The Impact of Information Technology Infrastructure and Supply Chain Capability on Operational Performance

Shih-Ming Pi* and Chiu-Yun Chang
Department of Information Management, Chung Yuan Christian University, Taiwan
**Corresponding Author: happypi@gmail.com*

Received 27 August 2024; received in revised form 13 October 2024; accepted 23 December 2024

Abstract

This study aims to explore the impact of foundational information technology (IT) capabilities and supply chain efficiency on operational performance, addressing the gap in research on the interplay between IT capabilities, supply chain efficiency, and firm performance. The integration of information technology in supply chain management is widely regarded as a catalyst for enhancing operational efficiency. Resource-based theory suggests that for firms to achieve a competitive advantage, it is not enough to merely possess unique resources; these resources must be effectively integrated and utilized to develop capabilities that differentiate a firm from its competitors. Employing a structured model with four hypothesized relationships, this study collected data through a survey, yielding 157 valid questionnaires. The analysis was performed using the partial least squares method within a structural equation modeling framework. The study found that foundational IT capabilities significantly enhance supply chain efficiency, which in turn has a direct positive impact on operational performance. Furthermore, supply chain efficiency mediates the relationship between IT capabilities and operational performance, suggesting that the supply chain acts as a conduit for IT capabilities to positively affect operational outcomes. The findings underscore the importance of integrating and utilizing resources within firms to transform them into capabilities, in line with resource-based theory. Foundational IT capabilities by themselves do not directly lead to improved operational performance; instead, their effect is mediated through enhanced supply chain efficiency. This research highlights the critical role of supply chain management in leveraging IT capabilities to achieve superior operational performance, emphasizing the need for firms to focus on developing integrated capabilities for competitive advantage.

Keywords: Information technology infrastructure, supply chain capability, operational performance

1. Introduction

The role of information technology (IT) capabilities is becoming increasingly crucial in the context of supply chain management. This study investigates the influence of a firm's IT capabilities on its operational outcomes, focusing on the mechanism through which supply chain competencies convert IT capabilities into elevated organizational value. The scope of supply chain management encompasses coordination and collaboration in the flow of information, finances, and goods with various channel partners, such as suppliers, intermediaries, logistics providers, or customers. Supply chain management integrates the supply and demand management both within and between enterprises. This study investigates how a company within the scope of the supply chain utilizes its own information technology resources to enhance supply chain activities with its suppliers and customers. Information technology is a necessary and crucial resource for realizing corporate visions (Feeny & Willcocks, 1998). In previous studies, many scholars have advocated for the use of the latest technologies in supply chain management (Rai et al., 2006; Wu et al., 2006).

Technologies related to Industry 4.0, such as the Internet of Things (IoT), cloud computing, big data analytics, artificial intelligence (AI), and blockchain, have been applied in the daily operations of businesses. Academically, numerous scholars have researched the impact of these emerging technologies on supply chain processes and corporate performance (Kim & Shin, 2019; Kristoffersen et al., 2021; Mikalef & Gupta, 2021). In practice, Starbucks' Digital Flywheel program, which integrates cloud computing and artificial intelligence for rewards, personalization, payment, and ordering, has enhanced customer loyalty and service quality. Beyond personalized marketing aimed at improving the customer experience, in supply chain management, from product development and procurement to logistics, all processes have been moved to the cloud, achieving an Omni-Channel model through the integration of online and offline channels.

Making information transparent can enhance trust and confidence among the various stakeholders within the supply chain, thereby improving the overall efficiency and resilience

of the supply chain. As mentioned in the study by Williams et al. (2013), information transparency allows businesses to better understand supply and demand conditions, enabling them to respond more promptly to external changes. However, the reality is that there is a lack of transparency in information. In today's rapidly changing environment, various measures can be taken to promote supply chain transparency and visibility through government leadership. For example, the Freight Logistics Optimization Works (FLOW) initiative launched by the U.S. Department of Transportation in March 2022 can facilitate better cooperation and information sharing among various roles within the supply chain, thereby promoting the smooth flow of goods, reducing transportation costs, and providing consumers with better products and services. Besides the COVID-19 pandemic, the Russia-Ukraine conflict has again highlighted the importance of supply chain risk management. In March 2023, Austria established the "Supply Chain Intelligence Institute." By setting up such a research institution, Austria can focus on in-depth analysis and study of supply chain risks, offering insights and reports to governments and businesses to assist them in making better strategic decisions.

