



# Digital supply chain transformation: effect of firm's knowledge creation capabilities under COVID-19 supply chain disruption risk

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## Abstract

Digital supply chain (SC) transformation has emerged as a way to improve information sharing, better manage demand, and reduce costs in supply chain management. However, the majority of firms are unable to transform their supply chains into digital models. Thus, this study aims to identify the key drivers of digital SC transformation and provide empirical evidence on the extent to which firms' knowledge creation capabilities could impact firms' level of digital supply chain transformation. Based on a knowledge-based view, this study proposes that firms' knowledge creation capabilities – which consist of the capacity to absorb external knowledge and the intent to learn with partners within the SC – are crucial to the successful knowledge transfer required to digitally transform, particularly under the effects of COVID-19 supply chain disruption risks. Survey data collected from 923 Vietnamese firms participating in cross-border trades were analyzed using partial least squares structural equation modeling (PLS-SEM). This study finds that firms' absorptive capacity and learning intent are critical drivers of their digital supply chain transformation. Moreover, the high uncertainties in external environments are found to substantially accelerate the digital transformation processes and influence the effectiveness of firms' knowledge creation capabilities in digital SC transformation. Significantly, firms are more inclined toward external knowledge sources to cope with disruption risks in the supply chain. This study contributes a novel approach to better understanding the role of knowledge creation capabilities in responding to supply chain disruption risks and fills a gap in research on drivers of successful digital SC transformation.

**Keywords** Digital supply chain transformation · Absorptive capacity · Learning intent · Knowledge-based view · Knowledge creation · Disruption risk · The COVID-19 pandemic

## 1 Introduction

Since digitalization has become an important business strategy for almost every firm, the need for digital supply chain (SC) transformation has become increasingly important over the last decade (Büyükközkın and Göçer 2018). Digital SC transformation has been identified as an essential platform to help improve supply response time by shortening the time it takes to transfer or access the required information (Raj and Sharma 2014). It also increases firms' flexibility by allowing supply chain members to adapt to changing situations, anticipate risky events, and use suitable measures to reduce disruption levels (Schrauf and Bertram 2016). It also expands global connectivity by enabling supply chain

members to build global hubs to effectively provide goods or services locally (Hanifan et al. 2014).

Relevant factors have been found to ensure successful transformation, including continuous collaboration, the alignment of suppliers, integration, highly evolved operating models, organizational flexibility, and technological competencies (Cichosz et al. 2020; Büyükközkın and Göçer 2018; Raj and Sharma 2014). Among them, continuous collaboration between firms within SCs has been extensively found to be one of the most essential factors for a firm's successful digital SC transformation (Annosi et al. 2021; Mussomeli et al. 2016; Monahan and Hu 2015). On the one hand, collaboration needs to motivate firms to accelerate their digital SC transformation. The need for real-time, seamless, and multichannel communications with suppliers, customers, and partners across supply chains motivates the learning and implementation of digital technologies to meet partners' requirements in

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the digital era (Mussumeli et al. 2016; Berman 2012). On the other hand, based on the knowledge-based view, strong learning relationships with partners that are enabled via collaborations and business integration provide unparalleled opportunities for firms with less digital maturity to access, learn, and evolve their traditional SC into digital ones (Sousa and Rocha 2019; Gupta and Bose 2019; Kong et al. 2020). Thus, this study argues that firms' ability to absorb external knowledge (absorptive capacity) and intent to form strong learning relationships (learning intent) with trading partners are crucial in successful digital SC transformation.

In addition, the need for digital SC transformation has recently intensified due to severe the interruptions to the workstreams of global SC caused by the COVID-19 pandemic (Sharma et al. 2020). Disruptions in the cross-border flow of physical products due to the pandemic further emphasize the need for better SC integration, resilience, and viability. These interruptions might lead to a poor connection between buyers and suppliers and disturb the supply of goods, as international transportation has been damaged (Villena and Gioia 2020). To reduce the SC disruption imposed by the COVID-19 pandemic, digital SCs urgently require a platform that ensures connectivity, real-time data transfer, and transparency with suppliers (Helo and Shamsuzzoha 2020). Although the COVID-19 pandemic could strongly motivate digital SC transformation, it is relatively unclear how extremely disruptive events such as the pandemic could affect firms' ability to transform their SC. In this regard, Büyükoçkan and Göçer (2018) have called for more research to develop frameworks to guide digital SC transformation processes. In addition, the COVID-19 pandemic has resulted in an exponential increase in COVID-19 medical waste production over the globe. In this circumstance, designing an efficient and dependable CMW reverse supply chain may assist prevent the spread of an epidemic (Liu et al. 2022a, b).

Due to the US-China trade war and the border lockdown in China due to the COVID-19 pandemic, firms are encouraged to use the "China plus one" strategy. Vietnam has emerged as a rational choice for international firms due to its competitive advantage of relatively low labor costs and foreign investment policy attraction (Schröder 2021). In addition, more than 70% of the population in Vietnam can easily access the internet (World Bank 2020), making it a promising place for digital transformation. According to the Vietnam Software and IT Services Association (VINASA), approximately 15% of 500,000 small and medium enterprises (SMEs) across the country have recently carried out digital transformation to bolster growth, cut down on expenses, and develop sustainably in the digital environment (VNA 2020). Such a substantial transformation rate was partly accelerated due to higher consumer adoption of digital services and products under COVID-19 social distancing restrictions.

