


The Impact of Digitalization on Supply Chain Integration and Performance: A Comparison Between Large Enterprises and SMEs

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ABSTRACT

The purpose of this paper is to investigate the relationships between digitalization, supply chain integration, and firm performance. Data are analyzed by the partial least square structural equation modeling (PLS-SEM). The results revealed that both digitalization in the supply chain and supply chain external integration positively affected company performance. Further, supply chain external integration partially mediated the relationship between supply chain digitalization and firm performance. In addition, it was found that financial performance is enhanced through different paths for large enterprises and SMEs. Large enterprises improve financial performance through supply chain integration after efforts spent on the digitalization of their supply chain, while SMEs improve financial performance directly through supply chain digitalization. These findings provide insights for managers and policymakers of large enterprises and SMEs in formulating appropriate implementation strategies for digital transformation.

KEYWORDS

Digitalization, Firm Size, Integration, Performance, Supply Chain

INTRODUCTION

Digitalization, which is identified as the top trend in next-generation supply chain development, facilitates the distribution of products, increases organizational flexibility to changing demand or supply situations, and boosts the efficiency of the supply chain (McKinsey, 2016). Later studies confirm that emerging digital technologies can improve the performance not only of firms (Dubey et al., 2019; Lal & Bharadwaj, 2020; Samuel Fosso et al., 2019; Sultana et al., 2021) but also of supply chains around the globe (Barreto et al., 2017; Björkdahl, 2020; Chen et al., 2020; Uniyal et al., 2021). For instance, big data analytics favors increased customer customization and, together with sensors, cloud solutions, and additive manufacturing (3D printing), enables a competitive business model that shortens the distance and responsive time to target markets, thereby benefitting relatively smaller

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and more responsive businesses (Organization for Economic Co-Operation and Development, 2019). Furthermore, almost 90% of respondents believe companies can gain a competitive advantage in the supply chain through digitalization in the next five years; however, 70% of firms are unclear about the context embedded in the supply chain digitalization (*SupplyChainDigest*, 2016). A substantial percentage of senior maritime Singaporean executives responding to a poll expressed doubt about a digital future for the sector (Tan, 2018). Additionally, some firms are struggling with the development of their digital strategies due to several challenges and barriers (Pereira et al., 2020), and the digital strategies of many other firms are failing (Bughin et al., 2018). Mixed trends are evident in the digitalization journey of small and medium-sized enterprises (SMEs) in Germany (Zimmermann, 2021). Enterprises that are not ready to leverage the advancements from these digital and technological improvements are likely to go out of business (Saxena, 2016).

Both researchers and practitioners have given ample attention to the process of digital transformation. Focusing on the physical movement of products and related processes, traditional businesses have been disrupted and have begun the digital transformation journey in the last few years (Queiroz Maciel et al., 2019). Since the global outbreak of the COVID-19 pandemic in late 2019, leveraging digital supply chain technologies to diversify and minimize supply chain risks and disruptions has become crucial for companies to build a resilient supply chain (Zouari et al., 2021). The latest HSBC Navigator survey of 3,000 businesses in the Asia-Pacific region reveals that companies expecting considerable business growth are increasing their investment in sustainability to boost resilience through digitalization (e.g., implementation of data science and AI, cloud-based software, automation, and robotics in business operations; HSBC, 2021).

Supply chain management (SCM), with the emphasis of satisfying customer needs by integrating different functional processes within a firm into an entire supply chain (Min & Mentzer, 2004), is considered strategic assets and sources of competitive advantage of a firm (Min et al., 2019). This perspective is mostly grounded in resource-based theory (RBV; Hunt & Davis, 2008, 2012), in which SCM-related activities and practices are considered important resources in the creation of a firm's capabilities to improve business performance (Blome et al., 2013; Narasimhan & Schoenherr, 2012). Supply chain integration is viewed as an essential attribute of modern SCM (Childerhouse & Towill, 2011; Som et al., 2019; Zhao et al., 2013) and is considered the key to obtaining a competitive advantage in the global environment (Rosenzweig et al., 2003). Through a high level of integration among partners in supply chains, firms can be more responsive to volatile customer demand because of increased supply chain information visibility (Kim, 2006). Furthermore, a highly integrated supply chain with external partners is likely to reduce the operational costs and the total costs to customers (Swink et al., 2007).

The Assessment of Excellence in Procurement (AEP) study by A. T. Kearney identified external supply chain integration with supply chain partners as a crucial element in gaining competitive advantages (Kearney, 2014). Business strategies have extended from a traditional firm-level focus to wider relationships with external parties across the supply chains (Trebilcock & Sandor, 2015). Previous studies generally support that external supply chain integration contributes to firm performance (Frohlich & Westbrook, 2001; Mora-Monge et al., 2019; Zhao et al., 2013). Moreover, the 2020 A. T. Kearney AEP survey indicates that among top-performing firms, collaboration across enterprises, together with a defined digital strategy, contributes to team excellence (Kearney, 2020).

