How to Improve Firm Resilience During COVID-19 Pandemic: the Role of Digital Technology Deployment

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Abstract. Enhancing supply chain resilience has gained attention due to the outbreak of the COVID-19 pandemic. Digital technology is considered an effective method for improving firm resilience due to its ability to anticipate risks, develop forward-looking strategies, and achieve real-time control. This study revealed the implications of digital technology deployment on firm resilience using 129 publicly listed automobile manufacturers in China from 2019 to 2022. In this study, the effect of digital technology deployment on firm resilience is revealed in two dimensions: investment and application. Based on the dynamic capabilities theory, econometric models are used to identify the impact of the two aforementioned dimensions of digital technology deployment under the dynamic capabilities view. The results indicate that the impact of digital technology investment on firm resilience is insignificant. However, the application of digital technology deployment to product innovation is conducive to enhancing firm resilience. Our research further expands operations and supply chain risk management and provides effective guidance for automobile manufacturers to address the risk of supply chain disruption caused by such emergencies.

Keywords: firm resilience; digital technology deployment; automobile supply chain

1 Introduction

With increasing supply chain disruptions caused by sudden events such as natural disasters, wars, trade disputes, and pandemic crises, firm performance has been negatively impacted. Firm resilience refers to a firm's capability to resist and recover from disturbances [1]. As the rising risk of future supply chain disruptions, to foster effective improvement of firm resilience is urgent.

Some studies suggest that digital technology can be used to optimize business processes, improve firm efficiency , reduce costs, enhance operational benefits, and increase firm resilience [2]. Such research discussed the firm resilience improvement under regular scenarios, and less attention has been paid to irregular scenarios, such as natural disasters and crises. Some scholars argue that digital technology deployment enables firms to predict risk, establish proactive strategies, and implement real-time control [3]. Which identified that digital technology deployment positively mitigates supply chain risk. However, there is a lack of data-driven empirical evidence that digital technology deployment has a positive effect on firm resilience. This study aimed to answer the following research questions: 1. Can digital technology deployment improve firm resilience under COVID-19 pandemic? 2. How digital technology deployment impacts the firm resilience during COVID-19 pandemic?

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To address these issues, we tracked 126 publicly listed Chinese automobile manufacturing firms from 2019 to 2022. Firm resilience was measured by using the severity of the decline in operating income after the outbreak of the COVID-19 pandemic We then employed econometric models to examine the effects of digital technology investment and application on firm resilience during the COVID-19 pandemic. This is one of the dearth of empirical studies attempting to analyze the impact of digital technology on firm resilience under the entire process of the COVID-19 pandemic.

2 Research hypotheses

In this study, a theoretical framework based on dynamic capabilities was applied to analyze the moderating effect of digital technology on firm resilience. Dynamic capabilities refer to a firm's ability to adapt and integrate internal and external resources to respond to rapid changes in the external environment. Digital technologies are recognized as valuable resources that can be used to create unique capabilities and achieve superior firm performance.

2.1 The impact of digital technology investment on firm resilience under COVID-19 pandemic

The COVID-19 pandemic brought a series of profitable losses to firms, which forced firms to improve their resistance to leverage them. Digital technology can detect and mitigate supply chain risks, which is an effective method to improve firm resilience. However, there is currently no consensus on the effects of digital technology on firm resilience. Some scholars have argued that digital technology investment can significantly enhance resilience. Terence et al. (2020) proved that digital investment enhanced a firm's ability to respond to turbulent environments, thus producing superior firm performance [4]. However, some studies believe that digital technology is not significantly related to firm resilience, or even has a suppressive effect. Gebauer et al. (2020) found that it is difficult for digital technology investment to achieve revenue growth corresponding to 52 industrial firms' evidence [5]. We follow this approach and believe that there is a positive relationship between digital technology investment and firm resilience during the COVID-19 pandemic, which is the current mainstream research view. Therefore, this paper proposes the following hypotheses:

H1: Digital technology investment has a significant positive impact on firm resilience under the COVID-19 pandemic.

