

Digital resilience and firm internationalization: a study of Chinese listed companies

Digital
resilience in
Chinese listed
companies

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Abstract

Purpose – The aim of this research is to explore the impact of digital resilience on firms' international performance. Using internal operation efficiency and innovation as channel variables, this paper explores the relationship between digital resilience and international firm performance of Chinese listed firms.

Design/methodology/approach – The research design follows a quantitative approach. Using firm-level panel data from 2007 to 2020, this paper tests the hypotheses between digital resilience and international firm performance through internal efficiency and innovation.

Findings – The results note that digital resilience has a positive effect on internationalization while operation efficiency is a channel through which digital resilience promotes internationalization. Digital resilience also facilitates innovation by improving research and development (R&D) efficiency and matching innovation collaborators.

Originality/value – This paper is one of the first to explore digital resilience in the context of internalization and international firm performance. This paper extends the notion of resource-based view (RBV) to examine the relationship between digital resilience, internal efficiency and innovation on international firm performance.

Keywords Digital resilience, Innovation, Internal efficiency, Internationalization

Paper type Research article

1. Introduction

Literature highlighting the role of digital technologies and digitalization in internationalization has been examined by several scholars. For example, [Bergamaschi et al. \(2021\)](#) explore the relationship between digitization and internationalization. They note the interaction between digitization and internationalization through interorganizational aspects and highlight the change in theoretical development linking the two domains. While examining the relationship between digitization and internationalization, [Yamin and Sinkovics \(2006\)](#) state that technologies impact transaction costs, i.e. in reducing the costs, resulting in improved efficiencies and overall supply chain integration ([Kim et al., 2018](#)). Further, [Chen and Kamal \(2016\)](#) note, that apart from improved supply chain integration, digitization also improves communication between suppliers and customers and reshapes organizational boundaries. Digitization also helps in securing new markets, especially international markets and in allowing access to resources and acquiring organizational capabilities in foreign markets ([Coviello et al., 2017](#); [Watson et al., 2018](#)). According to [Joensuu-Salo et al. \(2018\)](#),



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when considering antecedents for internationalization, digitization is a critical factor and plays a crucial role in a firm's ability to enter and operate in foreign markets.

While evidence has shown the impact of digitalization in internationalization, there is little information on how digital resilience contributes to internationalization. Expanding on [Wright et al. \(2016\)](#), [Jafari-Sadeghi et al. \(2022\)](#) define digital resilience as organizations' ability to use digital technologies, information and knowledge to deal with challenges and stresses resulted from technological disruptions and develop resilience in time of the digital transformation. Making connections between digitalization and digital resilience, [Troise et al. \(2022\)](#), state that digital resilience enhances digital transformation, i.e. resilience improves digital transformation and transformation enriches internationalization and international firm performance ([Jafari-Sadeghi et al., 2020](#)). Literature, though rich in the role of digitalization in internationalization and international firm performance ([Jafari-Sadeghi et al., 2020](#); [Singh et al., 2022](#)), the relationship between digital resilience and international performance in the context of digitalization has not been explored. Especially, through the lens of benefits of digital transformation, i.e. improved internal operation efficiency and increased innovation activities within the firm. Evidence has also shown that embedding of digital technologies in a firm can improve resource utilization, productivity and internal operation efficiency ([Kagermann, 2015](#)).

According to [Cozzolino et al. \(2018\)](#), digitalization and digital transformation have a substantial impact on innovation and innovation processes. Literature points to firms leveraging digital technologies to innovate and develop ecosystems that are geared for product and process innovation ([Appio et al., 2021](#); [Sukumar et al., 2023](#)), these, though informing the relationship between digitalization and efficiency, digitalization and innovation, in the context of internationalization, these need further exploration. Specifically, given that digital resilience influences transformation, it is important that its impact on internationalization and international firm performance is examined.

Recognizing the turbulence nature of business environment, resilience is key to sustain firms' competitive advantage ([Rego et al., 2022](#)). The impact of digitalization on firm performance has been a topic of discussion where various studies have studied the relationship from different angles. In particular, international business literature has emphasized that digitalization is a key driver for firms' internationalization ([Joensuu-Salo et al., 2018](#)). However, the concept of resilience has seldom made into the academic discussion. Thus, it is in addressing this gap that this research aims to explore the impact of digital resilience on internationalization performance. As research has demonstrated the positive impact of digitalization on businesses' internal operation efficiency ([Kagermann, 2015](#)) and innovation ([Appio et al., 2021](#)), this paper also investigates the mediating conditions of internal efficiency and innovation. Under the aegis of resource-based view (RBV), we examine the relationship between digital resilience and internationalization by following a quantitative approach. For this study, we obtained firm-level data of Chinese firms that included annual reports, patent data and financial data to examine the effect of digital resilience on international firm performance. By undertaking this research, we aim to further expand RBV in explaining the role of digital resilience in internationalization performance of firms and contribute towards theory. The rest of the paper is as follows; the second section undertakes a literature review building the theoretical framework while the third section develops the empirical model for this work. The fourth section discusses the results while the final section concludes with contribution and limitation from this work.