Research on digital transformation has extensively discussed its potential benefits, such as cost reduction, real-time supply chain management, and data-based solutions (Wang and Ritchie 2012; Stank et al. 2019; Handfield et al. 2019). For instance, Zhou et al. (2022) found that when transactions are conducted on digital platforms as opposed to conventional supply chains, transaction costs are reduced and trust is enhanced. In the context of the disruptions to the global supply chain due to the COVID-19 pandemic, Liu et al. (2022a, b) found that the pandemic also provided incentives for the creators of online platforms and mobile applications. More firms were able to afford this technology in order to thrive in their respective industries in China. Naz et al. (2021) conducted a systematic literature review of the role of artificial intelligence in building supply chain resiliency and proposed a framework to fight unforeseen supply chain hazards and interruptions so that project management may succeed beyond the pandemic. However, studies on specific mechanisms to effectively and sustainably implement digital technologies to achieve competitiveness and create value for firms are still very limited (Büyükoçkan and Göçer 2018). One study by Uddin and Akhter (2022) suggested that mechanisms via supply chain collaboration with top management commitment could help firms achieve sustainable environmental, economic, and social performance. This study aims to extend the literature on this topic and address this gap in knowledge by proposing a knowledge-based approach to identify the success factors of digital SC transformation in the recent disruptive business environment of the COVID-19 pandemic. Specifically, this study examines the relationship between firms' knowledge creation capabilities and digital SC transformation under the moderating impacts of extreme events such as the COVID-19 pandemic.

The remainder of this paper is organized as follows. First, the study's theoretical background and key concepts are discussed. Second, the data collection and methodologies are presented, followed by the study's results and a discussion of results. Finally, the conclusions and limitations of this study are summarized.

## 2 Theoretical framework and hypotheses

### 2.1 Digital supply chain transformation

Digital transformation is "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial 2019: 118). In the context of SC management, digital SC has been referred to as a customer-centric platform model, which allows chain members to maximize performance and reduce risks by acquiring real-time information coming from the

advancements of emerging digital technologies such as the Internet of Things, cloud computing, remote sensing and big data analytics (Zhao et al. 2020; Preindl et al. 2020; Schrauf and Bertram 2016).

Since one of the key purposes of SC management is to ensure the working flow is uninterrupted (Kim et al. 2008), when a greater risk of SC disruption is perceived, chain members are more likely to look for alternative initiatives to reduce the risk and avoid disruption. The literature on SC management has suggested that the decision to seek innovation, such as digital transformation, depends on a firm's perception of supply disruption risk (Ellis et al. 2010; Vial 2019). Therefore, facing extreme turbulence in business environments due to the COVID-19 pandemic, digital SC transformation has become a prominent choice for firms because of its ability to respond to disruption risks by improving SCs' agility, connectivity, and collaboration between firms within the SC (Nasir et al. 2020). For example, Khan et al. (2022a) found that blockchain technology could play an important role in innovative business models such as the circular economy by allowing visibility, transparency, relationship management, and smart contracting.

Therefore, motivated by the disruption to global SCs during the COVID-19 pandemic and expected significant capability upgrades when implementing new technologies, many firms have started to pursue digital SC transformation paths to achieve digital connectivity between stakeholders within the SC (Nasir et al. 2020; Sarkis 2021). However, more than 70% of all digital transformation projects do not reach their goals (Tabrizi et al. 2019). Thus, there is a high risk that not all firms' digital SC transformation initiatives to deal with the COVID-19 pandemic will achieve their expectations. Digital literacy and firms' knowledge creation capabilities become exceptionally crucial because digital SC transformation requires firms' knowledge of advanced technologies such as big data, RFID, or 3D printing to be successfully implemented (Handfield et al. 2019; Sasson and Johnson 2016). As a result, firms' knowledge creation capabilities is one of the primary drivers of successful digital SC transformation.

## 2.2 Knowledge-based view

The knowledge-based view (KBV) is an extension of the resource-based view (RBV) that focuses on knowledge-based resources as firms' strategic resources. In line with strategic resources in RBV (Barney 2002), KBV posits that specialized knowledge and know-how knowledge (tacit knowledge) are the key determinants of firms' long-term performance and sustainable advantages (Grant 1996; Curado and Bontis 2006). These kinds of knowledge are valuable to firms, difficult to acquire (rareness), difficult to imitate by competitors, and non-substitutable by other resources (Barney 2002; Andersén 2011).

Based on the KBV, it is often argued that firms' capability to innovate and utilize advanced technologies is strongly dependent on their ability to acquire, internalize, and extract value from novel knowledge (Smith et al. 2005). In the context of SC, the decision and ability to effectively apply digital SC transformation are also largely based on how current firms' technological competencies fit with the available options (Baker 2012). To achieve the required technological fit, firms often actively choose between two innovation strategies: develop the required knowledge and competencies internally (Andreu et al. 2008) (internal research and development) or develop an external knowledge acquisition strategy (Mansfield 1988; Zott 2003; Cassiman and Veugelers 2006; Nonaka 1994). In the context of digital SC transformation, knowledge creation capabilities usually consist of two processes: exchanging knowledge between firms and their partners within the SC, and combining new and existing knowledge to create novel knowledge internally (Kong et al. 2020; Shu et al. 2012). On the one hand, these two knowledge creation capabilities help firms access and absorb the knowledge gained from their partners within the SC and produce their specialized knowledge (absorptive capacity), which subsequently enables them to implement digital SC transformation (Lim et al. 2017). Firms' absorptive capacities help them recognize the value of external knowledge from partners and learn, understand, assimilate, and apply this knowledge to innovative initiatives (Wang and Ahmed 2007). By reconfiguring, merging, and synthesizing with existing knowledge, firms' absorptive capacity can help them develop radically novel knowledge (Collins and Smith 2006).

However, before exchanging information and conducting learning activities with partners within the SC, firms must first establish relationships with their partners. In the context of SCs, a learning relationship is a common agreement among partners to facilitate joint learning activities (Johanson and Vahlne 2003). Without a commitment to sharing information and a shared understanding between partners, joint learning activities among firms within SCs could be substantially hindered by advanced technological know-how (Chen et al. 2009). Therefore, to facilitate joint learning activities, firms in SCs should actively initiate learning relationships with their partners by showing strong learning intent (Khan et al. 2019). Learning intent is a necessary condition for establishing deliberate and intentional learning relationships with partners (Najafi-Tavani et al. 2020), which have proven to be an effective driver for technological innovation (Xue et al. 2021). It is arguable that firms with a stronger learning intent toward a particular partner put more effort and cognitive resources into learning activities and thus can absorb and learn much more specialized knowledge from that partner (Andersén and Kask 2012).