The literature generally supports that supply chain digitalization and supply chain integration contribute to firms' benefits (Björkdahl, 2020; Frohlich & Westbrook, 2001; Gimenez, 2006); however, how supply chain digitalization is linked up with supply chain integration for improving firm performance remains ambiguous (Stank et al., 2019). Therefore, further understanding of how the business interfaces with other entities in the supply chain in the digital age is necessary. Empirical evidence supporting the relationship between supply chain digitalization and supply chain integration is also scarce (Abdirad & Krishnan, 2020; Büyükköçkan & Göçer, 2018; Tian et al., 2019). Liu and Chiu (2021) have clarified this relationship by providing support to the idea that supply chain

digitalization positively moderates the relationship between internal supply chain integration and firm performance for companies in China, but their study is limited to internal integration without considering external entities in the supply chain.

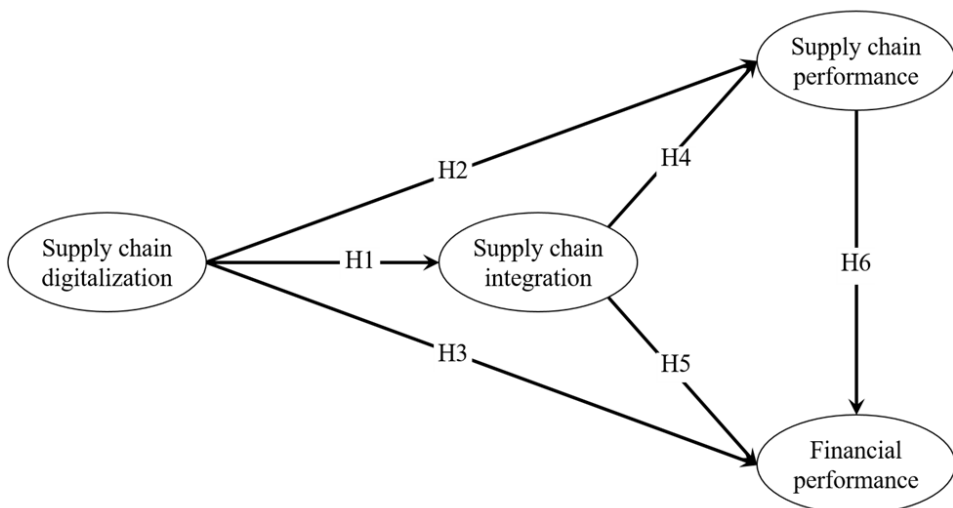
This study investigates the relationship between supply chain digitalization, supply chain integration, and firm performance. Specifically, a theoretical model is established, which links the supply chain digitalization and supply chain integration with measures of supply chain performance and financial performance. Based on the proposed model, different hypotheses are developed. A survey instrument is then generated to collect the data from supply chain practitioners on the adoption of digital technologies in their transactions with suppliers and customers, as well as the implementation of supply chain integration strategies in various supply chain activities. The analysis results suggest that supply chain digitalization and supply chain integration have a positive influence on supply chain performance and financial performance.

BACKGROUND

SCM has become a crucial element of strategic management to enhance the competitive advantage of companies in global business (Hult et al., 2007). Grounded in the resource-based view (RBV; Barney, 1991), SCM develops companies' agility, adaptability, and alignment across the supply chain (Dubey et al., 2018). In order to improve performance and achieve competitiveness in the business, firms have managed their efforts toward relationships and collaboration with supply chain partners (Xu et al., 2014).

Since the outbreak of the COVID-19 pandemic, supply chain disruptions and shortages of inventories have substantially impacted company performance (Shih, 2020; van Hoek, 2020). Leveraging digital supply chain technologies to diversify and minimize supply chain risks and disruptions has become crucial to building a resilient supply chain (Zouari et al., 2021). Hence, a research model guiding this study is developed in Figure 1.

Figure 1. Research model and hypotheses



H7a: Supply chain digitalization has a stronger impact on supply chain performance and financial performance for SMEs.

H7b: Supply chain integration has a stronger impact on supply chain performance and financial performance for large enterprises

SUPPLY CHAIN DIGITALIZATION

Digitalization has attracted significant interest from academics and practitioners since it can benefit companies and improve their performances (Barreto et al., 2017; Dubey et al., 2019). *Supply chain digitalization* is the application of digital technologies to make plans and process transactions, communicate, and perform supply chain activities (Sanders & Swink, 2020). The digital technologies in the scope of the supply chain can include the application of the big data analytics technique in forecasting, cloud computing, advanced robotics in warehousing automation, advanced tracking technologies in transportation management, and additive manufacturing (e.g., 3D printing; Ivanov et al., 2019).