2. Theoretical framework

2.1 Digitalization, digital resilience and internationalization

While international activities are key in boosting economic growth ([Dethine et al., 2020](#)) and are beneficial for organizations' development, there are also challenges particularly for Small

and Medium-sized enterprises (SMEs) due to their size and resource constraints (Bhatia and Thakur, 2018). Such challenges can be addressed by digitalization, at least partially (Safar *et al.*, 2018). Various studies have adopted the resource-based view (RBV) where digital technologies are regarded as strategic resources to drive organizations' competitive advantage and enhance international capabilities (Lee and Falahat, 2019). RBV provides a framework to understand firms' competitive advantage and argues that it is primarily driven and sustained by firm's resources and capabilities (Freeman *et al.*, 2021; Giustiziero *et al.*, 2023; Joseph *et al.*, 2022). RBV integrates both internal and external factors to conceptualize and explain firms' competitive advantage by taking into consideration of both tangible and intangible resources (Joseph *et al.*, 2022). This theory has been used by Chandler's (1977, 1990) to explain firms that thrived during the second industrial revolution: firms grew by enhancing and utilizing their resources and abilities while adopting novel transportation and communication technologies to internalize essential aspects of their value chain which allowed them to reduce transaction expenses and leverage their capabilities (Giustiziero *et al.*, 2023). Following this school of thought and as digital revolution has fundamentally changed the way businesses operate, digitalization and international activities are often studied through a process view with limited investigation on the operational aspects (Dethine *et al.*, 2020).

It is widely acknowledged that digitalization can transform the way organizations' create, deliver and capture value; and free organizations from constraints imposed by geographical boundaries (Baskerville *et al.*, 2020; Yoo *et al.*, 2012; Autio *et al.*, 2021). Moreover, benefiting from its infrastructure-related features, digitalization introduces an additional dimension and possibilities to the organizations' internationalization processes and has re-shaped how cross-border interactions can be initiated and coordinated (Autio, 2017; Autio *et al.*, 2021). It has demonstrated its ability in enhancing organizations' resilience level particularly in time of global disruptions (Autio *et al.*, 2021). For example, as the world hit hard and disrupted by the coronavirus disease 2019 (COVID-19) pandemic, it was businesses that implemented digital transformation initiatives (e.g. cloud-based collaboration tools, e-commerce and digital marketing channels, restaurants transitioned to delivery and takeout services) better survived and recovered. Digitalization has also been identified as a key element in fostering SMEs' internationalization capabilities and processes and provided additional sales channel (Dethine *et al.*, 2020). In this context, following RBV, digitalization can be viewed as a resource that firms can leverage to create value and gain competitive advantage. Moreover, in order to create sustained competitive advantage, firms need to develop their digital resilience capacity, i.e. the ability to withstand and recover from digital disruptions. Thus, digital resilience is also regarded as a key capability that firms should develop to leverage their digital resources effectively.

As digital artifacts do not exist in physical forms (Runde and Faulkner, 2019), digitalization can fundamentally diminish the need for physical proximity, such as required by transportation or co-location, for many economic and business-related activities (Mudambi, 2008). For SMEs, the rising digitalization level of the global economy offers tangible avenues in assisting their internationalization and scaling processes (Stallkamp and Schotter, 2019; North *et al.*, 2020). For instance, remote work or telecommuting has become more prevalent which has greatly assisted SMEs' international expansion activities. The digital multisided platforms have shortened the average time as required to penetrate digital innovation internationally from years to a few weeks (Shaheer and Li, 2020). In particular, growth-oriented SMEs tend to adopt various digital technologies in assisting their internationalization process in improving customer relationships and their offering and channels (Heikkilä *et al.*, 2018). Indeed, through surveying the digital technology adoption of 535 Canadian online SMEs', Westerlund (2020) found that SMEs that are operating internationally are 35% more inclined to utilize Customer Relationship Management (CRM)

software and 87% more inclined to use Enterprise Resource Planning (ERP) software than those only operate in domestic market.

Often referred as e-marketing, digital technologies can also be used to facilitate the marketing and promotion process (Mazzarol, 2015). To varying degrees, it can influence on all aspects of export management and contribute to improved profits, increased market share and enhanced brand reputation (Eid and El-Gohary, 2013). For instance, digital technologies can strengthen the online communications with customers (Roopchund, 2019; Eid *et al.*, 2019; Pergelova *et al.*, 2019; Xie *et al.*, 2023). They can further help collect and merge customer data from multiple sources which can then be analyzed to further understand the customer behavior (Dethine *et al.*, 2020). Indeed, by leveraging better and more timely customer insights, digital technologies can support firms in retaining current customers, acquiring new customers with increased satisfaction levels and up-selling their products or services (Guidici and Blackburn, 2013). While online meetings may not be able to fully replace in-person contact (Tseng and Johnsen, 2011), e-marketing tools has a more profound impact on international markets when they are used for developing communication channels, as opposed to solely for information searching and sales activities (Ghalandari, 2013; Joseph *et al.*, 2022).