Currently, some businesses heavily rely on information technology as a key tool to ensure their productivity and efficiency. However, past research on supply chain management has primarily focused on the capability of supply integration within a single dimension of supply chain capabilities (Flynn et al., 2010). Supply chain capabilities can be multifaceted (Ekanayake et al., 2021), with few studies exploring the relationship between the use of information technology, supply chain capabilities, and operational performance simultaneously. The changing industrial environment tests the adaptability of businesses. The emergence of new technologies has created numerous opportunities for businesses, which should consider how to apply these technologies to improve and augment their capabilities. Moreover, the pandemic has caused sudden halts in production due to lockdowns, leading to shortages and supply chain disruptions. On the other hand, due to lockdowns, air and sea freight may be affected, and products may not find transportation, impacting businesses' delivery capabilities. This makes longer supply chains more prone to issues. In such an unstable environment, businesses must respond to various emergencies to maintain operations and sustainable development. This study aims to explore the following questions:

1. The impact of IT foundational capabilities on operational performance?
2. The impact of supply chain capabilities on operational performance?
3. The influence of IT foundational capabilities on supply chain capabilities?
4. The mediating effect of supply chain capabilities between IT foundational capabilities and operational performance?

2. Literature Review

2.1 Resource-Based Theory

The Resource-Based Theory (RBT) is considered one of the most widely applied perspectives in discussing the competitive advantage of firms. Compared to SWOT or Porter's Five Forces analysis, the Resource-Based Theory offers a perspective with both depth and breadth to explain how the resources owned or controlled by a firm, such as those detailed by Barney in 1991, can create differences in business performance among competitors. The theory posits that there are two factors in how a firm maintains its competitiveness and achieves long-term success: resources and capabilities. Amit and Schoemaker (1993) defined resources as assets that can be traded and are not specific to a company; capabilities, on the other hand, are defined as the firm-specific, non-tradable abilities to integrate, deploy, and utilize resources internally.

2.2 Information Technology Capability

Bharadwaj (2000) interpreted information technology capabilities based on the Resource-Based Theory, explaining how information technology can create value for companies and enhance corporate performance. Information technology resources were also categorized into three types: tangible resources, intangible resources, and human resources. Information technology capability refers to a company's ability to combine, integrate, and apply IT resources effectively, enabling efficient use of IT resources, coordinating supply chain activities to meet business needs (Rai et al., 2006). Subsequent scholars have largely classified information technology capabilities in this manner (Tippins & Sohi, 2003). This study focuses on the fundamental capabilities of applying IT infrastructure, as IT capabilities are considered a primary business resource for enterprises, crucial for reducing costs and creating long-term competitive advantages (Keen, 1991; Hassan et al., 2013; Aydiner et al., 2019). Furthermore, based on the research by Tallon and Pinsonneault (2011), IT capabilities are divided into three dimensions: network connectivity, hardware compatibility, and software modularity.

2.3 Supply Chain Capability

Supply chain capability is an organization's ability to identify, utilize, and absorb internal and external resources/information to facilitate activities across the entire supply chain (Wu et al., 2006). The aspects of supply chain capability are numerous. Bruneau et al. (2003) believe that a supply chain system should possess the following three capabilities: (1) reduce the likelihood of supply chain disruptions, (2) mitigate the impact of disruptions, including the loss of life as well as negative effects on the economy and society, and (3) decrease the time to return to normal operations. Chowdhury and Quaddus (2016) categorized supply chain capability into seven types: risk anticipation capability, resilience, contingency capability, visibility, coordination ability, responsiveness, and recovery capability. Pettit et al. (2013) even identified up to 14 types. This study conceptualizes supply chain capability into four dimensions based on the research by Wu et al. (2006): information exchange, inter-firm activity integration, responsiveness, and coordination ability.