Previous research has revealed that the application of digital technologies plays a key role in integrating processes in a supply chain (Gautr, 2020; Mukhopadhyay & Kekre, 2002). Srinivasan et al. (1994) identified that the use of electronic data interchange (EDI) provides benefits to the company by integrating the information across the supply chain processes and significantly cutting down the number of shipping mistakes. Rai et al. (2006) indicated that the application of ERP and CRM digital transformational tools facilitates process integration in a supply chain, which can generate improvement in firm performance. Gautr (2020) reinforced this argument, claiming that digitalization favors integration across the different departments of a firm to facilitate teams moving toward common goals. Khajavi & Holmström (2015) investigated how various digital manufacturing technologies (e.g., additive manufacturing and 3D printing production techniques) enhance the visibility and efficiency of the production systems, thus enabling the highly integrated global supply chains. Deepu & Ravi (2021) pointed out the importance of the adoption of value-added shared information systems, through which enhanced supply chain capabilities and performance can be achieved. Although these studies seem to support that digitalization enables supply chain integration for better firm performance, Stank et al. (2019) have raised the research need to further examine how a firm interfaces with other entities in the supply chain in the digital age. Therefore, the following hypothesis is suggested.

H1: Supply chain digitalization has a positive influence on supply chain integration.

Many prior studies have examined the impact of digitalization on firm performance; however, the research work on how digitalization would affect firm performance in the scope of the supply chain is still deficient (Björkdahl, 2020; Rai et al., 2006). With regard to firm performance, different studies have adopted various measurements, which can be mainly divided into operational measures and business-related measures (Abdallah & Al-Ghwayeen, 2020; Flynn et al., 2010; Germain & Iyer, 2006). In this study, two important indicators for measuring firm performance are considered, namely, supply chain performance and financial performance. In terms of supply chain performance, the application of digital technologies in the supply chain improves the efficiency of business processes, for example, by reducing production costs, improving inventory turnover, promptly billing customers, and promptly paying suppliers. (Mukhopadhyay & Kekre, 2002). Enterprises can increase their production output and reduce breakdown occurrences by applying more digital technologies (Björkdahl, 2020). Digitalization in supply chain activities is chiefly regarded to benefit firms (Barreto et al., 2017; Gorbach, 2017; Loske & Klumpp, 2020). In terms of financial performance, digitalization and technology-based solutions enable firms to achieve more cost-efficient operations through effective resource allocation and transparent and accurate information that flows inside and outside the firm's networks (Baird & Raghu, 2015; Opresnik & Taisch, 2015). In addition, advanced digital capabilities, such as cloud technology, the Internet of things (IoT), 3D visualization, and advanced robotics, integrated into manufacturing and service processes will enhance a firm's competitive advantage in the market and therefore generate higher long-term profit (Westerman et al., 2014). Thus, the digitalization strategy presents a strong correlation with the financial performance of a firm. Following this rationale, the following hypotheses are proposed.

H2: Supply chain digitalization has a positive influence on supply chain performance.
H3: Supply chain digitalization has a positive influence on financial performance.

SUPPLY CHAIN INTEGRATION

Supply chain integration is viewed as an essential attribute of modern SCM (Childerhouse & Towill, 2011; Som et al., 2019; Zhao et al., 2013). It is commonly classified into internal and external integration (Flynn et al., 2010; Frohlich & Westbrook, 2001). *External integration* is the integration of a firm's logistics activities with its customers and suppliers across boundaries (Frohlich & Westbrook, 2001), whereas *internal integration* is the extent to which a firm can align its organizational practices and procedures into processes in unison to satisfy customer needs (Kahn & Mentzer, 1996).

The existing literature generally supports the positive influence of external integration and internal integration on firm performance. However, various studies report mixed findings (Ada et al., 2021; Flynn et al., 2010; Leuschner et al., 2013). For instance, external integration is not shown to be significantly correlated with supply chain performance (Flynn et al., 2010). No significant relationship between supplier integration and flexibility performance is observed by Jayaram and Xu (2013). In their meta-analysis study, Leuschner et al. (2013) demonstrated no significant relationship between supply chain integration as a whole and firm financial performance. Som et al. (2019) surprisingly showed the negative effect of relational integration with supply chain partners on supply chain performance in Ghana's manufacturing industries.

A few studies have highlighted internal supply chain integration as a pre-condition for external supply chain integration (Errassafi et al., 2019; Zhao et al., 2011). Internal integration and external integration are apparently two distinct dimensions embedded in supply chain integration. The intensifying competition in the global market has prompted many firms to create cooperative and mutually beneficial partnerships with supply chain partners (Mofokeng & Chinomona, 2019; Wisner & Tan, 2000). Firms strive to collaborate and build close relationships with external parties in a supply chain to improve performance and survive in a competitive environment (Xu et al., 2014). External integration with supply chain partners is the focus of this study. From the performance perspective, the supply chain integration allows for a higher level of information sharing within the supply chain network, thus enabling the supply chain to operate in a more responsive and agile manner and create a sustained competitive advantage for all the supply chain partners (Jajja et al., 2018). Meanwhile, the manufacturing and other supply chain operations can be effectively coordinated through supply chain integration to avoid cost of capital on the excess inventories (Yu et al., 2013). Based on these arguments, the following hypotheses are proposed.