While it is vital to adopt digital technologies to facilitate the international activities, it also calls for businesses to stay current in the space and build resilience in the rapid changing environment. For instance, digital marketing tools and trends evolve continuously from the use of Search engine optimization (SEO) and social media to the adoption of data analytics and artificial intelligence for more personalized approach. Such changes require businesses to develop capabilities in accessing and using their data and expertise, as well as adopting digital technologies in time of technological disturbances and ultimately develop resiliency in the age of digital transformation.

Therefore, we hypothesize that:

H1. Digital resilience has a positive influence on the firm's international performance.

2.2 Digital resilience, internal operation efficiency and internationalization

The concept of digitalization gained its popularity and received increased investment partly due to the strategic belief that it can improve an organization's operation efficiency by reducing costs and enhance system effectiveness (Ahmad and Murray, 2019; Giustiziero *et al.*, 2023). For instance, the wider societal digital transformation has enabled the reduction of spatial transaction cost at exponential rate (Castells, 2003). E-commerce serves as a great example: through platforms such as Amazon, Alibaba and eBay, buyers and sellers can connect and transact from anywhere in the world at much lower cost but with much wider range of options for both sides. Thus, to understand the impact of digitalization on international activities, it is essential to consider the organizational impact of digitalization on firms which needs to take into consideration of a range of factors such as resources, abilities and aptitudes (Dethine *et al.*, 2020). The value of digitalization is indeed realized depending on the effective implementation and utilization of it within the firm (Dethine *et al.*, 2020).

The adoption of digital technologies and digitalization of firms can mitigate various risks, decrease the time required and lower the cost associated with their internationalization processes (Neubert, 2018; Ojala *et al.*, 2018; Fraccastoro *et al.*, 2021). Specifically, digital communication technologies have long been studied as a way of improving operation efficiency and reducing the expenses relating to coordinating and managing geographically scattered activities (e.g. Yates, 1989; Langlois and Robertson, 1992; Fraccastoro *et al.*, 2021). For instance, digitalization facilitated by such technologies can enhance activities such as cross-border sourcing (Agerfalk and Fitzgerald, 2008), expansion into foreign markets and management of customer relationships (Poulter *et al.*, 2020), optimizing business models

(Furlonger and Uzureau, 2019) and local production and operation processes (Bilberg and Malik, 2019). Moreover, the internal management and production processes perspective can be enhanced by the adoption of digital technologies (e.g. cloud computing, Internet of Things, mobile services, ERP applications) (Cassetta *et al.*, 2020; Dethine *et al.*, 2020). Such digital technologies can also lead to the reduction in cycle time, enhanced flexibility in supply chains and more timely delivery of goods to the customers, reduction of entry and distance costs (Jardim-Goncalves *et al.*, 2013; Cook, 2015; Dethine *et al.*, 2020) which can subsequently improve key indicators on internal operational efficiency such as cash flow and assets turnover. Ahmad and Muray's (2019) study has also indicated the positive relationship between investment in digital technology and sales. Take real-time tracking and logistics software in supply chain management as an example. Companies can monitor the movement of goods through their supply chain more efficiently and in turn reduce cycle time and enhance flexibility.

Moreover, the use of digital collaborative technologies can support information and knowledge sharing among organizations' internal stakeholders and prospect partners (Costa *et al.*, 2020). The adoption of such digitally enabled collaborative approaches made it possible for businesses and their partners to take part in activities that "require group coordination, behavioral adaptation and alignment between the objectives and of the group and individual actors" more effectively (Dethine *et al.*, 2020). For instance, the use of digital technologies such as platforms for common databases, video or telephone conferencing, screen sharing by the businesses and their partners can lead to reduced level of inter-organizational uncertainty, improved common understanding and language (Bahri Korbi *et al.*, 2019). These improvements are especially crucial in a global context as they help with aspects such as lowering the risks of conflict, alleviating cultural differences among partners and even serving as an asset for the partnership (Trabelsi, 2016) which can in turn improve the internal operational efficiency of the firms.

On the other hand, while digitalization brings enhanced international opportunity for the organization, the consistent benefits also depend on how resilience the digital system is. For instance, there are various recognized risks associated with digital adoption such as potential harm to the digital systems, damage or loss of data files, financial loss, damage to reputation, decreased productivity or the inadvertent disclosure of confidential clients' data (M. Rahman and Lackey, 2013). Compared to its large counterparts, SMEs are more vulnerable to such risks due to often limited resources and control (Dethine *et al.*, 2020; Akpan *et al.*, 2022). Thus, while digitalization can bring benefits to the firm's international performance partly by improving its internal operation efficiency, it is the digital resilience level determines such benefits and impact can sustain and do not turn negative. Moreover, it should not be overlooked that sometimes the implementation of digitalization can be expensive where short-term financial benefits may be difficult to be realized (Choshin and Ghaffari, 2017). It is therefore important for businesses to be capable of not only realizing the opportunities brought by digitalization, but also be able to develop resilience strategies and practices in time of digital transformation.

Therefore, we hypothesize that:

H2. Digital resilience improves internationalization performance through improving organizations' internal operation efficiency.