2.4 Operational Performance

In previous studies, numerous indicators have been used to measure corporate performance. Some scholars focus exclusively on a company's financial performance, employing metrics such as profit, earnings per share, return on assets (ROA), and return on equity as evaluation standards (Wu et al., 2006; Yu et al., 2018). However, some scholars highlight the limitations of measuring corporate performance solely with financial performance indicators, arguing that they cannot fully capture corporate performance (Jun & Rowley, 2014). Another set of scholars' measure performance from three dimensions: supply chain operational performance, customer relationships, and financial performance, providing a more comprehensive perspective on assessing the performance of a company's supply chain (Rai et al., 2006; Ou et al., 2010). This study uses operational performance as a measure of supply chain effectiveness. In today's highly competitive global market, companies seek competitive advantages, necessitating improvements in price, quality, product variety, order fulfillment time, delivery time, and frequency capabilities (Tracey et al., 1999). Additionally, operational performance is divided into four dimensions according to the study by Ward and Duray (2000): delivery performance, cost performance, quality performance, and production flexibility.

3. Research Methods

Based on the previous discussion, we have summarized the research framework as shown in Figure 1. This framework is based on the Resource-Based Theory and examines the impact of "IT infrastructure capabilities" and "supply chain capabilities" on "operational performance." This study adopts a second-order model that includes the first-order variables of each construct. IT infrastructure capabilities encompass three key abilities related to the use of IT infrastructure resources: hardware compatibility, software modularity, and network connectivity. Supply chain capabilities consist of information exchange, activity integration, responsiveness, and coordination abilities, while operational performance is measured through four indicators: delivery performance, cost efficiency, quality performance, and production flexibility. Reflective indicators are used for both the second-order and first-order dimensions. Table 1 presents the operational definitions of each research variable and their sources of reference. This study designed the questionnaire based on operational definitions of the research variables and used questionnaire items from previous scholars as references. Please refer to Appendix 1 for the questionnaire items. To ensure that respondents could clearly understand the content of the questionnaire, we also conducted a pretest and a pilot survey, both of which showed favorable results.

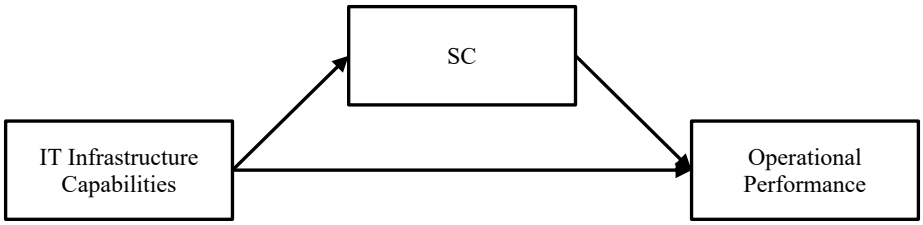


Figure 1: Research Framework

Table 1: Research Variables and Operational Definitions

Research Variable	Operational Definition	Reference
Hardware Compatibility	Hardware devices with interoperability, interchangeability, and compatibility to achieve rapid transmission, access, and sharing of data across different functions and enterprises.	Tallon and Pinsonneault (2011)
Software Modularity	Software that can add or delete functions.	Tallon and Pinsonneault (2011)
Network Connectivity	Applications and devices that can connect to networks, linking internal and external users with other IT resources.	Tallon and Pinsonneault (2011)
Information Exchange	The ability of a company to share knowledge and information about products and processes with supply chain partners in an effective manner.	Wu et al. (2006)
Activity Integration	The relationships established by a company with its supply chain partners.	Wu et al. (2006)
Responsiveness	The ability of a company to respond quickly to changes in the environment.	Wu et al. (2006)
Coordination Capability	The ability of a company to coordinate supply chain activities related to transactions (e.g., procurement, sales, and delivery) with customers and suppliers.	Wu et al. (2006)
Delivery Performance	The level of emphasis on customer service, measured by the reliability or speed of delivery.	Ward and Duray (2000)
Cost Efficiency	The ability to reduce production costs and inventory, and to improve productivity.	Ward and Duray (2000)
Quality Performance	The ability to meet customer needs through control and management of the production process.	Ward and Duray (2000)
Production Flexibility	The ability to reduce costs associated with changes in products or product portfolios.	Ward and Duray (2000)

In enterprises, having a well-established IT infrastructure can enhance operational efficiency. Hardware compatibility and uniform data formats reduce the need for converting formats during data exchange across platforms; software is reused through modularity, lowering the frequency of redeveloping the same functions; and good network connectivity allows relevant personnel to access data in a timely manner. Haseeb et al. (2019) suggested that this can bring sustainable performance benefits to enterprises. Integrating IT infrastructure capabilities can improve operational process efficiency, such as product quality, cost, and delivery time. These improvements make organizational processes smoother, enhance organizational operational performance, and enable faster and more effective internal and external information communication (Chung et al., 2005). Saryatmo and Sukhotu (2021) stated that digitalizing the supply chain could optimize operational performance in terms of quality, production flexibility, and cost. Therefore, it can be inferred that there might be a direct relationship between integrated IT infrastructure capabilities and business operational performance. Hence, the following hypothesis is proposed:

H1: IT infrastructure capabilities have a positive impact on operational performance.