H4: Supply chain integration has a positive influence on supply chain performance.
H5: Supply chain integration has a positive influence on financial performance.

SUPPLY CHAIN PERFORMANCE AND FINANCIAL PERFORMANCE

The measurement of supply chain performance covers operational and logistical performance, including improvements undertaken by a firm in response to the changing competitive environment, the rate at which a firm can modify a product to meet customer requirements, and the capacity of a firm to promptly deliver products to major customers (Flynn et al., 2010; Mofokeng & Chinomona, 2019). The fact that supply chain managers heavily focus on maximizing the daily supply chain performance is not surprising; nonetheless, managers should be aware of the impact of daily operations on the overall financial performance of the firm (Elgazzar et al., 2012). The literature also provides evidence that supply chain performance positively influences financial performance via the improved fulfillment of customer requirements (Germain & Iyer, 2006; Inman et al., 2011). In this case, the

measurement items of growth in sales, profit, market share, and return on investment are adopted in financial performance (Germain & Iyer, 2006; Narasimhan & Kim, 2002). Therefore, the following hypothesis is proposed.

H6: Supply chain performance has a positive influence on financial performance.

THE DIFFERENCE BETWEEN LARGE ENTERPRISES AND SMES

Recent studies have suggested that large enterprises differ from SMEs in the level of digitalization in the supply chain (Kergroach, 2020; Sven-Vegard et al., 2021). SMEs mostly lag behind in their supply chain digitalization efforts compared to large enterprises due to continual shortages in management, communication, or problem-solving skills that are crucial for innovation and technology adoption in small firms (Kergroach, 2020). In addition, significant financial investments that are required for collaborating with vendors in terms of the implementation and operation of new technologies may explain the lag in the supply chain digitalization of SMEs (Sven-Vegard et al., 2021). Therefore, the impact of supply chain digitalization on supply chain integration and performance may differ between large enterprises and SMEs.

Moreover, the extant literature has also indicated that supply chain integrative efforts differ between large enterprises and SMEs. Compared with SMEs, firms with a larger size denote a higher level of deployment in resources, investment, technology, and expertise, thereby positively affecting the plans for improving performance; furthermore, the size of an organization affects supply chain practices (Jabbour et al., 2011; Tortorella et al., 2017). This disparity might be due to the bigger budgets of large enterprises and differences in the power they exert in these supply chain relationships with external supply chain partners (Jabbour et al., 2011; Villena et al., 2009).

However, as previously stated, the mixed findings on supply chain integration and firm performance have left unanswered questions for both research and practice (Leuschner et al., 2013). That is, the role of supply chain integration in firm performance (i.e., supply performance and financial performance) is still unclear between large enterprises and SMEs. It should be noted that an enhanced understanding of the relationship between supply chain integration and firm performance is thus necessary, including the circumstances in which supply chain integration has the largest effect on performance (Mackelprang et al., 2014). Therefore, given the different characteristics of large enterprises and SMEs, this study predicted that the relationships in the proposed research model would differ between large enterprises and SMEs. Hence, the following hypothesis is proposed.

H7a: Supply chain digitalization has a stronger impact on supply chain performance and financial performance for SMEs.

H7b: Supply chain integration has a stronger impact on supply chain performance and financial performance for large enterprises.

METHODS

Participants and Data Collection

The data was collected through practitioners in the supply chain industry in mainland China. China has rapidly become a trade titan in the past three decades (Nicita & Razo, 2021). More recently, China has become a global manufacturing center and a considerably important player in the supply chain; the latter status is especially evident during the COVID-19 pandemic, notwithstanding some criticisms regarding over-dependency on sourcing in China (García-Herrero, 2020). In particular, practitioners in the supply chain industry were recruited via an online survey platform, Wenjuanxing (www.wjx.cn), a Chinese online survey company functioning similarly to Amazon Mechanical Turk and Qualtrics.

Data were obtained from more than 260 million registered members in Wenjuaxing’s sample pool with diverse demographics (e.g., gender, age, region, and occupation). To control the reliability and validity of data, a series of strict quality control mechanisms was employed during data collection to target a specific population and remove invalid responses via an automatic or manual inspection. Furthermore, one attention check question was used in the online survey to avoid inauthentic responses and ensure data quality (Chmielewski & Kucker, 2019; Hauser & Schwarz, 2016).

A total of 264 completed questionnaires were collected. Data screening was subsequently conducted to identify the multivariate outliers based on the Mahalanobis distance (Hair et al., 2010), but 27 outliers were then identified and removed, resulting in 237 responses from 237 firms for further data analysis. The detailed respondent characteristics are reported in Table 1. The majority of respondents (78.9%) have been in their position for more than three years, indicating adequate knowledge about the survey items.