Despite the importance of KBV, the roles of knowledge creation capabilities as key drivers of digital SC transformation have been underestimated, and very few researchers have taken KBV as an overarching framework for examining effective digital SC transformation (Neumann and Evangelista 2019; Ilvonen et al. 2018). Given the complex and fast-paced changing nature of digital technologies (i.e., artificial intelligence, big data, digital twin) and the fact the knowledge to successfully implement these technologies are increasingly scattered outside organizations, firms' absorptive capacity to internalize external knowledge and learning intent to facilitate knowledge sharing and joint learning activities are crucial to the success of digital transformation (Roth et al. 2016).

### 2.3 Absorptive capacity and digital SC transformation

Digitizing SCs allows firms to respond to external factors such as competition and disruption risks, but it requires organizations to acquire internal capabilities such as absorptive capacity. When an organization does not have sufficient internal resources, the intention to adopt or learn new things might be delayed or even prevented. According to Fang and Zou (2010), absorptive capacity refers to a firm's "ability to understand, assimilate, and apply knowledge owned by another international joint venture partner" (909).

A firm's absorptive capacity has been widely acknowledged as a critical determinant of innovating or learning new knowledge. Gray (2006) highlighted that small to medium enterprise (SME) owners who have a higher absorptive capacity and a higher level of education or expertise are more likely to adopt new technology. Kostopoulos et al. (2011) indicated that a firm's absorptive capacity has a direct influence on its innovation and financial performance. Knowledge transformation and exploitation, as part of absorptive capacity, have been found to exert a significant impact on innovation performance in high-tech firms (Volberda et al. 2010; Xie et al. 2018a, b), and the more absorptive capacity the business owners possess, the more likely they will be able to innovate the business model and have strategic flexibility. In the scope of this study, a firm's business innovation model and strategic flexibility will be referred to as its SC digital transformation strategy, which requires changes or adaption to a new working platform in almost every SC member's operation. For example, Pan et al. (2021) showed that the specific conditions of each region such as land, resources, energy, technology, and funds determined the efficiency of E-Agriculture in different regions in China. The internal absorptive capacity of the chain members determines whether they are able to adapt to a new digital SC model. Thus:

**H1:** A firm's absorptive capacity is positively associated with its digital SC transformation level.

### 2.4 Learning intent

Learning intent is defined as a firm's willingness or intention to explore new knowledge and adopt new techniques into business operations (Lane et al. 2006; Gebauer et al. 2012). Learning intent is regarded as one of the essential conditions for effective learning from external sources (Tsang 2002). Given that absorptive capacity is the ability to learn and internalize external knowledge, a firm's learning intent could have positive impacts on its absorptive capacity. Businesses with strong learning intent tend to be more motivated to learn and are inclined toward novel solutions (Miroshnychenko et al. 2021). Moreover, given firms' cognitive attention paid to learning relationships within an SC, the more a firm has learning intent with a particular partner, the more they commit to investing in the learning relationship to absorb novel knowledge from that partner (Andersén and Kask 2012). Especially in emerging markets, local firms need to overcome significant capacity gaps to catch up with firms from developed economies (Kim and Inkpen 2005). Thus, for local firms within global SCs, forming alliances with foreign multinational enterprises to learn and acquire critical know-how and advanced technologies is crucial (Hamel 1991).

Priyono et al. (2020) found that SMEs with limited digital literacy but supported by a high level of network relationships with trading partners accelerated their process of digital transformation most effectively. In addition, Ali et al. (2021) found that given the limited time and resources available to SMEs, an agile approach that focuses on collaboration, information sharing, communication, and quick SC redesign between SC members should be the priority strategy for SMEs to survive the COVID-19-related SC disruption risks. In fact, with solid learning relationships with external partners, SMEs' potential absorptive capacity could be transformed into actual absorptive capacity and practically contribute to firms' learning and innovation processes (Andersén and Kask 2012). Moreover, Khan et al. (2022b) found there is a proven trend toward the use of innovative technology, as well as open and transparent connections with external partners within supply chains, which could be utilized to refocus firms efforts to promote sustainable development, especially among low-tier suppliers in developing nations. Similarly, Khan et al. (2021a) used panel data from 50 countries and found empirical evidence of the positive association between knowledge spillover and international trades. Thus, firms' strong intent to form and enter learning relationships with their trading partners in the SC could have positive effects on firms' absorptive capacity and firms' digital transformation (Khan et al. 2019).

- H2a:** A firm's learning intent with partners is positively associated with its digital SC transformation level.
- H2b:** A firm's learning intent with partners is positively associated with its absorptive capacity.

### 2.5 COVID-19 SC disruption risk

The COVID-19 pandemic has created severe challenges for supply chains, creating disruptions in many critical products' supply, including foods and agricultural products (Yu and Khan 2021; Khan et al. 2021a, b, 2022b). Therefore, utilizing digital technologies is not a new concept in SC management practices (Büyüközkan and Göçer 2018; Shashi et al. 2020). However, the shocks triggered by the COVID-19 pandemic have attracted a great deal of attention to the importance of digital connectivity between stakeholders in the SC (Ivanov 2020; Nasir et al. 2020; Sarkis 2021). Lockdowns and social distancing measures have made it more complicated for businesses in the SC to keep the information flow uninterrupted, as the interactions in the SC comprise multiple layers of communication (Wang and Fang 2012; Zhao et al. 2018). As a result, firms must innovate their information processing capabilities to respond to a highly dynamic business environment and match the information processing requirements (Bode et al. 2011). In many cases, digital transformation is necessary to satisfy the increased information processing requirements of a highly unpredictable market (Verhoef et al. 2021). Thus, this study proposes that the environmental factors of the COVID-19 pandemic have significantly accelerated the process of digital transformation. As a result, under the pressures of the pandemic, firms' knowledge creation capabilities could be utilized more intensively as firms attempt to find novel solutions to deal with such an unprecedented event and supply chain disruptions. Eventually, the massive disruptions in global supply chains might accelerate firms' digital SC transformation