2.2 The impact of digital technology application on firm resilience under COVID-19 pandemic

The application of digital technology to product innovation can enhance market response, precise demand exploration, and innovative resource restructuring, thereby improving firm resilience. By utilizing techniques such as big data analysis, machine learning, and cloud computing, firms can accurately understand customer behavior and respond to market changes. In addition, digital technology strengthens firms' capture capabilities, as they rely on these technologies to obtain consumption data, location data, and other valuable information. By leveraging customer information, firms can integrate and mobilize resources to enhance product innovation. Firms that employ digital technology in product innovation by collecting, acquiring,

and integrating valuable resources to adapt to external changes develop a dynamic capability that positively affects their ability to withstand and recover from disruptions. Based on these insights, the following hypotheses are proposed:

H2: The application of digital technology (product innovation dimension) has a significant and positive impact on firm resilience under COVID-19 pandemic.

Existing research has demonstrated that the application of digital technology in the process provides firms with a competitive edge, particularly in their ability to withstand and recover from the challenges posed by the COVID-19 pandemic [6]. In this study, we examine the application of digital technology in production, transaction, and sales processes. At the production level, the application of digital technology connects all links of production and manufacturing, accelerates the information propagation and communication speed upstream and downstream, and helps firms flexibly arrange production. In terms of transactions, digital technology augments the transparency of transaction information, makes the transaction process more direct and transparent, increases the trust level among different entities in the supply chain, reduces external transaction costs, and improves firm resilience. In the realm of marketing, social entertainment tools are widely used in the marketing schemes of various industries as part of their marketing strategies, which reduces transaction costs, greatly improves marketing processes and efficiency, and accelerates recovery work after the pandemic . Based on this, the following research hypotheses are proposed:

H3: The application of digital technology (process innovation dimension) has a significant positive impact on firm resilience under COVID-19 pandemic.

3 Methodology

3.1 Date Source and variable selection

This paper selected listed automobile manufacturing firms in the Shanghai and Shenzhen markets from 2019 to 2022 as the research objects. The databases used for these listed firms included financial statements, financial indicator analysis, governance structure, and enterprise digital transformation.

Firm resilience. Referencing the measurement methods of firm resilience by Ortiz-de-mandojana (2016) [2] , this paper adopts the decline in business income under the COVID-19 pandemic shock event to measure firm resilience. **Digital technology.** Digital technology investment (DTI) is measured by taking the logarithm of digital asset investment. A digital technology application word dictionary is formed by grabbing the frequency of digitalization-related words in the firm's annual report, and the frequency of keywords related to the product (PTI) and process dimensions (PSI) is counted, and a logarithm value is taken. **Control variables.** This study selects a series of factors that have been proven to influence firm resilience in the literature for control, specifically, firm size (Size) , firm listing age (Listage) , asset-liability ratio (Lev) , board size (Board) , proportion of independent directors (Indep) , and sales period expense ratio (SE).

3.2 Model Design

In order to test the research hypotheses proposed in this, we follow the research of Li et al.(2022) [2] and use ordinary least squares to test firm resilience.

$$Resistance_{i,t} = \alpha + \beta_1 DTI_{i,t} + \sum Control + \sum Firm + \sum Quarter_i + \varepsilon_{i,t} \quad (1)$$

$$Resistance_{i,t} = \alpha + \beta_1 DTA_{i,t} + \sum Control + \sum Firm + \sum Quarter_i + \varepsilon_{i,t} \quad (2)$$