Table 1. Characteristics of respondents (N = 237)

	Number	Percentage
Industry Type		
Operations and manufacturing	189	79.7
Traders, wholesalers, distributors, and retailers	34	14.3
Logistics or other service providers	13	5.5
Other	1	0.4
Position		
Top management	20	8.4
Middle management	84	35.4
General staff	133	56.1
Years in the Current the Position		
< 3 years	50	21.1
3–5 years	80	33.8
5–10 years	84	35.4
> 10 years	23	9.7
Number of Employees in the Firm		
< 101	34	14.3
101–500	116	48.9
501–1000	45	19.0
> 1000	42	17.7
Annual Sales Revenue (RMB)		
< 50 million	67	28.3
50 million – 100 million	75	31.6
100 million – 500 million	64	27.0
> 500 million	31	13.1

SURVEY INSTRUMENT

The survey instrument was generated based on an extensive literature review to identify valid measures for related constructs; in addition, existing measurement scales were adapted. It covered four sections, namely supply chain digitalization, supply chain integration, supply chain performance, and financial performance. First, the scale of supply chain digitalization (seven items) was adapted and modified from previous studies (Xue, 2014; Xue et al., 2013) to capture the extent to which firms implement SCM systems to electronically connect and conduct transactions with their suppliers and customers in the supply chain. Second, supply chain integration (six items) was adapted from previous studies on customer integration (three items) and supplier integration (three items; Flynn et al., 2010; Germain & Iyer, 2006; Mofokeng & Chinomona, 2019). Third, the scale of supply chain performance (six items) was adapted and modified from previous studies (Flynn et al., 2010; Mofokeng & Chinomona, 2019). Fourth, the scale of financial performance (four items) was obtained and modified from previous studies (Germain & Iyer, 2006; Narasimhan & Kim, 2002). Both supply chain performance and financial performance were subjectively evaluated compared to major industry competitors. All the indicators were measured using a seven-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

As the scales drawn from the literature were in English, the back-translation approach Brislin (1970) was employed to translate the initial questionnaire developed in English into Chinese. The questionnaire items were carefully reviewed by a panel of academic scholars and practitioners to verify the appropriateness of the contents of the questionnaire and ensure its fitness for the purpose.

DATA ANALYSIS

The partial least squares structural equation modeling (PLS-SEM) using SmartPLS 3.0 (Ringle et al., 2015) was performed for data analysis. Prior to the PLS-SEM analysis, common method bias was examined due to the single-survey data (Craighead et al., 2011; Podsakoff et al., 2003). The examination of common method bias was conducted by evaluating variance inflation factors (VIFs) in the full collinearity test. According to Kock (2017), the VIF values should be lower than 3.3 to eliminate the problem of common method bias. All the VIF values for all the items and constructs were found to be lower than 3.3, indicating the absence of common method bias in this study.

Prior to PLS-SEM, the sample size requirement was examined. In the research model, there are three antecedents directing to an outcome variable (i.e., financial performance), and therefore, 103 observations are necessary for this study to achieve the statistical power of 80% for detecting a minimum R^2 equal to 0.10 at a 5% level of significance (Hair et al., 2022). As such, the sample size ($N = 237$) was deemed appropriate for this study.

PLS-SEM was conducted in two phases to assess the measurement model (i.e., internal consistency reliability, convergent validity, and discriminant validity) and the structural model (i.e., hypotheses; Hair et al., 2022). In addition, a multi-group analysis was performed to explore the differences between large enterprises and SMEs in the hypothesized model. In accordance with the recommendations from (Jabbour et al., 2011; Tortorella et al., 2017), this study categorized the firm based on the number of employees. Firms with more than 500 employees were regarded as large enterprises ($n = 87$), and firms with less than 500 employees were considered SMEs ($n = 150$). In accordance with the recommendations from (Jabbour et al., 2011; Tortorella et al., 2017), firm size in this study is categorized based on the number of employees: large firms (i.e., more than 500 employees) and small firms (less than 500 employees).

RESULTS

Measurement Model Assessment

The initial assessment showed that one item of supply chain performance (SCP) had a low factor loading (i.e., < .40), resulting in inadequate construct reliability and validity. Therefore, this item was removed to improve the reliability and validity without compromising the meaning of the construct (Hair et al., 2022). As reported in Table 2, internal consistency reliability was established because all the CR values and Cronbach’s alpha coefficients were above the cut-off value (.70; Hair et al., 2022). Moreover, convergent validity was supported because all the factor loadings exceeded the criterion (.70), and the AVE values were higher than the recommended value of .50 (Hair et al., 2022). In addition, discriminant validity was examined by the heterotrait–monotrait ratio of correlations (HTMT) proposed by (Henseler et al., 2015). In this study, discriminant validity was established, as the HTMT scores of all the constructs needed to be lower than the suggested criterion of .85 (see Table 3).