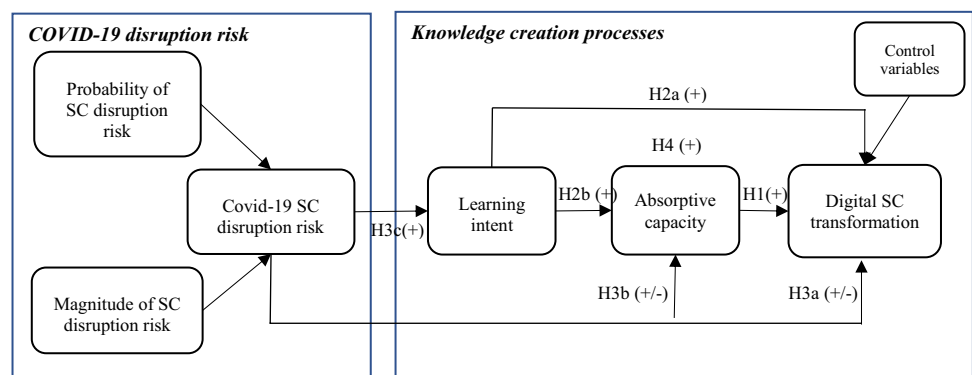
by deploying their knowledge creation capabilities more intensively. Notably, firms disrupted by COVID-19 would have an increased intention to learn about different technologies to deal with their challenges and would have increased absorptive capacity as a result, and would have accelerated their digital transformation processes. Therefore this study proposes that firms' learning intent of new digital technologies and their absorptive capacity of external knowledge and know-how can mediate the effects of COVID-19-related disruption risks on firms' innovation processes.

On the other hand, when market uncertainty is exceptionally high, firms are constantly under survival conditions and may hesitate to invest in innovative resources (Lin et al. 2016). Firms tend to prioritize cost-cutting as a coping strategy in crises (Nguyen et al. 2021), which reduces their capacity to learn and innovate. Thus, the mixed impact of the COVID-19 pandemic on firms' knowledge processes raises questions about how SC disruption risks affect firms' knowledge creation capabilities (absorptive capacity and learning intent) and digital SC transformations. Thus, the following hypotheses are proposed:

- H3a:** A firm's perceived COVID-19 SC disruption risk is positively associated with its digital SC transformation level.
- H3b:** A firm's perceived COVID-19 SC disruption risk is positively associated with its absorptive capacity.
- H3c:** A firm's perceived COVID-19 SC disruption risk is positively associated with its learning intent.
- H4:** A firm's learning intent and absorptive capacity positively mediate the effects of perceived COVID-19 SC disruption risk on its digital SC transformation.

All hypotheses are presented in the conceptual research model in Fig. 1.

**Fig. 1** Conceptual research model





## 3 Methodology

### 3.1 Data collection

To test the proposed hypotheses, a list of registered importer-exporter firms in Vietnam was drawn from the General Department of Vietnam Customs. The study purposely used companies that participated in international trade sectors during 2019–2020 – the early COVID-19 period – explore the cross-border impacts of the COVID-19 pandemic on their SCs. Moreover, Vietnamese firms with international trade partners are more likely to invest in digital SC technologies to meet the requirements of international trade activities.

More than 2000 companies from an exporter-importer list were contacted via email and phone calls from mid-January 2021 to the end of April 2021 to complete a survey using a self-administered questionnaire. In each firm, one respondent who had been working for the firm for at least three years and currently served in the top management team, such as line managers, functional managers, chief executive officers, or board members, were surveyed. The questionnaire was first pilot tested to ensure face validity and that it was free from wording errors after translating the questions from English to Vietnamese. The survey drew responses from 1020 firms, achieving a response rate of 51%. After excluding responses with missing data, the final sample included 923 companies from 15 different industries.

### 3.2 Measures

All items in the questionnaire were adapted from previous studies and operationalized using a 7-point Likert scale (Table 1). As a mediator for the relationship between absorptive capacity and digital SC transformation, the learning intent construct was operationalized using six items from Khan et al. (2019). This study focuses on realized absorptive capacity, as the company's capability to immediately implement digital transformation in the SC is the study's key area of interest. Thus, this study adapts the scales from Szulanski (1996) and Khan et al. (2019), which use three items to operationalize absorptive capacity. Five items from Nasir et al. (2020) were used to operationalize the construct of digital SC transformation.

Finally, this study uses perceived risk literature to operationalize risk-related constructs of SC disruption. According to the common approach for risk perceptions (Teigen 1996), SC disruption risk encompasses companies' perceived risks, is expressed in terms of probability and magnitude perspectives, and is operationalized using

items from Ellis et al. (2010). Regarding the perceived COVID-19 SC disruption risk, drawing on the conceptual work of Wilson et al. (2019), this study uses a one-item scale to measure the construct.

### 3.3 Data analysis

Hypotheses were tested using the partial least squares approach of structural equation modeling (PLS-SEM) in SmartPLS 3.0. PLS-SEM was chosen over the covariance-based SEM (CV-SEM) because of the prediction-oriented objective of this study (Hair et al. 2019). To test the moderating effects of COVID-19 SC disruption risks on the relationship between knowledge creation capabilities (absorptive capacity and learning intent) and digital SC transformation, a moderated mediation analysis was employed using the approach of Hayes (2015). The moderated mediation analysis allows contextual conditions to express their impacts on a mediating relationship, thus the underlying mechanism governing the complex interactions between multiple factors can be explored (Lin et al. 2016; Xie et al. 2018a, b). The moderated mediation analysis was executed using 5,000 bootstrapping resamples in SPSS 22.

## 4 Empirical results

The empirical results are based on a sample of 923 firms whose characteristics are described in Table 2. Specifically, the sample was composed of firms from 15 different industries, including commercial (208 companies), consumer goods (91), construction (69), and food (57). Of the 923 companies, there were 540 small-sized firms with revenue less than 10 billion VND (58.5%), 282 medium-sized firms with revenue from 10 to 1000 billion VND (about 30.5%), and 101 large-sized firms with revenue of more than 1000 billion VND. The company size proportion reflected Vietnamese business sectors, given the fact that more than 80% are small and medium enterprises. Regarding services offered by participating firms, about 39% were original equipment manufacturers, 36% were distributors, and 14% were service providers. The correlations between the constructs can be observed in Table 3.