Previous research indicates that supply chain capabilities not only have a positive impact on finances (Wu et al., 2006) but also positively affect operational performance (Naway & Rahmat, 2019; Hautala-Kankaanpää, 2022). Wang et al. (2006) believe that in uncertain environments, a company with good responsiveness can positively impact operational performance in terms of production and cost, and having good coordination capabilities can help with performance in terms of production flexibility. Thatte et al. (2013) argued that supply chain responsiveness can create a competitive advantage, hence the following hypothesis is proposed:

H2: Supply chain capabilities have a positive impact on operational performance.

IT infrastructure capabilities are considered to facilitate the establishment of close connections between enterprises and their supply chain partners, achieving high levels of integration, information sharing, and coordination among supply chain capabilities. According to Rai et al. (2006), the integration capability of IT infrastructure is a foundational capability of an enterprise. Integrating IT infrastructure capabilities into supply chain management leverages them to create advanced supply chain integration abilities, leading to significant and sustained performance growth. Hence, the following hypothesis is proposed:

H3: IT infrastructure capabilities have a positive impact on supply chain capabilities.

While some research findings suggest that there may be a direct relationship between IT infrastructure capabilities and business operational performance, from the perspective of Resource-Based Theory, the relationship between IT infrastructure capabilities and business operational performance might be more

distant and challenging to directly influence. IT infrastructure capabilities might need to impact operational performance through mediating variables. Additionally, past research has confirmed the mediating effect of supply chain capabilities between IT infrastructure capabilities and business operational performance (Rai et al., 2006; Hautala-Kankaanpää, 2022). This study posits that when enterprises have a strong foundation in supply chain capabilities, it can foster effective interaction in information exchange and activity integration between the enterprise and its supply chain partners, and when facing changes in the external environment, the enterprise can quickly coordinate internal resources and respond, thereby improving supply chain performance and enhancing business competitiveness. Hence, the following hypothesis is proposed:

H4: Supply chain capabilities have a positive mediating effect on the impact of IT infrastructure capabilities on operational performance.

4. Data Analysis

This study collected a total of 163 questionnaires. After removing invalid samples, there were 157 valid samples. The sample data is shown in Table 2. Among the respondents, nearly half (49.68%) are middle to senior managers, junior managers account for 24.20% of the overall data, and non-managerial positions comprise 26.11%. The most represented department among the respondents is the sales department, accounting for 31.85%. Those from the supply chain management department make up 17.83%, the IT department 15.29%, manufacturing 11.46%, administrative management 19.75%, and logistics (operations) 3.82%. For these respondents, we clearly explained the purpose of the research and the variables to be measured in advance, and also confirmed their ability to provide the necessary information in the questionnaire, ensuring the representativeness of the survey sample.

Table 2: Distribution of Respondent Sample Characteristics (N=157)

Variable	Value	Frequency	% Respondents
When was the/your company established?	3 years or less	5	3.18
	4 to 20 years	61	38.85
	21 years or more	91	57.96
Total Number of Employees in Company	10 or less	23	14.65
	11 to 200	71	45.22
	201 or more	63	40.13
Position	Middle to Senior Management	78	49.68
	Junior Management	38	24.20
	Non-managerial Positions	41	26.11
Department	Supply Chain Management	28	17.83
	Logistics (Operations)	6	3.82
	Manufacturing	18	11.46
	IT	24	15.29
	Sales	50	31.85
	Administrative Management	31	19.75

Based on the data in Table 3, the Cronbach's alpha values for each dimension of this study are greater than 0.7, indicating that the questionnaire has good reliability. The Composite Reliability (CR) values for the latent variables are also above 0.7, suggesting that the internal consistency of the measurement variables for each dimension is satisfactory. As for the Average Variance Extracted (AVE) of the measurement variables for each dimension, all are above 0.6, indicating good convergent validity for the measurement variables of each dimension.