2.3 Digital resilience, innovation and internationalization

The emergence and rapid development of digital technologies and digital infrastructures have resulted in significant changes in firm-level innovation (Nambisan, 2017) and led to new ways of doing businesses and facilitated various new innovation processes (Tekic and Koroteev, 2019). New types of collaborations between businesses as enabled by digitalization

can also contribute to novel product or service offerings and new ways of interacting with employees and customers (Rachinger *et al.*, 2018). Holding the promises of fostering innovation, digital technologies can in turn drive more equitable and sustainable economic growth (OECD, 2021).

Organizations' digitalization process is often associated with varied degrees of innovation activities (Hanelt *et al.*, 2021). From a strategic perspective, it is essential to not only integrate digital technologies internally focusing on operational aspects but also aim at creating digital innovation, such as creating new products/services, processes or business models (Hinings *et al.*, 2018). For instance, by leveraging digital innovation, novel business models can be created that facilitates instant release (Huang *et al.*, 2017). Take cloud computing as an example, through which, business can store and access data in real time and remotely where instant release of new products and services and updates can be facilitated. With its generative nature, continuous innovations are also made possible, which frequently arise from outside sources such as consumers or developers, as can be often observed in platform ecosystems (Parker *et al.*, 2017).

Additionally, with significant reduction in search and monitoring cost, digitalization made it possible for firms to adopt new ways in searching and accessing knowledge resources that are widely spread out such as distributed and combinatorial innovation (Yoo *et al.*, 2012), which can frequently be observed in foreign branches/subsidiaries and overseas partner firms (Autio *et al.*, 2021). Thus, digitalization has made it possible for international businesses to search, access and monitor resources in places and contexts that otherwise not financially feasible (Awate *et al.*, 2015) which lowered the possibility of losing talents which is a particular prominent issue in large markets such as China and India (Autio *et al.*, 2021). Digitalization has also removed or at least lowered barriers imposed by geographical localities on collaborative innovative value-adding activities (Autio *et al.*, 2021). Many of the services people now commonly use in life, such as Amazon, video conferencing and online chat, are made possible by this characteristic.

The advancement of digitalization processes has constantly been enhancing firms' ability to innovate and empowering them to leverage digital tools to drive innovation (Lin and Li, 2022). For instance, the emergence and rapid development of digital and technology infrastructure including communication network infrastructure (e.g. industrial Internet, satellite Internet, 5G, data center and computing center) have fundamentally changed the way society work, communicate and live. Such infrastructure provides the foundation for firms to innovate in ways of connecting various operational aspects and reconfiguring physical components in creating value and accessing new markets (Yoo *et al.*, 2010; Tortora *et al.*, 2021). By removing any structural barriers in accessing information and resources, digital infrastructure and transformation enhance businesses' structure and operational processes which in turn lead to improved innovation efficiency and capabilities (Lim and Li, 2022).

For instance, digital infrastructure and technologies make it possible to collect and analyze large user data and interact with users in real time which facilitate the research and development (R&D) activities in improving existing or designing new product or service offerings (Kopalle *et al.*, 2020). As such, the whole organization innovation process becomes data-driven with user being placed at the central place to assess, respond and even predict market needs (Narver *et al.*, 2004; Saura *et al.*, 2021; Lin and Li, 2022). As a result, a conducive environment are formed for businesses to perform both exploitative and exploratory innovation activities which ultimately enhancing the innovation capability and performance (Kocak *et al.*, 2017). It should also be noted that the resilience of such digital environment is key in the process as it determines the extent to which business can consistently keep up with rapid changing environment especially in times of disruptions. Without digital resilience, digitalization alone have limited or at least unstable impact on innovation outcomes and business performance as a whole.

Innovation supports successful internationalization (Williams and Shaw, 2011). For instance, innovation can help businesses to better navigate and penetrate into overseas market through producing novel and competitive products (Becker and Egger, 2013). However, mixed results have been reported in prior empirical research where positive, negative and statistically insignificant relationships have been found on the impact of innovation on internationalization (e.g. Wakelin, 1998; Sterlacchini, 1999; Xie and Li, 2013). Saridakis *et al.* (2019) argues that such negative or statistically insignificant results maybe due to the under-report of innovation activities by SMEs. In some more recent studies, the adoption of innovation is found to be have a positive impact on organizations' international performance (Azar and Ciabuschi, 2017) where innovation is regarded as a channel for business to internationalize their operations (Gunday *et al.*, 2011; Wang *et al.*, 2008). Therefore, through synthesizing previous studies, it is reasonable to suggest that innovation is a key factor in supporting the organization's international expansion.

Hence, we hypothesize that:

H3. Digital resilience improves internationalization performance through strengthening organizations' innovation.

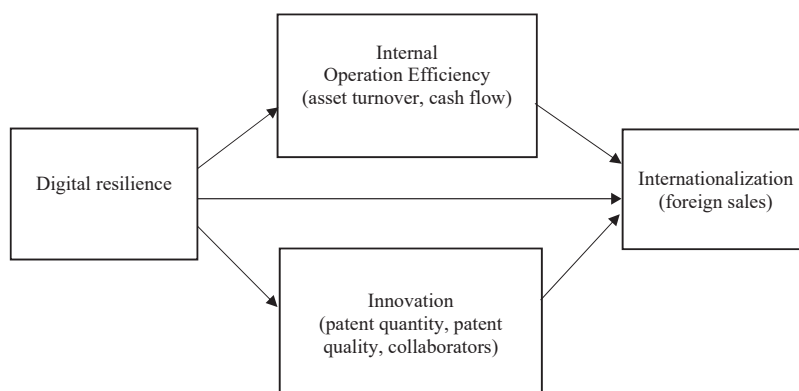
In summary, the proposed theoretical model is shown as in Figure 1.