### 4.1 Common method bias

As this study used self-administered questionnaires to collect data, the common method bias could be a concern for the validity of the model. This study followed the approach of Shashi et al. (2020) and produced an unmeasured marker variable (UMV) to account for common method bias using unrotated factor analysis. The factor analysis was executed

**Table 1** Constructs, codes, and items

Constructs/sources	Items	Convergent validity		Internal reliability		
		Loadings	AVE	$\alpha$	CR	
Absorptive capacity (Khan et al. 2019)	AC1	My company has a common language to deal with the technology	0.907	0.831	0.898	0.936
	AC2	My company has the necessary skills to implement the technology	0.907			
	AC3	My company has the ability to integrate and apply external knowledge for improving components and processes	0.921			
Learning intent (Hamel 1991; Szulanski 1996; Pucik 1988)	LI1	My company understands the technology possessed by our clients/partners	0.848	0.758	0.936	0.949
	LI2	My company benefits from understanding the partners' technology	0.872			
	LI3	My company analyzes the feasibility of adopting the partners' technology	0.847			
	LI4	My company communicates with the partners regarding the technology acquired	0.901			
	LI5	When deciding to enter into the business relationship, my company has a strong desire to learn about a particular technology/process owned by our client/partners	0.887			
	LI6	The business relationship with our client is viewed as a means to learn about a particular technology/ process held by the client/partners	0.867			
Digital supply chain transformation (Frank et al. 2019; Nasir et al. 2020)	DSC1	My company aims to digitalize everything that can be digitalized	0.887	0.776	0.928	0.945
	DSC2	My company collects large amounts of data from different sources	0.837			
	DSC3	My company aims to create stronger networking between the different business processes with digital technologies	0.900			
	DSC4	My company aims to enhance an efficient customer interface with digitality	0.888			
	DSC5	My company aims at achieving information exchange with digitality	0.892			
The following constructs/items operationalizing companies' SC disruption risk due to the impact of the COVID-19 pandemic (X: essential inputs in the production process; Y: main suppliers of X)						
Probability of SC disruption risks (Ellis et al. 2010)	PDR1	It is highly unlikely that we will experience an interruption in the supply of Item X from Supplier Y due to the impacts of the COVID-19 pandemic	0.740	0.692	0.774	0.870
	PDR2	There is a high probability that Supplier Y will fail to supply Item X to us due to the impacts of the COVID-19 pandemic	0.868			
	PDR3	We worry that Supplier Y may not supply Item X as specified within our purchase agreement due to the impacts of the COVID-19 pandemic	0.881			

**Table 1** (continued)

Constructs/sources	Items	Convergent validity		Internal reliability		
		Loadings	AVE	$\alpha$	CR	
Magnitude of supply chain disruption risks (Ellis et al. 2010)	MDR1	An interruption in the supply of Item X from Supplier Y due to the impacts of the COVID-19 pandemic would have severe negative financial consequences for our business	0.906	0.827	0.895	0.935
	MDR2	Supplier Y's inability to supply Item X due to the impacts of the COVID-19 pandemic would jeopardize our business performance	0.915			
	MDR3	We would incur significant costs and/or losses in revenue if Supplier Y failed to supply Item X due to the impacts of the COVID-19 pandemic	0.907			
COVID-19 supply chain disruption risk (Wilson et al. 2019)	SDR	Overall, the supply of Item X from Supplier Y is characterized by high levels of risk due to the impacts of the COVID-19 pandemic	1.000	1.000	1.000	1.000

AVE average variance extracted, CR composite reliability,  $\alpha$ —Cronbach's  $\alpha$

using SPSS software, and the factor score of the first unrotated factors was used as data for the UMV. Then, the UMV was included as an exogenous variable in the structural model to explain all endogenous variables.  $R^2$  in the new model was then compared to that of the original model (without the UMV). The results are shown in Table 4, which indicates that the presence of UMV does not lead to significant changes in  $R^2$  for all endogenous variables. Thus,

common method bias is not an issue for the validity of the findings.

## 4.2 Measurement model

The measurement model was assessed to ensure the validity and reliability of the research model's constructs. Convergent validity and reliability were first examined by means of

**Table 2** Sample characteristics

Profile	n	%	Profile	n	%
<b>Respondent variable</b>					
Gender			Company position		
Male	497	54%	Chief executive officer	109	12%
Female	426	46%	Line manager	248	27%
Industry expertise			Board member	97	11%
< 1 year	30	3%	Senior manager	120	13%
1–5 years	197	21%	Functional manager	231	25%
6–10 years	375	41%	Other top management position	118	13%
> 10 years	321	35%			
<b>Company variable</b>					
Industry			Size (employee number)		
Information technology	59	6%	< 100	504	55%
Logistic service	55	6%	100–500	224	24%
Consumer goods	91	10%	501–1,000	82	9%
Metal processing	56	6%	1,001–5,000	49	5%
Chemical and pharmaceutical	49	5%	5,001–10,000	21	2%
Constructions	69	7%	> 10,000	43	5%
Food industry	57	6%	Sale (billion VND, last year)		
Commercial	208	23%	< 10	540	59%
Utility	43	5%	10–100	172	19%
Other	236	26%	101–1000	110	12%
			> 1000	101	11%



**Table 3** Correlations between constructs

		1	2	3	4	5	6
1	Absorptive capacity	1					
2	Digital sc transformation	0.781	1				
3	Learning intent	0.803	0.811	1			
4	Magnitude of sc disruption	-0.555	0.507	0.567	1		
5	Covid-19 SC disruption risk	-0.595	0.623	0.699	0.589	1	
6	Probability of SC disruption	-0.509	0.499	0.532	0.697	0.539	1

internal consistency. Table 1 indicates that 20 of 20 indicators had outer loadings greater than 0.7 and three loadings were between 0.6 and 0.7 (Hair et al. 2019). All the constructs' average variance extracted (AVE) were greater than the recommended threshold of 0.5 (Li et al. 2021). These results support the convergent validity of the constructs. All Cronbach's  $\alpha$  and composite reliability (CR) values exceeded 0.7, as suggested by Hair et al. (2019). Thus, the internal reliability of the construct was established.