Table 3: Validity and Reliability

Second-order Construct	First-order Construct	Cronbach α	CR	AVE
IT Infrastructure Capabilities	Hardware Compatibility	0.852	0.854	0.693
	Software Modularity	0.858	0.860	0.702
	Network Connectivity	0.780	0.781	0.603
Supply Chain Capabilities	Information Exchange	0.943	0.946	0.854
	Activity Integration	0.943	0.943	0.898
	Responsiveness	0.940	0.940	0.848
	Coordination Capability	0.927	0.928	0.820
Operational Performance	Delivery Performance	0.908	0.923	0.787
	Cost Efficiency	0.920	0.920	0.807
	Quality Performance	0.934	0.935	0.884
	Production Flexibility	0.892	0.897	0.821

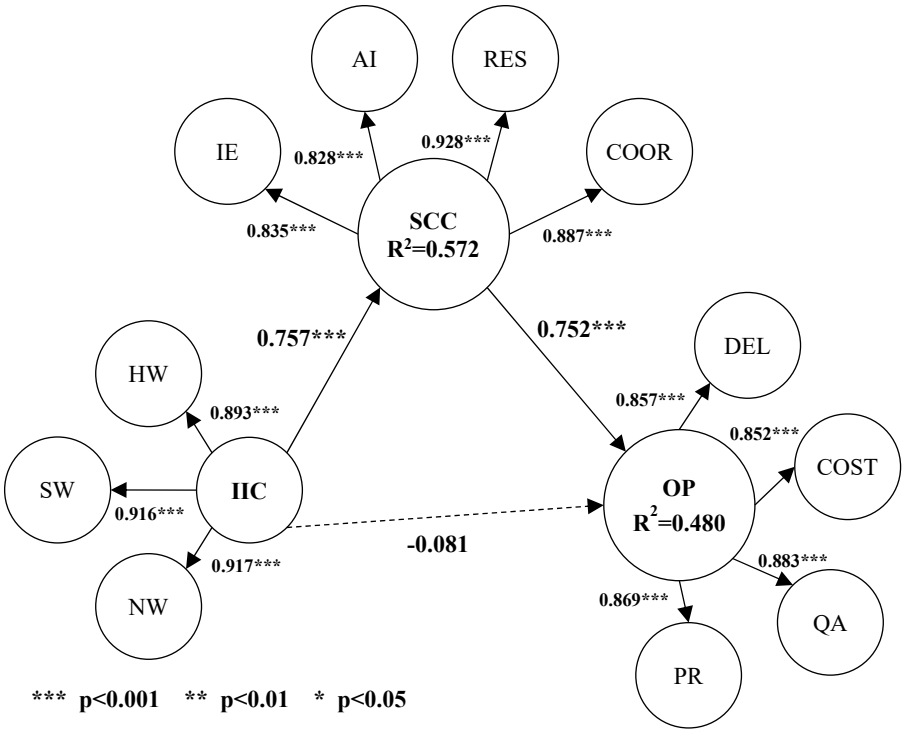
In Table 4, we can also observe that the discriminant validity of this study meets the standards, as the square root of the AVE is greater than the correlations among the constructs. The bold diagonal elements represent the square root of the variance shared between the latent constructs. To ensure strong discriminant validity, the diagonal elements should be larger than any other corresponding entries in the same row or column.

Table 4: Correlation Coefficient Matrix

	HW	SW	NW	IE	AI	RES	COOR	DEL	COST	QA	PR
HW	**0.833**										
SW	0.703	**0.838**									
NW	0.736	0.776	**0.777**								
IE	0.558	0.651	0.694	**0.924**							
AI	0.602	0.594	0.635	0.677	**0.948**						
RES	0.523	0.641	0.631	0.663	0.672	**0.921**					
COOR	0.495	0.613	0.568	0.582	0.611	0.854	**0.906**				
DEL	0.261	0.333	0.366	0.363	0.37	0.608	0.553	**0.887**			
COST	0.317	0.467	0.436	0.401	0.444	0.597	0.634	0.624	**0.898**		
QA	0.366	0.396	0.409	0.352	0.381	0.655	0.601	0.707	0.612	**0.94**	
PR	0.352	0.469	0.43	0.415	0.48	0.701	0.66	0.609	0.677	0.766	**0.906**