Table 2. Summary of constructs and items adopted in the model

Constructs and Items	λ
Supply chain digitalization ($M = 5.50, SD = .83, \alpha = .89, CR = .91, AVE = .60$)	
Digital technologies are constantly applied within the company.	.700
Digital technologies are adopted in transactions with high percentages of suppliers in the company.	.732
Digital technologies are adopted in a high percentage of transactions with suppliers in the company.	.784
Digital technologies are always applied to transact with suppliers in general.	.806
Digital technologies are adopted in the transactions with a high percentage of customers in the company.	.801
Digital technologies are adopted in a high percentage of transactions with customers in the company.	.759
Digital technologies are always applied to transact with customers in general.	.835
Supply chain integration ($M = 5.48, SD = .73, \alpha = .81, CR = .86, AVE = .51$)	
Our company works with customers to develop a joint sales forecast that is used as the basis for replenishment.	.657
Our company exchanges point-of-sale information with customers to drive both replenishment and billing activities from actual sales data.	.737
Customers notify us about planned promotions and exchange with us information on activities against a promotion.	.685
Our company and our major suppliers share information on the available inventory.	.734
Our company and our major suppliers share production schedules.	.680
Our company helps our major supplier to improve the latter’s process to improve the fulfillment of our needs.	.775
Supply chain performance ($M = 5.65, SD = .70, \alpha = .89, CR = .91, AVE = .60$)	
Our company can quickly modify products to meet our major customer’s requirements.	—
Our company can rapidly introduce new products to the market.	.769
Our company can swiftly respond to changes in market demand.	.728
Our company has an outstanding record of on-time delivery to our major customer.	.694
Our company’s lead time for fulfilling customer orders is short.	.625
Our company provides a high level of customer service to our major customers.	.731
Financial performance ($M = 5.12, SD = .92, \alpha = .878, CR = .916, AVE = .731$): “Compared to the major competitors in your industry, the performance of _____ is better.”	

Table 2 continued on next page

Table 2 continued

Constructs and Items	λ
Sales growth	.856
Profit growth	.839
Market share growth	.857
Return on investment growth	.869

Table 3. Discriminant validity (HTMT)

Constructs	1	2	3	4
Supply chain digitalization				
Supply chain integration	.71			
Supply chain performance	.63	.82		
Financial performance	.50	.57	.64	

HYPOTHESIS TESTING

The structural model was assessed via PLS algorithm procedures to examine the hypothesized relationship by determining the path coefficients and significance level (.05). As shown in Table 4, supply chain digitalization had a positive impact on supply chain integration ($\beta_{SCD @ SCI} = .61, t = 10.59, p < .001$), supply chain performance ($\beta_{SCD @ SCP} = .21, t = 2.90, p = .003$), and financial performance ($\beta_{SCD @ FP} = .17, t = 2.38, p = .021$), hence supporting H1, H2, and H3. Moreover, supply chain integration positively affected supply chain performance ($\beta_{SCI @ SCP} = .52, t = 7.58, p < .001$) and financial performance ($\beta_{SCI @ FP} = .17, t = 2.00, p = .045$); therefore, H4 and H5 were supported. Finally, supply chain performance had a positive influence on financial performance ($\beta_{SCP @ FP} = .32, t = 5.00, p < .001$).

Table 4. Summary results of the hypothesized model testing

Hypotheses	Standardized Coefficient (β)	Standard Deviation	t-Value
H1: SCD @ SCI	.61	.05	10.59***
H2: SCD @ SCP	.21	.07	2.90**
H3: SCD @ FP	.17	.07	2.38*
H4: SCI @ SCP	.52	.07	7.58***
H5: SCI @ FP	.17	.08	2.22*
H6: SCP @ FP	.32	.07	5.00***

Note: SCD = supply chain digitalization, SCI = supply chain integration, SCP = supply chain performance, FP = financial performance, *** means $p < .001$, ** means $p < .01$, and * means $p < .05$.

MULTI-GROUP ANALYSIS

The partial least squares multi-group analysis (PLS-MGA) was conducted to determine whether the path coefficients vary between large enterprises ($n = 87$) and SMEs ($n = 150$) in the proposed model. Prior to PLS-MGA, measurement invariance of composites (MICOM) was assessed by three steps recommended by Henseler et al. (2016): (1) configural invariance, (2) compositional invariance, and (3) quality of composite mean values and variances. As a result, only configural invariance and compositional invariance were established in this study, indicating the partial measurement invariance and feasibility of performing PLS-MGA in the research model. In PLS-MGA, the differences are examined by comparing two groups' bootstrap estimates for the same parameter (Sarstedt et al., 2011). As demonstrated in Table 5 and Figure 2, two paths showed significant differences between the two groups. More specifically, the coefficient of the path from supply chain digitalization to financial performance was significantly higher for SMEs ($p = .014$), supporting H7a. Additionally, the impact of supply chain integration on financial performance ($p = .015$) was significantly stronger for large enterprises. Therefore, H7b was supported.