3. Empirical design

This paper explores the relationship between digital resilience and international firm performance of Chinese listed firms. China has the largest optic and mobile networks in the world, with more than 60 million devices connected to the industrial Internet. In 2020, the Computer Numerical Control (CNC) rate of key processes and the popularization rate of digital R&D tools in key areas of Chinese manufacturing enterprises reached 52.1 and 73% [1] respectively. Using Chinese firm-level panel data from 2007 to 2020, this paper tests hypotheses between digital resilience and international firm performance mediated by internal efficiency and innovation.

3.1 Data

In the empirical study, we match the data from 3 aspects to obtain the firm-level panel data from 2007 to 2020. The sample used for the empirical analysis of this paper includes all firms listed on the Chinese A-shares, including both Shanghai and Shenzhen exchanges.



Source(s): Authors work

Figure 1.
The theoretical model

We organize the data of firm annual reports, firm financial data and patent micro data for the empirical study. Specifically, the firm annual report data is obtained through Python crawler; the firm financial data are obtained through China Stock Market & Accounting Research (CSMAR) database; the patent micro data are compiled by China's State Intellectual Property Office, with data sources from the Institute for Contemporary China Studies of Tsinghua University and Shenzhen Tekglory Technology Co. Ltd. To obtain more accurate results, we exclude the firms classified as special treatment, which indicates abnormal financial or operating conditions; exclude firms in the information transmission, software and information technology service industry that belong to the digital industry; and perform a 1% tail shrinkage process, so as to reduce the influence of outliers. The patent micro data are patent-level data, in which we match the "applicant" information with the annual report data and financial data of firms to obtain the panel data at the firm level from 2007 to 2020.

The descriptive statistics of the main variables in the empirical study are shown in Table 1.

3.2 Variables

3.2.1 Dependent variable. In the empirical study of this paper, the dependent variable *International* is the internationalization performance of firms, which is measured by each firm's foreign sales in each year, taken logarithm. Foreign sales are the total business income of firms' selling to foreign countries and regions. This indicator visually reflects firms' international operations and measures their internationalization performance. Since the foreign sales of some samples are zero, we take the foreign sales of all samples +1 and take logarithm. In addition to this indicator, we also use the number of firms' foreign subsidiaries as a proxy variable for internationalization, thus improving the robustness of the empirical study.

3.2.2 Core independent variable. The core independent variable in this paper is *Digital × Change*, the interaction term between the degree of each firm's digitization and the speed of technological change in each industry. This variable measures the role of firms' digitization in the context of technological change and reflects the effect of digital resilience.

Digital, the degree of firm digitization, is measured by identifying the contents of firm annual reports about firm digitization, then calculating the degree of firm digitization (Wu *et al.*, 2021; Li *et al.*, 2022). First, we use the Python crawler function to organize the firm annual reports, then based on the Jieba Chinese word separation function for the firm annual reports, we conduct word separation and statistics to obtain the information pool of the firm annual report content. Next, we add the keywords related to firm digitization to the text pool

Variables	Observations	Mean	Std. Dev	Min	Max
<i>International</i>	15,724	3.042	0.124	2.619	3.218
<i>Digital</i>	15,724	1.319	1.216	0	4.683
<i>Change</i>	15,724	0.204	0.193	0.091	1
<i>Size</i>	15,724	22.207	1.342	19.366	25.993
<i>LOAR</i>	15,724	0.447	0.223	0.046	0.988
<i>ROE</i>	15,724	0.071	0.127	-0.627	0.416
<i>SOE</i>	15,724	0.569	0.493	0.000	1.000
<i>Age</i>	15,724	1.981	0.931	0.000	3.229
<i>Board</i>	15,724	2.155	0.201	1.609	2.709
<i>CF</i>	15,724	0.046	0.075	-0.180	0.257
<i>Growth</i>	15,724	0.162	0.331	-0.562	1.771
<i>Tangible</i>	15,724	0.278	0.191	0.003	0.801

Table 1.

Descriptive statistics

Source(s): Authors work

and expand the word dictionary by including important policies and research reports related to digitization. Based on this, we extracted the before and after texts from firm annual reports according to the key words related to digitalization and analyzed the combination of contents with high frequency to identify the contents related to firm digitalization from five aspects, including Internet and its business model, big data and its application, artificial intelligence and its application, modern information system and cloud computing and its application. Finally, we use Jieba to sub-word all samples and count the disclosure of key contents to calculate the index of firm digitalization.

Change, the speed of technological change in the industry, is measured by the technology life cycle of the invention patents granted in the year in the industry in which the firm is located, taking inverse. The patent technology life cycle can reflect the speed of technological development and industries with shorter patent technology life cycles have a faster speed of technological change (OECD, 2009; Cheng *et al.*, 2022). For example, the technology life cycle of the semiconductor industry is about 3 years, while the technology life cycle of the shipbuilding industry is about 8 years. The technology life cycle of each industry also varies over time, with shorter technology life cycles in development stages where technology changes more rapidly.