Discriminant validity was tested using the heterotrait-monotrait (HTMT) ratio of correlations. The more conservative fixed cut-off value of 0.75 suggested by Shashi et al. (2020) and Sklyar et al. (2019) was used as the criterion for examining the HTMT correlations between constructs. The closer the HTMT correlation value is to 1.0, the more likely the discriminant validity is violated. The results in Table 4 indicate that all HTMT values were less than 0.75, except for three values of DSC ↔ AC (0.756), LI ↔ AC (0.776), and LI ↔ DSC (0.769) relationships. The second way of using HTMT correlations includes the null hypothesis test ( $H_0$ : HTMT ≥ 1). If  $H_0$  holds, then the discriminant validity is violated. The bias-corrected confidence interval analysis presented in Table 5 rejected the null hypothesis, indicating that the discriminant validity of all constructs was supported.

### 4.3 Hypothesis testing

First, this study examined the collinearity between constructs in the structural model. The results show that the variance inflation factor (VIF) values of all exogenous variables were below the recommended threshold of 3.3 (Li et al. 2021). Next, the direct and indirect relationships between constructs were evaluated (see Fig. 2).

**Table 4** Assessment of common method bias

Endogenous	$R^2$	$R^2$ (with UMV)	Differences
Digital SC transformation	0.712	0.714	0.002
COVID-19 SC disruption risk	0.379	0.383	0.004
Learning intent	0.645	0.648	0.003

Results of  $R^2$  is bootstrap based on 5,000 resample (two-tailed)

Ascertaining the key drivers of digital SC transformation, this study proposes that firms' knowledge creation processes (absorptive capacity and learning intent) determine firms' practices of digital SC transformation. The direct effects of AC → DSC ( $H1$ :  $\beta=0.347, p<0.01$ ) and LI → DSC ( $H2a$ :  $\beta=0.464, p<0.01$ ) were all significant, suggesting that  $H1$  and  $H2a$  are supported. In addition, this study confirms that stronger intent to form learning relationship with partners actually increases firms' capacity to acquire and internalize external knowledge as the direct effects of LI → AC ( $H2b$ :  $\beta=0.757, p<0.01$ ) was significant.

The direct effects of SDC → DSC ( $H3a$ :  $\beta=0.086, p<0.05$ ) was significant, showing that the COVID-19 SC disruption risks positively motivated firms to increase their digital SC transformation level to cope with the pandemic.  $H3a$  is supported. The effects of SDC → AC ( $H3b$ :  $\beta=0.066, p=0.069$ ) were positive but not significant at 5%, showing that the supply chain disruption risk does not directly affect firms' absorptive capacity.  $H3b$  is not supported. In contrast, SDC positively and significantly influences firms' learning intent as shown in the direct effect of SDC → LI ( $H3c$ :  $\beta=0.699, p<0.001$ ).  $H3c$  is supported. These finding give empirical evidence to clarify the impacts of COVID-19 SC disruption risks on firms' knowledge creation process.

This study also investigates the indirect effects of COVID-19 supply chain disruption risks on firms' SC digital transformation via the knowledge creation processes. First, even though SC disruption risk did not have significant direct effects on firms' absorptive capacity, the indirect effect between the two via learning intent was confirmed in this study (SDC → LI → AC,  $\beta=0.529, p<0.001$ ). The indirect effect of SDC → LI → AC → DSC ( $H4$ :  $\beta=0.182, p<0.001$ ) was also significant, suggesting that firms badly affected by the pandemic are keen to use their knowledge creation to accelerate their SC digital technologies adoption as a way to combat with the disruption in the markets.  $H4$  is supported.

In addition, based on the literature on perceived risk theory, this study proposed that the COVID-19 SC disruption risk (SDR) is formatively constructed by the probability of SC disruption risk (PDR) and the magnitude of SC disruption risk (MDR). The results in Table 6 confirm this theoretical assumption, showing that the direct effect of PDR → SDR ( $\beta=0.250, p<0.01$ ) was significant, as was the direct effect of MDR → SDR ( $\beta=0.415, p<0.01$ ).

**Table 5** Assessment of discriminant validity using the heterotrait-monotrait ratio of correlations criterion (HTTM 0.85 Criterion)

	AC	DSC	LI	MDR	SDR
DSC	0.75[0.70–0.80]				
LI	0.77[0.73–0.81]	0.76[0.71–0.81]			
MDR	0.61[0.53–0.68]	0.61[0.53–0.68]	0.61[0.53–0.68]		
SDR	0.62[0.56–0.68]	0.62[0.56–0.68]	0.62[0.56–0.68]	0.62[0.56–0.68]	
PDR	0.61[0.53–0.68]	0.61[0.53–0.68]	0.61[0.53–0.68]	0.61[0.53–0.68]	0.61[0.53–0.68]

Bootstrap based on 5,000 resample (two-tailed), *SDR* COVID-19 SC disruption risk due to the COVID-19 pandemic, *PDR* probability of SC disruption risk due to the COVID-19 pandemic, *MDR* magnitude of SC disruption risk due to the COVID-19 pandemic, *AC* absorptive capacity, *LI* learning intent, *DSC* digital SC transformation, Number in the bracket is the lower and upper value of 95% confident interval bias-corrected of HTMT correlations using bootstrapping