HW：Hardware Compatibility SW：Software Modularity NW：Network Connectivity
IE：Information Exchange AI：Activity Integration RES：Responsiveness
COOR：Coordination Capability DEL：Delivery Performance COST：Cost Efficiency
QA：Quality Performance PR：Production Flexibility

According to the data from this study (Figure 2), IT foundational capabilities do not have a direct positive effect on operational performance (path coefficient = -0.081, t = 0.811), thus hypothesis H1 is not supported. Supply chain capabilities have a positive effect on operational performance (path coefficient = 0.752, t = 9.559), thus hypothesis H2 is supported. IT foundational capabilities have a positive effect on supply chain capabilities (path coefficient = 0.757, t = 20.357), thus hypothesis H3 is supported. Supply chain capabilities have a positive mediating effect on the impact of IT foundational capabilities on operational performance (path coefficient = 0.569, t = 8.366), thus hypothesis H4 is supported.



IIC：IT Infrastructure Capabilities SCC：Supply Chain Capabilities OP：Operational Performance
HW：Hardware Compatibility SW：Software Modularity NW：Network Connectivity
IE：Information Exchange AI：Activity Integration RES：Responsiveness
COOR：Coordination Capability DEL：Delivery Performance COST：Cost Efficiency
QA：Quality Performance PR：Production Flexibility

Figure 2: Structural Model

5. Conclusion

This study examines the effects of a company's IT foundational capabilities and supply chain capabilities on operational performance, with a particular focus on the mediating role of supply chain capabilities. The findings reveal that IT foundational capabilities do not exert a direct influence on operational performance. Instead, their impact is realized indirectly through the enhancement of supply chain capabilities. These results suggest that companies aiming to improve operational performance should prioritize strengthening their supply chain capabilities to leverage the full potential of their IT investments.

From a managerial perspective, the increasing importance of digitalization for both companies and their supply chains underscores the need for improved utilization of information technology to achieve sustainable development. The insights derived from this study offer managers a clearer understanding of how IT investments contribute to operational performance. The interconnected nature of supply chain capabilities indicates that companies must consider not only their internal requirements but also their collaborative relationships with supply chain partners when allocating IT resources. Each dimension of supply chain capabilities—information exchange, activity integration, responsiveness, and coordination—exerts varying degrees of influence on operational performance. Given the constraints of limited resources, companies should make informed strategic decisions regarding resource allocation to develop the most effective supply chain capabilities. By carefully assessing business needs, analyzing the characteristics of each supply chain link, and identifying the capabilities most critical to achieving operational objectives, companies can optimize their resource allocation to enhance specific capabilities. Regular monitoring and performance evaluation, followed by adjustments to resource distribution based on actual results, will enable companies to achieve maximum operational efficiency even with constrained resources.

Regarding the limitations and future research directions, the first consideration is the potential influence of respondents' understanding of their own companies on the accuracy of their questionnaire responses. Since the questionnaire encompasses multiple departments, including IT infrastructure and supply chain management, respondents must possess a comprehensive understanding of their company's operations to provide accurate and complete responses. Although the study ensured that respondents were well-informed of the research objectives and capable of providing the required information, cognitive limitations may still affect their responses. Future studies may need to apply more stringent screening criteria for respondents. Secondly, the scope of this study could be expanded by including additional company resources. Beyond tangible IT foundational capabilities, intangible assets and human resources could provide a more holistic view of how companies utilize their resources to enhance operational performance. Moreover, this study focused on four dimensions of supply chain capabilities; future research should explore other critical capabilities, such as risk anticipation, flexibility, and innovation, which may also significantly impact supply chain performance. Future studies could also examine the role and interaction of supply chain partners, as companies may demonstrate different supply chain capabilities to their suppliers and customers, with potentially varying effects on operational performance. Overall, the findings of this study offer valuable recommendations for businesses seeking to strategically invest in IT and supply chain management to optimize their operational outcomes.

References

Amit, R., & Schoemaker, P. J. (1993). Strategic assets and organizational rent. *Strategic Management Journal, 14*(1), 33-46.

Aydiner, A. S., Tatoglu, E., Bayraktar, E., & Zaim, S. (2019). Information system capabilities and firm performance: Opening the black box through decision-making performance and business-process performance. *International Journal of Information Management, 47*, 168-182.