3.2.3 Control variables. In the empirical study, we include a series of control variables that reflect firm characteristics and include firm fixed effects and year fixed effects. The control variables include: *Size*, the size of firms, measured by the total assets of firms, taken logarithm; *LOAR*, loan of asset ratio, measured by the ratio of total liabilities to total assets of firms; *ROE*, return on equity, measured by the ratio of net profit to net assets of firms; *SOE*, type of property right, 1 for state-owned firms and 0 for private firms; *Age*, the age of firms, measured by the time from the year of listing, taken logarithm; *Board*, size of the board, measured by the number of board members, taken logarithm; *CF*, cash flow, measured by the ratio of net cash flow to total assets; *Growth*, the growth of sales, measured by the ratio of the growth of main business income to the previous year's main business income; *Tangible*, tangible property, measured by the ratio of fixed assets to total assets.

3.3 Model

In testing our hypotheses, a regression model has been designed in examining the effect of firms' digital resilience on their internationalization. Based on firm-year panel data, the regression model can be described as follows:

$$International_{it} = \beta_0 + \beta_1 Digital_{it} \times Change_{it} + \beta_2 Digital_{it} + \beta_3 Change_{it} + \beta_4 X_{it} + \eta_i + \theta_t + \varepsilon_i$$

i and *t* indicate firm and year respectively. The dependent variable, *International_{it}*, is the internationalization performance of firm *i* in year *t*. The core independent variable, *Digital_{it} × Change_{it}*, is the interaction term between digitalization and technological change. The vector *X_{it}* is a series of control variables, including the firms' size, loan of asset ratio, return on equity, the age of firms, type of property right, size of the board, cash flow, the growth of sales and tangible property. The variable *η_i* and *θ_t* indicate firm and year fixed effect respectively. The coefficient *β₁* represents the effect of firms' digital resilience on their internationalization.

In the empirical study, we use Stata to organize and calculate the data. For measuring the degree of digitalization, we use Python to organize firms' annual reports, then use Jieba to analyze their Chinese words. In the regression analysis, in order to improve the robustness of the results, all regression models use the heteroskedasticity-robust standard error.

4. Results

4.1 Basic results

First, we analyze the effect of firms' digital resilience on internationalization based on the regression model. Table 2 reports the basic regression results, showing that digitalization can promote internationalization more under the faster technological change. In column (1), the coefficient of the interaction term between digitalization and technological change is 0.162 and significant at the 1% level, without the inclusion of control variables and fixed effects. In column (2), the coefficient of digital resilience remains significantly positive after adding a series of control variables. On this basis, the coefficient of digital resilience remains significantly positive at the 1% level in column (3) with the inclusion of firm and year fixed effects. Thus, the basic regression results suggest that firms' digital resilience has a positive effect on internationalization.

4.2 Heterogeneity analysis

Next, we conduct the heterogeneity analysis for firms of different sizes. We sort the full sample by the size of asset into three subsamples. Among them, the 0–33% quantile subsample has the smallest firms and the 67–100% quantile subsample has the largest firms. We conduct regressions respectively for each subsample group and report the results in Table 3.

Table 2. Digital resilience's effect on internationalization

Variables	(1) Foreign sales	(2) Foreign sales	(3) Foreign sales
<i>Digital</i> × <i>Change</i>	0.162*** (0.023)	0.121*** (0.017)	0.098*** (0.011)
<i>Digital</i>	0.093*** (0.012)	0.079*** (0.010)	0.063*** (0.009)
<i>Change</i>	0.041 (0.036)	0.037 (0.028)	0.037 (0.028)
Controls		Y	Y
Fixed effects			Y
Observations	15,724	15,724	15,724
R-squared	0.573	0.608	0.633

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses
Source(s): Authors work

Table 3. Heterogeneity analysis for firms of different sizes

Variables	(1) 0–33% quantile	(2) 34–66% quantile	(3) 67–100% quantile
<i>Digital</i> × <i>Change</i>	0.136*** (0.015)	0.107*** (0.013)	0.088*** (0.010)
<i>Digital</i>	0.076*** (0.010)	0.068*** (0.009)	0.059*** (0.009)
<i>Change</i>	0.044 (0.034)	0.040 (0.029)	0.038 (0.028)
Controls	Y	Y	Y
Fixed effects	Y	Y	Y
Observations	5241	5241	5242
R-squared	0.698	0.646	0.629

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses
Source(s): Authors work

The results in Table 3 show that digital resilience's positive effect on internationalization is heterogeneous, with a stronger effect for smaller firms. From columns (1) to (3), the coefficients of the interaction terms of digitalization and technological change are all significantly positive at the 1% level, but their magnitudes are respectively 0.136, 0.107 and 0.088, showing a decreasing trend. Small firms have more flexibility and are able to make more use of digital resilience to promote their internationalization performance. Therefore, the results of the heterogeneity analysis suggest that digital resilience has a stronger effect on the internationalization of smaller firms.