## 5 Discussion

### 5.1 Theoretical implications

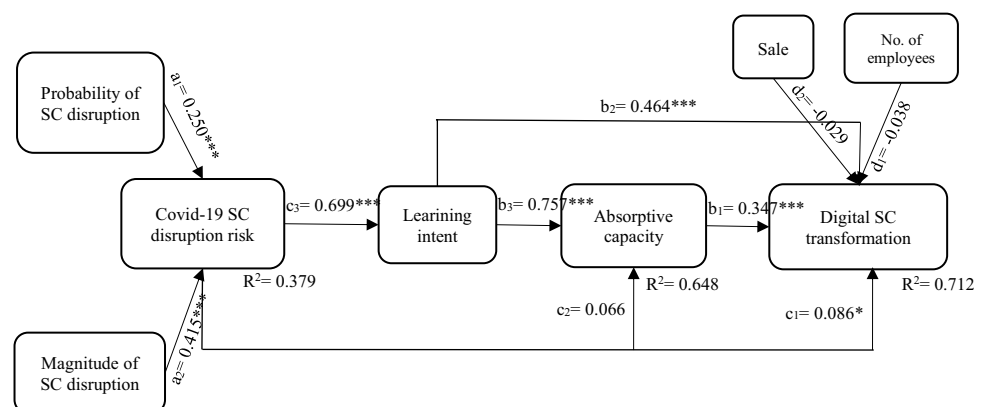
This study contributes to the cumulative theoretical development of digital SC transformation in several ways. First, to fill the gap surrounding the digital SC implementation mechanisms, this study focused on testing the effects of firms' knowledge creation capabilities, which are absorptive capacity and learning intent, as key drivers of firms' digital SC transformation. The results suggest that absorptive capacity and learning intent both have substantial positive impacts on firms' level of digital SC transformation. This finding confirms the usefulness of the KBV as a sound theoretical background to explore and define the determinant factors of digital SC transformation. This approach is rarely mentioned in the literature on digital SC transformation research (Carlo et al. 2012) and has largely been ignored compared to technology acceptance models (Katsoni and Poulaki 2021; Magni et al. 2021). This finding is also consistent with the results from Wacker and Samson (2021), who found the urgent need to merge knowledge bases from different firms' operational areas such as marketing, production, and supply chains to fight uncertainties in business environments and the increase in customer purchasing power. Wacker and

Samson (2021) found that combining supply chain tactics with marketing choices is crucial to the entire optimization of a firm's strategy, including the design of its goods and their features, pricing, and positioning.

Second, with regard to the particular context of SC management, digital transformation initiatives are usually characterized by complexity and network dependence (Nasir et al. 2020). Firms primarily rely on external sources of knowledge, especially technological know-how, to successfully integrate digital technologies into their SC management (Agrawal et al. 2019). This study confirms the critical role of firms' absorptive capacity to internalize external knowledge into firms' digital SC transformation processes. Especially in the context of emerging economies, firms usually require support and external know-how from their trading partners to initialize their digital model of SC (Cherbib et al. 2021; Fredrich et al. 2019). External knowledge or open innovation in general play a substantial role in the success of digital transformation in the supply chain context (Trantopoulos et al. 2017).

However, in their comprehensive literature review of the digital supply chain, Büyüközkan and Göçer (2018) found that one of the key challenges for digital SC transformation is the lack of information sharing and benefit alignment between firms in SCs. This creates barriers for firms, especially small and medium firms, to access external knowledge

**Fig. 2** Research model estimation results. Note: \* $p < 0.05$ ; \*\* $p < 0.01$ , \*\*\* $p < 0.001$



**Table 6** Hypothesis testing

Hypothesis/Path		$\beta$	Standard error	t-value	p-value	BC 95% Confident interval
a <sub>1</sub>	PDR → SDR	0.250***	0.044	5.661	<0.001	[0.163, 0.334]
a <sub>2</sub>	MDR → SDR	0.415***	0.046	9.070	<0.001	[0.324, 0.502]
b <sub>1</sub>	H1: AC → DSC	0.347***	0.055	6.291	<0.001	[0.242, 0.456]
b <sub>2</sub>	H2a:LI → DSC	0.464***	0.057	8.107	<0.001	[0.346, 0.572]
b <sub>3</sub>	H2b:LI → AC	0.757***	0.033	23.152	<0.001	[0.692, 0.818]
c <sub>1</sub>	H3a: SDR → DSC	0.086*	0.036	2.408	0.016	[0.019, 0.192]
c <sub>2</sub>	H3b: SDR → AC	0.066	0.036	1.825	0.069	[-0.014, 0.132]
c <sub>3</sub>	H3c: SDR → LI	0.699***	0.023	29.845	<0.001	[0.653, 0.742]
c <sub>3</sub> b <sub>3</sub>	SDR → LI → AC	0.529***	0.031	16.962	<0.001	[0.469, 0.591]
c <sub>3</sub> b <sub>3</sub> b <sub>1</sub>	H4: SDR → LI → AC → DSC	0.182***	0.031	5.877	<0.001	[0.121, 0.240]
d <sub>1</sub>	Sale → DSC	-0.029	0.021	1.266	0.206	[-0.078, 0.016]
d <sub>2</sub>	No. employee → DSC	-0.038	0.023	1.777	0.076	[-0.074, 0.008]

BC bias-corrected, Bootstrap based on 5,000 resample (two-tailed), SDR SC disruption risk due to the Covid-19 pandemic, PDR probability of SC disruption risk due to the Covid-19 pandemic, MDR magnitude of SC disruption risk due to the Covid-19 pandemic, AC absorptive capacity, LI learning intent, DSC digital SC transformation

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

and technological know-how to foster their digital SC model. Therefore, before firms use their absorptive capacity to create novel knowledge, firms should actively seek to form strong and meaningful learning relationships with partners within the SC. This study's finding of the substantial positive effects of learning intent on firms' absorptive capacity and digital SC transformation suggest an effective means to overcome this challenge. Strong learning intent toward a partner is a prerequisite for forming long-term learning relationships with the partner, which has been proven to be essential for innovation (Najafi-Tavani et al. 2020; Xue et al. 2021). In this regard, firms' learning intent can significantly increase their complementarity, commitment, and compatibility with partners (Fredrich et al. 2019; Sandulli et al. 2017). Based on a sound collaborative context between partners in SCs, information exchange and learning activities can occur seamlessly. Furthermore, implementing digital technologies usually comprises complex, tactical, and multilayer communications (Sandulli et al. 2017). Thus, a strong intention to learn, which leads to deliberate learning plans and commitments of resources toward learning relationships with partners, is vital for successful knowledge transfer and absorption (Xie et al. 2018a, b). This finding supports Uddin and Akhter's (2022) argument that supply chain collaboration plays a critical role in firms' sustainable performance. However, to achieve collaboration between firms within a supply chain, past literature also emphasized the role of top management teams to develop firms' dynamic capabilities and formulate contingency plans to deal with turbulent business environment (Uddin and Akhte 2022; Chatterjee and Chaudhuri 2021).