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: an empirical investigation. *MIS Quarterly*, 169-196.

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., ... & Von Winterfeldt, D. (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. *Earthquake Spectra, 19*(4), 733-752.

Chowdhury, M. M. H., & Quaddus, M. (2016). Supply chain readiness, response and recovery for resilience. *Supply Chain Management: An International Journal, 21*(6), 709-731.

Chung, S. H., Byrd, T. A., Lewis, B. R., & Ford, F. N. (2005). An empirical study of the relationships between IT infrastructure flexibility, mass customization, and business performance. *ACM SIGMIS Database: The DATABASE for Advances in Information Systems, 36*(3), 26-44.

Ekanayake, E. M. A. C., Shen, G. Q., & Kumaraswamy, M. M. (2021). Identifying supply chain capabilities of construction firms in industrialized construction. *Production Planning & Control, 32*(4), 303-321.

Feeny, D. F., & Willcocks, L. P. (1998). Core IS capabilities for exploiting information technology. *MIT Sloan Management Review*.

Flynn, B. B., Huo, B., & Zhao, X. (2010). The impact of supply chain integration on performance： A contingency and configuration approach. *Journal of Operations Management, 28*(1), 58-71.

Haseeb, M., Hussain, H. I., Ślusarczyk, B., & Jermsittiparsert, K. (2019). Industry 4.0: A solution towards technology challenges of sustainable business performance. *Social Sciences, 8*(5), 154.

Hassan, M. G., Hussain, F., & Rahman, M. B. S. (2013). Exploring usefulness of CRM and IT in Malaysian hotel industry: A qualitative approach. *Journal of Information and Communication Technology, 12*, 21-37.

Hautala-Kankaanpää, T. (2022). The impact of digitalization on firm performance: examining the role of digital culture and the effect of supply chain capability. *Business Process Management Journal, 28*(8), 90-109.

Jun, W., & Rowley, C. (2014). Change and continuity in management systems and corporate performance: Human resource management, corporate culture, risk management and corporate strategy in South Korea. *Business History, 56*(3), 485-508.

Keen, P. P., & Pinsonneault, A. (2011). Competing perspectives on the link between strategic information technology alignment and organizational agility: insights from a mediation model. *MIS Quarterly*, 463-486.

Kim, J. S., & Shin, N. (2019). The impact of blockchain technology application on supply chain partnership and performance. *Sustainability, 11*(21), 6181.

Kristoffersen, E., Mikalef, P., Blomsma, F., & Li, J. (2021). The effects of business analytics capability on circular economy implementation, resource orchestration capability, and firm performance. *International Journal of Production Economics, 239*, 108205.

Mikalef, P., & Gupta, M. (2021). Artificial intelligence capability： Conceptualization, measurement calibration, and empirical study on its impact on organizational creativity and firm performance. *Information & Management, 58*(3), 103434.

Naway, F., & Rahmat, A. (2019). The mediating role of technology and logistic integration in the relationship between supply chain capability and supply chain operational performance. *Uncertain Supply Chain Management, 7*(3), 553-566.

Ou, C. S., Liu, F. C., Hung, Y. C., & Yen, D. C. (2010). A structural model of supply chain management on firm performance. *International Journal of Operations & Production Management, 30*(5), 526-545.

Pettit, T. J., Croxton, K. L., & Fiksel, J. (2013). Ensuring supply chain resilience: development and implementation of an assessment tool. *Journal of Business Logistics, 34*(1), 46-76.

Rai, A., Patnayakuni, R. and Seth, N., 2006. Firm Performance Impacts of Digitally Enabled Supply Chain Integration Capabilities, *MIS Quarterly, 30*(2), 225-246.

Saryatmo, M. A., & Sukhotu, V. (2021). The influence of the digital supply chain on operational performance: a study of the food and beverage industry in Indonesia. *Sustainability, 13*(9), 5109.

Tallon, P. P., & Pinsonneault, A. (2011). Competing perspectives on the link between strategic information technology alignment and organizational agility: insights from a mediation model. *MIS Quarterly*, 463-486.

Thatte, A. A., Rao, S. S., & Ragu-Nathan, T. S. (2013). Impact of SCM practices of a firm on supply chain responsiveness and competitive advantage of a firm. *Journal of Applied Business Research (JABR), 29*(2), 499-530.