4.3 Robustness tests

To improve the robustness of the empirical analysis, we conduct robustness tests in 3 aspects and report the results in Table 4. In column (1), we change the measure for firms' digitalization by further expanding the keyword pool beyond the original 5 dimensions to cover a wider range of digitalization. Column (1) still uses foreign sales as the dependent variable and the regression results show that digital resilience has a positive effect on internationalization and is significant at the 1% level. In column (2), we identify and exclude the 10% sample that may have an abnormal number of disclosures, considering the possibility of exaggerated disclosures by firms. We first estimate the number of possible disclosures for each firm in each year and then remove the samples above the 90% quantile of the residuals and conduct the regression with the remaining samples. Column (2) shows that the regression results after excluding outliers are still positively significant, so digital resilience can significantly promote internationalization. In column (3), we change the measure of internationalization and use the number of firms' foreign subsidiaries as the dependent variable for internationalization. The coefficient of the core independent variable in column (3) is also positively significant. Thus, the results of the robustness tests indicate that the findings of the empirical analysis are robust.

5. Mechanisms

5.1 Operation efficiency

In the mechanism tests, we first analyze whether operation efficiency is a channel through which firms' digital resilience promotes internationalization. Table 5 shows that firms' digital resilience can reduce operation cost and improve operation efficiency. In column (1), we use firms' asset turnover ratio as the dependent variable, measured by the ratio of total turnover to

Variables	(1) Digitalization measure	(2) Eliminating exaggeration	(3) Foreign subsidiaries
<i>Digital</i> × <i>Change</i>	0.087*** (0.011)	0.075*** (0.019)	0.151*** (0.031)
<i>Digital</i>	0.054*** (0.008)	0.059*** (0.009)	0.092*** (0.019)
<i>Change</i>	0.037 (0.028)	0.037 (0.028)	0.029 (0.020)
Controls	Y	Y	Y
Fixed effects	Y	Y	Y
Observations	15,724	14,150	15,724
R-squared	0.615	0.593	0.584

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses

Source(s): Authors work

Table 4.
Robustness tests

Variables	(1) Asset turnover	(2) Cash flow
<i>Digital</i> × <i>Change</i>	0.011*** (0.002)	0.032*** (0.004)
<i>Digital</i>	0.006*** (0.001)	0.019*** (0.002)
<i>Change</i>	0.003*** (0.001)	0.004*** (0.001)
Controls	Y	Y
Fixed effects	Y	Y
Observations	15,724	15,724
R-squared	0.681	0.627

Table 5. Digital resilience's effect on operation efficiency

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses
Source(s): Authors work

total assets. The results in column (1) show that the digital resilience of firms can improve the asset turnover ratio and is significant at the 1% level. In column (2), we use firms' cash flow as the dependent variable, measured by the ratio of net cash flow to total assets. The results in column (2) show that digital resilience of firms can significantly improve cash flow. Digital resilience facilitates the better use of resources and to optimize decision making through digital technology, thereby reducing operation cost and improving operation efficiency.

On this basis, we examine the effect of firms' operation efficiency on internationalization. In column (1) of Table 6, we use the firms' asset turnover ratio as the independent variable and foreign sales as the dependent variable. In column (2), we use the firms' cash flow as the independent variable and foreign sales as the dependent variable. Both coefficients are positive and significant at the 1% level. The results in Table 6 indicate that the promotion of firms' operation efficiency can significantly contribute to internationalization.

5.2 Innovation

Next, we analyze whether innovation is a channel through which firms' digital resilience promotes internationalization. Table 7 shows that firms' digital resilience can promote different types of innovation. In column (1), we use firms' patent quantity as the dependent variable, measured by the number of invention patents granted in the year, +1 and taken logarithm. The results in column (1) show that digital resilience of firms can increase patent quantity and is

Variables	(1) Foreign sales	(2) Foreign sales
Asset turnover	0.526*** (0.042)	
Cash flow		0.438*** (0.142)
Controls	Y	Y
Fixed effects	Y	Y
Observations	15,724	15,724
R-squared	0.801	0.768

Table 6. Operation efficiency's effect on internationalization

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses
Source(s): Authors work

Digital
resilience in
Chinese listed
companies

Variables	(1) Patent quantity	(2) Patent quality	(3) Collaborators
<i>Digital</i> × <i>Change</i>	0.054*** (0.007)	0.038*** (0.005)	0.309*** (0.046)
<i>Digital</i>	0.038*** (0.005)	0.018*** (0.003)	0.281*** (0.034)
<i>Change</i>	0.017*** (0.003)	0.018*** (0.003)	0.104*** (0.017)
Controls	Y	Y	Y
Fixed effects	Y	Y	Y
Observations	15,724	15,724	15,724
R-squared	0.631	0.598	0.582

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses

Source(s): Authors work

Table 7.
Digital resilience's
effect on innovation

significant at the 1% level. In column (2), we use the firms' patent quality as the dependent variable, measured by firms' average exclusive time, exclusive scope and exclusive strength of patents (Cheng *et al.*, 2022). The results in column (2) show that digital resilience of firms can significantly increase patent quality. In column (3), we use the firms' innovation collaborators as the dependent variable, measured by the number of applicants who jointly apply for invention patents in the year. The results in column (3) show that firms' digital resilience can significantly increase innovation collaborators. Digital resilience facilitates innovation by improving R&D efficiency and matching innovation collaborators.