Third, this study also concerns the role of external drivers and turbulent business environments in the digital SC

transformation process by investigating the impact of the SC disruption risk created by the COVID-19 pandemic. The results confirm that the COVID-19 SC disruption risk is a direct external driver of firms' digital SC transformation. In the pre-pandemic period, firms could be held back by lacking funding in digital initiatives and usually focused on efficient and low-cost strategies for their SC (Thirion 2020). However, under an unprecedented pandemic such as COVID-19, those who are behind the digital curve have to deal with many complex issues at once, such as struggling to measure demand, create more flexibility for the system, and gain visibility for accurate decision making (Nikolopoulos et al. 2021). Thus, firms tend to move toward digital models to build SC resilience and reduce complexity and uncertainty across networks (Karmaker et al. 2021). This study confirms that dynamics in the business environment play a significant role in motivating or demotivating firms to use digital technologies in their SC management.

Finally, this study also found significant complex inter-relationships between internal and external drivers of firms' SC transformation. Specifically, the environmental uncertainty created by the COVID-19 SC disruption risk was found to positively affect firms' intent to learn about novel technologies and know-how to combat the disruption in global SCs. On the one hand, SC disruption risk does not have direct impacts on firms' capacity to absorb external knowledge. On the other hand, increased SC disruption risk motivates firms to look for novel solutions to survive and have stronger intent to learn from their partners. Due to the unprecedented impacts of the COVID-19 pandemic, firms have been looking for cost-effective and novel digital initiatives that can pay off in a crisis immediately, such as maneuvering old warehouses

and paper processes toward digital formats (Kumar et al. 2021; Barman et al. 2021). This paper also confirms the importance of knowledge creation processes as mediators to transmit the effects of extreme market uncertainty to firms' innovation (Rice et al. 2008). Notably, this paper suggests that managers are more inclined toward external knowledge resources or open innovation strategies in the context of high uncertainty in the SC. We agree with Singh et al. (2022), who found that a knowledge-based supply chain is crucial to overcome multiple barriers such as technological issues, knowledge and skill issues, and cultural and social issues, so that multiple stakeholders (e.g., organizations, suppliers, governments, and consumers) can cooperate to achieve sustainable development in the 'new normal' environment.

## 5.2 Managerial implications

Based on these findings, managers in emerging markets must acknowledge the importance of knowledge creation capabilities and routines to acquire, internalize, and exploit knowledge from external sources. For instance, employing learning-enhancing technologies such as interactive media is critical for firms in emerging markets to deeply connect with their partners within SCs and successfully implement advanced innovations such as digital SC models (Cherbib et al. 2021). The finding that strong learning intention can effectively channel the effects of absorptive capacity on digital SC transformation in high uncertainty markets also highlights the need for top management teams to actively seek and establish long-term learning relationships with partners within SCs. Knowledge management research found that upper management teams' commitment to learning if communicated and illustrated frequently could create a ripple effect of learning habits to lower management levels and employees across a firm (Nguyen and Mohamed 2011; Singh et al. 2019).

Moreover, because of the massive impact of the current health crisis, firms have pulled together to work collaboratively and openly at an unprecedented level (Bertello et al. 2021; Dahlander and Wallin 2020). Taking advantage of these meta trends, one of the most effective strategies for firms in the current period is to use open innovation and relational capital with partners for successful digital SC transformation.

## 6 Conclusion and limitations

This study examines how internal and external factors drive firms' digital SC transformation, using a sample of 923 firms in Vietnam currently participating in global SCs.

Based on the knowledge-based viewpoint, this study proposes that firms' knowledge creation capabilities, which includes their external knowledge absorption capacity and their learning intent with partners within the SC, are critical to the successful knowledge transfer required in digital transformation under the effects of COVID-19 supply chain disruption risks. Therefore, managers in developing markets must recognize the relevance of knowledge-generation skills and procedures for acquiring, internalizing, and exploiting external information. In addition, a substantial increase in COVID-19 SC disruption risk as an external environment factor has allowed firms to recognize the crucial role of digital SC models to mitigate disruption risks in the future. As a result, in the long-term, one of the most effective strategies for SMEs for sustainable development is to accelerate its efforts to achieve digital SC transformation. Furthermore, this study also explores the interactions between external and internal forces of firms' digital SC transformation efforts in the context of the COVID-19 pandemic. One specific mechanism that this study proposes is to use relational capital and relationship learning between firms to improve firms' ability to absorb external knowledge from partners within supply chains. In the context of the pandemic, firms are beginning to work jointly and transparently. Therefore, this learning mechanism of relationship learning could be exploited effectively, especially for firms in emerging markets.

This study still has some limitations due to the absence of assessing industry-specific risks, company heterogeneity, and its research methods. First, the paper has not incorporated industry-specific risk factors in the analysis to identify specific disruption threats across the studied industries. Further research might look at this problem in businesses most affected by the pandemic, such as tourism and transportation. Other studies might strengthen the relevance of the results by including secondary data proxied for industry-specific risk variables. Second, this study only examines the direct impacts of external environmental factors in the form of supply chain disruption risks due to the COVID-19 pandemic. Future research could extend the investigation to assess the moderating and mediating roles of external environment factors on the relationship between firms' knowledge creation processes and their digital transformation. Third, this study focuses only on the knowledge creation processes triggered by the COVID-19 pandemic (firms' learning intent and absorptive capability). Future research could look at more components of relationship learning between firms in a supply chain such as asymmetric learning and open innovation to expand understandings of knowledge-based and organizational learning factors on digital SC transformation in a crisis, which was shown in this study to be significantly different from those in a normal circumstance. Fourth, because this research is cross-sectional, it is difficult to evaluate the



exact causation between the components, resulting in endogeneity issues. Longitudinal studies with suitable econometric analyses would allow researchers to examine the model's causal relationships more accurately. Finally, additional studies using different methodologies, particularly qualitative research, are encouraged, to provide scientific evidence and in-depth case studies to strengthen and refine this study's findings on the complex and critical digital transformation issues of the ongoing COVID-19 pandemic.

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## Declarations

**Competing interests** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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