result is consistent with the findings of the past research (Boonyathan & Power, 2007; Wang, 2018). When demand uncertainty increases, firms face the unpredictability of current customer needs as well as the inability to predict customer demand in the future. In such circumstances, they should strive to deepen their relationship with customers in order to obtain information that is more accurate. Firms are advised to reinforce process integration when faced with demand uncertainty. Process integration can increase the flow of information from customers, with the aim of learning more about changing customer needs and desires.

### 6.2. Managerial implications

From a practical standpoint, since most of the supported hypotheses are related to process integration compared to internal and product integration, it can be concluded that the role of process integration is highly influential in the operational and financial performance of the firms. Therefore, firms are advised to give higher priority to process integration compared to other types of integration. In addition, given the benefits of SCI as supported by the study results, it is suggested that firms increase their interactions with customers and suppliers by shifting their focus from their internal to external environment.

Our research questionnaire was developed using validated questions used in previous studies. Therefore, firms can utilize it to examine their current status in terms of SCI, demand uncertainty, and operational and financial performance and use its results in formulating policies for implementing different types of SCI in line with their strategies. They can increase the level of integration of their firm's supply chain by continuously measuring their progress over time and reap the benefits of improving their performance.

### 6.3. Future directions

There are several suggestions for future research. First of all, this research has been performed in the steel and automotive parts industries in Iran. It is suggested that similar research be conducted in other industries and the results be compared across industries. Furthermore, conducting the study in similar industries in other countries can increase the validity and generalizability of results. It can also help firms to learn about their own strengths and weaknesses by comparing themselves with companies in similar industries in other countries. Second, based on the feedback from participating companies, there is a difference in the firms' behavior in relation to international suppliers and customers

compared to domestic ones. Thus, it is recommended that future studies consider this effect and investigate research hypotheses for international and domestic supply chain partners, separately.

Third, in this study, we used survey method for collecting data and testing our research hypotheses. Using other methods of data collection such as semi-structured interviews with open-ended questions can help in getting more insight regarding the moderating effect of demand uncertainty on the relationship between SCI and firm performance. In addition, considering other measures for assessing organizational performance can contribute to the study results. Finally, in this study, we combined responses related to questions on integration with suppliers and customers. It would be worthwhile to separately analyze data related to customer and supplier integration.

## 7. Conclusion

There are two perspectives on the relationship between SCI and firm performance (Huo et al., 2014). The first perspective, referred to as universal perspective, focuses on SCI dimensions and asserts that certain types of SCI can have positive effects on firm performance (Flynn et al., 2010; Huo & Zhao, 2012). The second perspective, referred to as contingency perspective, emphasizes the role of moderating variables such as environmental factors on the relationship between SCI and firm performance (Wong et al., 2011a). This study attempts to empirically examine the predictions of these two perspectives by testing the effect of SCI dimensions on firm performance both directly and in interaction with demand uncertainty (Iyer et al., 2009). Our results suggest that internal and process dimensions of SCI have positive effects on operational performance. In addition, internal, product, and process dimensions have positive effects on financial performance. Furthermore, demand uncertainty moderates this relationship. In the face of demand uncertainty, process integration improves financial performance. Therefore, firms are advised to reinforce process integration when faced with demand uncertainty to improve their financial performance. In total, our study results suggest the importance of examining the role of different moderators on the relationship between SCI and firm performance in future research. In addition, testing such relationship in other countries and industry contexts can improve the generalizability of results.

## Funding

The authors received no direct funding for this research.

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## Citation information

Cite this article as: Supply chain integration and firm performance: the moderating role of demand uncertainty, Rosa Hendijani & Reza Saeidi Saei, *Cogent Business & Management* (2020), 7: 1760477.

## Cover image

Source: Author.

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