Figure 2. Results of PLS-MGA between large enterprises and SMEs

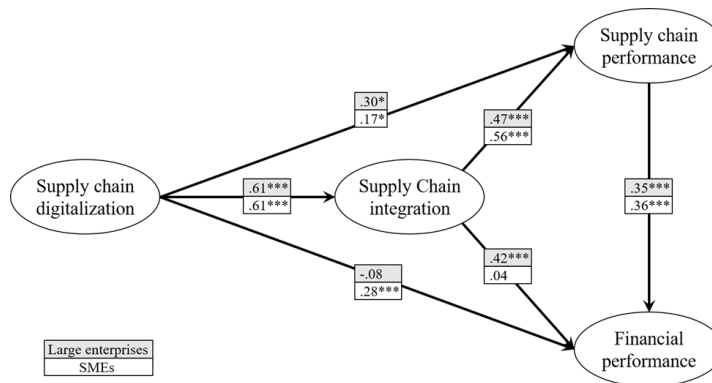


Table 5. Results of PLS-MGA between large enterprises and SMEs

Paths	Path Coefficient (<i>t</i> -Value)		Path Coefficient Differences	<i>p</i> -Values	Remarks
	Large Enterprises ($n = 87$)	SMEs ($n = 150$)			
SCD @ SCI	.61 (6.99***)	.61 (8.65***)	.00	.997	
SCD @ SCP	.30 (2.15*)	.17 (2.08*)	-.13	.427	
SCD @ FP	-.08 (.70)	.28 (3.68***)	.36	.014	SMEs > Large enterprises
SCI @ SCP	.47 (3.50***)	.56 (7.04***)	.09	.563	
SCI @ FP	.42 (3.71***)	.04 (.38)	-.38	.015	Large enterprises > SMEs
SCP @ FP	.35 (3.40***)	.36 (4.60***)	.01	.942	

Note. SCD = Supply chain digitalization, SCI = supply chain integration, SCP = supply chain performance, FP = financial performance, *** means $p < .001$, ** means $p < .01$, and * means $p < .05$.

CONCLUSION

The primary objective of this study is to understand the relationships among supply chain digitalization, supply chain integration, and firm performance. The conceptualized research model is established based on the extant literature. Seven hypotheses (H1–H7) are consequently formulated. Based on the empirical results, all seven hypotheses are statistically supported and found to be significant. With firm size as a moderator in this study, the results provide researchers and businesses with theoretical and practical implications.

THEORETICAL IMPLICATIONS

The findings contribute to the extant literature in several aspects. First, supply chain digitalization has shown a strong and positive influence on external supply chain integration (H1), which is consistent with Song et al. (2021)'s latest finding in omnichannel retailing that digitalization benefits the process integration with supply chain partners. This result also addresses the query from Stank et al. (2019) regarding the issue of how a firm interfaces with other entities in the supply chain in the digital age. It also provides empirical support to Iddris (2018) and Büyüközkan and Göçer (2018)'s argument that digitalization is highly associated with supply chain integration with external parties. Moreover, this finding offers additional evidence to generalize Björkdahl's (2020) in-depth case studies with 26 sample firms that digitalization boosts supply chain integration with customers and suppliers by facilitating the traceability of products, easing the access to customers' production systems and inventory management systems, and improving the control over materials and components with the firms' suppliers.

Second, supply chain digitalization has shown a positive influence on supply chain performance (H2), which is consistent with Loske's and Klumpp's (2020) empirical study on the retail industry. This finding provides empirical support to Barreto et al. (2017) and Björkdahl (2020)'s viewpoint that the implementation of digital technologies can shorten the lead time for the delivery of products to customers; reduce the time to respond to an unforeseen event; increase the agility, transparency, and efficiency of the supply chain; and improve customer satisfaction (Gorbach, 2017). Supply chain digitalization has also demonstrated a positive influence on financial performance (H3), which is generally consistent with Barua et al. (2004) study on customer and supplier-side digitization efforts to improve financial performance. However, when classifying firms into larger and smaller sizes, the result reveals that supply chain digitalization is positively correlated with financial performance for SMEs only but not for large enterprises.

Firm size thus moderates the relationship between supply chain digitalization and financial performance (H7). This outcome can be partly explained by the fact that SMEs mostly lag behind in their supply chain digitalization efforts (Kergroach, 2020; Sven-Vegard et al., 2021) compared to large enterprises that exhibit a significantly higher level of digitalization (Byung-Gak et al., 2021; Sven-Vegard et al., 2021). Moreover, slight enhancements in digitalization for SMEs can contribute to significant marginal returns to their financial performance, which is in line with the top priority of the Organization for Economic Co-Operation and Development (OECD) in boosting SME digitalization (OECD, 2019). The findings provide practical implications for SMEs that intend to undertake a digitalization journey.