On this basis, we examine the effect of firms' innovation on internationalization. In column (1) of Table 8, we use the firms' patent quantity as the independent variable and foreign sales as the dependent variable. In column (2), we use the firms' patent quality as the independent variable and foreign sales as the dependent variable. In column (3), we use the firms' innovation collaborators as the independent variable and foreign sales as the dependent variable. All the coefficients are positive and significant at the 1% level. The results in Table 8 indicate that the promotion of firms' innovation can significantly contribute to internationalization. Thus, firms' innovation is a channel through which digital resilience promotes internationalization.

Variables	(1) Foreign sales	(2) Foreign sales	(3) Foreign sales
Patent quantity	0.058*** (0.011)		
Patent quality		0.053*** (0.010)	
Collaborators			0.113*** (0.028)
Controls	Y	Y	Y
Fixed effects	Y	Y	Y
Observations	15,724	15,724	15,724
R-squared	0.781	0.786	0.797

Note(s): *, ** and *** indicate significant at 10%, 5 and 1% level respectively. Robust standard errors in parentheses

Source(s): Authors work

Table 8.
Innovation's effect on
internationalization

6. Discussion and conclusion

The paper examines the influence of digital resilience on international firm performance. The results have demonstrated that digital resilience has a positive relationship on international firm performance, it also improves internationalization performance through strengthening organizations' internal efficiency and innovation capability and outcomes. Using RBV, this paper, extends the notion that digital resilience plays a part in improving organization's capabilities which in turn improves innovation performance. Similarly, digital resilience, improves internationalization performance through strengthening organizations' innovation capability and outcomes.

In terms of contribution to theory, this paper provides a model of digital resilience and firm performance in the context of internationalization and extends our knowledge in this area. Under RBV, a firm's resources and capabilities are the fundamental sources of its competitive advantage (Freeman *et al.*, 2021; Giustiziero *et al.*, 2023; Joseph *et al.*, 2022). In the context of increasingly digitized environment, digital resilience can be considered as a valuable resource that contributes significantly to a firm's overall competitive advantage, particularly in improving its internationalization performance as shown in our paper. It underlines the significance of digital resilience as a main driver of business success particularly in this digital age (Autio *et al.*, 2021). In particular, digital resilience can be viewed as a valuable intangible resource, which is a key component of RBV theory, that is hard to be replicated by competitors and therefore valuable for firms longer term sustained performance.

The development of digital resilience is arguably complex that could involve multiple aspects of the firm, such as its organizational culture, leadership and technology infrastructure (Costa *et al.*, 2020; Dethine *et al.*, 2020). This complexity suggests that digital resilience is a valuable and rare resource that can contribute to a firm's competitive advantage. Through recognizing the role of digital resilience in improving internationalization performance, researchers and practitioners can enhance their understanding on different factors that contribute to business success in the digital environment. In attempting to debunk this complexity, our research has shown that internal operational efficiency and innovation capability and outcomes are two key factors.

From a practical perspective, this paper highlights the need for developing digital resilience and using it as a capability in improving firm performance. Businesses that prioritize digital resilience with appropriate strategy in place can improve their competitiveness and adaptability in facing uncertainties and particularly digital disruptions (Trabelsi, 2016). Thus, managers and the top management team should focus attention on improving digital resilience for developing competitive advantage and in the expansion of foreign markets. However, businesses should be prepared to adopt a holistic approach in managing the firms' resources and capabilities in attempting to enhance their digital resilience level (Dethine *et al.*, 2020). This may involve, for instance, developing a culture that cultivate innovation and learning, investing in new technologies and infrastructure, stay up to date with the latest development, developing stronger partnerships with suppliers and other stakeholders and implementing more effective cybersecurity measures to mitigate risks.

In the increasingly globalized world, the results of our research offered a pathway for business to focus on in order to improve their internationalization levels: through improving digital resilience levels. We have also pointed out two significant areas that businesses should focus on: internal efficiency and innovation capability and outcomes. The nature of the two areas also indicates that developing digital resilience requires consistent monitoring and evaluation of the firm's digital environment and performance. This calls for not only process-related actions but also management's ability to process the situation, identify potential threats and areas of improvement and opportunities and be able to respond appropriately. Thus, developing true digital resilience requires a long-term commitment and strategy for continuous improvement with focus on creating value for customers and stakeholders.

While we believe this paper has made significant to the literature, we do also recognize the limitation which can be improved in the future. When measuring firms' digitalization level, this paper collects the annual reports of each firm and measures the digitization level through analyzing the textual content within the annual reports. As a new method surfaced in recent years, the accuracy level of this approach needs further empirical testing. As an example, certain firms may exaggerate their progress in their digital development. Future research in this area can focus on examining the pathways of digital resilience and its impact on firm and international performance while a more qualitative approach can highlight the challenges in linking resilience with international firm performance within an organizational behavior perspective.

Note

1. According to Digital China Development Report (2020), released by China's National Internet Information Office.

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