Tippins, M. J., & Sohi, R. S. (2003). IT competency and firm performance: is organizational learning a missing link?. *Strategic Management Journal, 24*(8), 745-761.

Tracey, M., Vonderembse, M. A., & Lim, J. S. (1999). Manufacturing technology and strategy formulation: keys to enhancing competitiveness and improving performance. *Journal of Operations Management, 17*(4), 411-428.

Wang, E. T., Tai, J. C., & Wei, H. L. (2006). A virtual integration theory of improved supply-chain performance. *Journal of Management Information Systems*, *23*(2), 41-64.

Ward, P. T., & Duray, R. (2000). Manufacturing strategy in context: environment, competitive strategy and manufacturing strategy. *Journal of Operations Management, 18*(2), 123-138.

Williams, B. D., Roh, J., Tokar, T., & Swink, M. (2013). Leveraging supply chain visibility for responsiveness: The moderating role of

internal integration. *Journal of Operations Management, 31*(7-8), 543-554.

Wu, F., Yeniyurt, S., Kim, D., & Cavusgil, S. T. (2006). The impact of information technology on supply chain capabilities and firm performance: A resource-based view. *Industrial Marketing Management, 35*(4), 493-504.

Yu, W., Chavez, R., Jacobs, M. A., & Feng, M. (2018). Data-driven supply chain capabilities and performance: A resource-based view. *Transportation Research Part E: Logistics and Transportation Review, 114*, 371-385.

Appendix 1: Questionnaire

Hardware Compatibility

1. Software applications can be easily transferred and used across multiple platforms.
2. Our system user interface provides cross-platform data access.
3. Our company offers multiple interfaces or entry points for external users (e.g., Web access).
4. Our company extensively uses middleware to integrate key enterprise applications.

Software Modularity

1. Our IT department extensively utilizes reusable software modules.
2. Our company's legacy systems do not hinder the development of new IT applications.
3. We can quickly add features to applications based on end-user requirements.
4. Our company can easily handle data format modifications when necessary.

Network Connectivity

1. Our company's systems are highly interconnected.
2. Our systems are sufficiently flexible to connect to external partners' websites (e.g., our suppliers or customers).
3. Remote users can smoothly access data.
4. Our employees can access the necessary data in real-time.

Information Exchange

1. Our company exchanges a large volume of information with external partners (e.g., our suppliers or customers).
2. The flow of information between our company and external partners (e.g., our suppliers or customers) is smooth.
3. Our company benefits significantly from information exchanges with external partners (e.g., our suppliers or customers).
4. The information exchange between our company and external partners (e.g., our suppliers or customers) is effective.

Activity Integration

1. Our company collaborates with partners to develop strategic plans.
2. Our company works with partners to conduct forecasting and planning.
3. Our company collaborates with partners to forecast and plan for future demand.

Responsiveness

1. Compared to competitors, our supply chain responds faster and more effectively to changes in customer and supplier demands.
2. Compared to competitors, our supply chain develops and launches new products faster and more effectively.
3. In most markets, our supply chain has effective competitiveness.
4. Through collaboration, our relationships with partners have improved our supply chain's responsiveness to market changes.

Delivery Performance

1. Our delivery time is shorter than the industry average.
2. Our delivery accuracy is good, or better than the industry average.
3. Our delivery reliability is strong, or better than the industry average.
4. Our order processing speed is superior to the industry average.

Cost Performance

1. Our production costs are lower than the industry average.
2. The storage costs for our products are lower than the industry average.
3. The overhead costs for our products are lower than the industry average.
4. The price competitiveness of our products is better than the industry average.

Quality Performance

1. The quality of our products is stable and reliable.
2. The quality deviation of our products is smaller than the industry average.
3. Compared to the industry average, our products are more reliable and meet customer standards.

Production Flexibility

1. Our ability to adjust production volume is superior to the industry average.
2. Our product customization capability is better than the industry average.
3. Our product design change speed is faster than the industry average.

About Authors

Shih-Ming Pi is a professor of the Department of Information Management at Chung Yuan Christian University in Taiwan. His recent articles can be found in Computers in Human Behavior, Communications of the ACM, European Journal of Information Systems, Journal of the Association for Information Systems, and other Chinese information management journals.

Chiu-Yun Chang is a graduate student of the Department of Information Management at Chung Yuan Christian University in Taiwan. Her research interests focus on supply chain management.