4 Result

4.1. Regression results of firm resilience

Table 1. Regression results of firm resilience

	Fundamental regression			Roubustness Test		
VARIABLES	Resistance	Resistance	Resistance	Resistance	Resistance	Resistance
DTI	-0.054***			-0.058***		
	(-2.68)			(-3.17)		
PTI		0.028**			0.019*	
		(2.15)			(1.7)	
PSI			-0.003			-0.011
			(-0.18)			(-0.76)
Size	1.629***	1.635***	1.638***	1.423***	1.430***	1.434***
	(13.76)	(13.75)	(13.7)	(14.49)	(14.41)	(14.38)
Lev	0.307*	0.304*	0.295*	0.290**	0.284**	0.273*
	(1.95)	(1.91)	(1.85)	(2.09)	(2.02)	(1.94)
Board	-0.175***	-0.195***	-0.186***	-0.158***	-0.176***	-0.169***
	(-2.86)	(-3.14)	(-3.03)	(-3.01)	(-3.30)	(-3.22)
Indep	-0.104	-0.252	-0.205	-0.052	-0.194	-0.153
	(-0.49)	(-1.21)	(-0.98)	(-0.28)	(-1.08)	(-0.84)
Listage	0.045	-0.014	-0.012	0.106	0.044	0.043
	(0.25)	(-0.08)	(-0.07)	(0.7)	(0.3)	(0.29)
SE	-0.425***	-0.421***	-0.429***	-0.367***	-0.366***	-0.372***
	(-4.49)	(-4.42)	(-4.50)	(-4.47)	(-4.42)	(-4.49)
Constant	-36.773***	-37.621***	-37.651***	-32.266***	-33.190***	-33.216***
	(-14.79)	(-14.92)	(-14.89)	(-15.67)	(-15.76)	(-15.75)
Observations	1,520	1,520	1,520	1,520	1,520	1,520
code/quarter FE	YES	YES	YES	YES	YES	YES
r2_a	0.85	0.849	0.849	0.84	0.838	0.838

Note: *** p<0.01, ** p<0.05, * p<0.1

Table 1 reports the impact of digital technology deployment on firm resistance. The results in column (1) indicate that digital technology investment has a significant and negative impact on firm resistance during the COVID-19 pandemic, which indicates that digital technology investment cannot improve the resistance of firms to COVID-19; thus, hypothesis H1 is not supported.Columns (2) and (3) show the effects of different digital technology application fields on firm resistance. In column (2), product innovation has a significant and positive impact on firm resistance, while the process innovation is not significant. This indicates that the application of digital technology in product innovation enhances the resistance of firms during the COVID-19 pan-demic, supporting hypothesis H2.

4.2 Robustness test

To enhance the accuracy and reliability of the findings, a robustness test was conducted on the regression results. An alternative approach was measured by comparing the decline with the maximum value before the impact to measure the dependent variables in order to ensure the robustness of the results. The results of the regression test displayed in Table 1 (Robustness Test)are largely consistent with the conclusions drawn in this study, further attesting to the robustness of the research findings.

5 Conclusion

This research explored the implications of digital technology deployment and specific applications on firm resilience during COVID-19. This study tested the hypotheses using firm performance data from 126 automotive firms from 2019 to 2022 during the COVID-19 pandemic. Econometric models were addressed to identify the effect of digital technology deployment investment and application on firm resilience. The results show that digital technology investment does not directly improve firm resilience during the COVID-19 pandemic. Meanwhile, the application of digital technology deployment to product innovation is conducive to enhancing firm resistance.

5.1 Theoretical contribution

This research proposes a research framework based on the dynamic capability theory and reveals the relationship between specific applications of digital technology deployment and firm resilience using automobile manufacturing firms' data. Although existing research suggests digital technology as a crucial means for firms to enhance firm resilience, the authors discovered that digital technology is capable of improving firm resilience. Meanwhile, this research explored how digital technology enhances firm resilience during the COVID-19 pandemic from the application category. This study expands the role of digital technology in supply chain risk control.

5.2 Management implication

Firstly, managers should pay more attention to supply chain digitization and strengthen their focus on low-frequency and high-impact events. Solving the problem of how to respond to such long duration, high uncertainty sudden public events and quickly recover after the event occurs can help enterprises minimize interruption losses when facing supply chain disruption.

Additionally, when investing in digital technology, managers of automobile manufacturing firms should fully consider digital technology applications. The empirical results show that digital technology investment can work is closely related to the application of digital technology. Digital technology investment and applications are complex projects for any firm, and different applications of digital technology have different abilities to respond to different types of risks. Our research provides new insights for automobile manufacturing firms responding to low-frequency and high-impact risks.

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