Third, supply chain integration has shown a strong and positive impact on supply chain performance (H4), which is consistent with the extant literature (Errassafi et al., 2019; Flynn et al., 2010; Germain & Iyer, 2006). This finding shows that integration with supply chain partners can improve the responsiveness to customer demand, delivery performance, and customer service level. In addition, supply chain integration has demonstrated a positive impact on financial performance (H5), which is consistent with Flynn et al. (2010), although no significant correlation between supply chain integration and financial performance is found in Leuschner et al. (2013). An in-depth analysis

of the relationship between supply chain integration and financial performance shows significant differences between larger and SMEs. The result indicates that supply chain integration is positively correlated with financial performance for large enterprises only but not for SMEs.

In other words, firm size moderates the relationship between supply chain integration and financial performance (H7). This outcome can be explained by the fact that a larger firm size denotes a higher level of deployment in resources, investment, technology, and expertise, which positively affects the plans for improving performance; after all, the size of an organization affects its supply chain practices (Jabbour et al., 2011; Tortorella et al., 2017). This finding helps to explain why mixed findings were reported in the past studies; it also provides support to meta-analyses by Leuschner et al. (2013) and Mackelprang et al. (2014) regarding supply chain integration and firm performance that the inconsistencies and mixed findings might be due to the study's heterogeneous factors and unknown moderators (e.g., type of company, industry).

Fourth, supply chain performance has shown a positive impact on financial performance (H6), which is consistent with previous studies (Abdallah & Al-Ghwayeen, 2020; Germain & Iyer, 2006; Zacharia et al., 2009). The result indicates that improving a firm's daily operational performance enhances its financial performance.

PRACTICAL IMPLICATIONS

The findings of this study provide significant justification for firms to pursue the digitalization of their supply chains. Companies that are not ready to leverage digital and technological transformation are likely to be lagging behind in the business competition (Saxena, 2016). Most firms believe that digitalization efforts in their supply chain can benefit their business, although they are unclear about how and where digitalization can benefit their supply chains (*SupplyChainDigest*, 2016). Furthermore, ROI is typically considered a hindrance to digitalization (Gorbach, 2017). Based on the results of this study, the application of digital technologies, including EDI, RFID, cloud technology, 3D printing, and big data analytics, can simplify the processes of seamlessly sharing real-time information and closely collaborating with supply chain partners, thereby facilitating a high level of external supply chain integration and eventually reaching high levels of supply chain performance and financial performance.

Specifically, the findings indicate that financial performance is enhanced through different paths for large enterprises and SMEs. Large enterprises improve financial performance through supply chain integration after efforts spent on the digitalization of their supply chain, while SMEs improve financial performance directly through supply chain digitalization. These findings provide insights for managers and policymakers of large enterprises and SMEs in formulating appropriate implementation strategies for the digital transformation journey, although firms generally believe digitalization can boost a resilient supply chain and business growth by investing in digitalization (HSBC, 2021).

In particular, the finding has shown that digitalization positively influences financial performance for SMEs only. This outcome can be explained by the fact that SMEs mostly lag behind in their supply chain digitalization efforts (Kergroach, 2020) compared to large enterprises that demonstrate a significantly higher level of digitalization (Byung-Gak et al., 2021; Sven-Vegard et al., 2021). This finding indicates that slight enhancements in digitalization for SMEs can substantially contribute to their financial performance. The result provides insights for SMEs (e.g., SMEs) that they might even gain more advantages compared to large enterprises in this digitalization journey. The finding can offer additional support to the latest OECD agenda that SME digitalization has become a top policy priority in OECD countries (OECD, 2021).

With regard to the relationship between supply chain integration and financial performance, a positive correlation is found for large enterprises only but not for SMEs. This result might be due to the fact that large enterprises have more integrative resources (e.g., people, technology) to be deployed for collaboration with external parties in contrast to smaller companies where the resources are limited

(Villena et al., 2009). This finding implies that large enterprises should undertake further digitalization efforts with their external supply chain partners. Compared to SMEs, large enterprises may be in a better position to achieve performance gains due to their scale efficiencies in information sharing and possession of more resources to develop inter-organizational integration efforts (Villena et al., 2009).

LIMITATIONS AND FUTURE RESEARCH

This study carries some limitations as in any research, and at the same time, it opens opportunities for future research. First, the number of samples collected in this study was relatively small due to the difficulty of obtaining a large number of responses from various organizations. Future studies could classify the data from different industries and perform the comparison of the results between various industries. Moreover, the survey was conducted during the outbreak of the COVID-19 pandemic, which might have affected the responses of the participants. The impact of the COVID-19 pandemic on the supply chain industry may be explored in future research.

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