Unraveling the performance puzzle of digitalization

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Unraveling the Performance Puzzle of Digitalization: Evidence from Manufacturing Firms

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Abstract:	The COVID-19 pandemic has boosted firms' investments in digital technologies, and digitalization is booming. However, it remains unclear how and when digitalization leads to superior performance. To demystify this phenomenon, we develop a moderated moderation model to investigate the combined effects of digitalization, knowledge inertia, and organizational integration mechanisms on firm performance. Based on survey data from 192 Chinese manufacturing firms with different degrees of digitalization, we find that although digitalization has a positive relationship with firm performance, that relationship is negatively moderated by knowledge inertia. More interestingly, a formal organizational integration mechanism, but not an informal organizational integration mechanism, mitigates the negative moderation effect of knowledge inertia. We contribute to the literature by articulating how knowledge inertia and organizational integration mechanisms jointly determine the effect of digitalization on firm performance. Our study also provides implications for firms to modify their practices to prosper in the digital revolution.

Unraveling the Performance Puzzle of Digitalization: Evidence from Manufacturing Firms

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Response to Editors

Response: Our paper is formatted as per the guidelines of JBR.

Unraveling the performance puzzle of digitalization: Evidence from Chinese manufacturing firms

Abstract. The COVID-19 pandemic has boosted firms' investments in digital technologies, and digitalization is booming. However, it remains unclear how and when digitalization leads to superior performance. To demystify this phenomenon, we develop a moderated moderation model to investigate the combined effects of digitalization, knowledge inertia, and organizational integration mechanisms on firm performance. Based on survey data from 192 Chinese manufacturing firms with different degrees of digitalization, we find that although digitalization has a positive relationship with firm performance, that relationship is negatively moderated by knowledge inertia. More interestingly, a formal organizational integration mechanism, but not an informal organizational integration mechanism, mitigates the negative moderation effect of knowledge inertia. We contribute to the literature by articulating how knowledge inertia and organizational integration mechanisms jointly determine the effect of digitalization on firm performance. Our study also provides implications for firms to modify their practices to prosper in the digital revolution.

Keywords: Digitalization; Knowledge inertia; Organizational integration mechanisms; Firm performance; China

1. Introduction

Digitalization, referring to the use of digital technologies to transform business processes and organizational management (Nasiri, Ukko, Saunila, & Rantala, 2020), is a key development for all firms (Bresciani, Huarng, Malhotra, & Ferraris, 2021). However, successful digitalization is proving elusive and a puzzle that needs urgently to be unraveled (Kohtamäki, Parida, Patel, & Gebauer, 2020). McKinsey (2018) reports that, worldwide, fewer than one-third of firms have improved and sustained their performance through digitalization; in some traditional manufacturing industries, such as pharmaceuticals and the automotive sector, the success rates of digitalization merely fall between four and eleven percent. Given that digitalization has dramatically reshaped various sectors and production processes (Verhoef, Broekhuizen, Bart, Bhattacharya, Dong, Fabian, & Haenlein, 2021), those firms that prove unable to implement it, or have been unable to improve their performance by doing so, have poor prospects (Jantunen, Tarkiainen, Chari, & Oghazi, 2018). Against this backdrop, understanding which factors may enhance or hinder the relationship between digitalization and firm performance is critical for both academics and practice (Ye, Liu, Li, Lai, Zhan, & Kumar, 2022).

The association between digitalization and performance has been primarily investigated from the perspective of capabilities (Ciampi, Demi, Magrini, Marzi, & Papa, 2021; Gupta, Drave, Dwivedi, Baabdullah, & Ismagilova, 2020; Mikalef, van de Wetering, & Krogstie, 2021). However, digitalization not only helps firms to develop new capabilities but also aids in synthesizing, improving, and accelerating intra- and inter-firm knowledge management (Schniederjans, Curado, & Khalajhedayati, 2020). In particular, digitalization necessitates a solid

commitment to converting digital data into new knowledge, which lays the groundwork for more transparency and better-informed decision-making (Dalenogare, Benitez, Ayala, & Frank, 2018). Moreover, digitalization enables firms to quickly interact and share in-depth information and knowledge (via digital channels), boosting knowledge exchange between parties (Kamalaldin, Linde, Sjödin, & Parida, 2020). Hence, further research on the association between digitalization and performance from the perspective of knowledge management is required.

Although digitalization theoretically offers firms valuable insights and possible action plans, such insights and action plans may conflict with the firm's previous experience of success (Tripsas, 2009). A notorious example of the conflict between digitalization and past experience was Google's use of big data to forecast influenza outbreaks, which had a stunning 140% error rate (Kucharski, 2013). *Knowledge inertia* is defined as a firm's inclination to handle issues in the same way as it always has done, on the basis of prior experience and knowledge (Fu, Luan, Wu, Zhu, & Pang, 2021). Prior studies primarily investigate the influence of knowledge inertia on innovation (Fu et al., 2021; Yu, Hao, & Wang, 2020). To the best of our knowledge, no research has explored the role of knowledge inertia in digitalization, which may lead to a limited understanding of the new phenomena associated with digitalization (Mikalef et al., 2021). Given that digitalization is more than simply the use of digital technologies but should also result in changes to management cognition and decision-making (Sestino, Prete, Piper, & Guido, 2020), firms must make a trade-off between prior experience and data-driven insights. Hence, our first research question is: *how does knowledge inertia affect the relationship between digitalization and firm performance?*

Knowledge inertia arises from the employment of routine problem-solving strategies that rely on redundant, stagnant knowledge and previous experience without recourse to fresh knowledge and new cognitive processes (Liao, Fei, & Liu, 2008). To overcome knowledge inertia, companies need to supplement existing knowledge with diverse types of information (i.e., new learning, new thinking, and new experience) (Xie, Fang, Zeng, & Huo, 2016). *Organizational integration mechanisms* reflect how firms enhance knowledge exchange and integration amongst employees (Jansen, Tempelaar, van den Bosch, & Volberda, 2009). *Cross-functional interfaces* represent formal organizational integration mechanisms, which allow employees with different knowledge and skills and in various fields to identify and solve common problems (Gupta & Govindarajan, 2000). Typical examples include liaison persons, task forces, and cross-functional teams. In contrast, *connectedness* represents an informal organizational integration mechanism, which allows individuals within the organization with disparate experience and knowledge to freely transmit new ideas (Jansen et al., 2009). Connectedness can be achieved by ensuring that there is a comfortable organizational culture that fosters informal or social ties between employees.

To the best of our knowledge, few studies have explored the impacts of these two different types of organizational integration mechanisms on knowledge inertia, and this omission may lead to incomplete insights into how firms might be able to reduce their level of knowledge inertia. Understanding the role of organizational integration mechanisms within a firm is particularly important in the digital environment. This is because the human component is the soft side of digitalization, and to be successful in digitalization, firms must harness their

employees' passion for knowledge exchange and exploration (Tabriz, Lam, Girard, & Irvin, 2019). Accordingly, our second research question is: *which type of organizational integration mechanisms, formal or informal, has the greater influence on the combined effect of knowledge inertia and digitalization on firm performance?*

Because China is the global manufacturing engine (Zhang, Xue, & Dhaliwal, 2016), and because manufacturing is one of the industries with a relatively low rate of success in digitalization (McKinsey, 2018), we surveyed Chinese manufacturing firms in the second quarter of 2021. Through the systematic analysis of how digitalization, knowledge inertia, and organizational integration mechanisms affect firm performance, our study contributes to the literature in the following three respects.

First, past studies primarily use dynamic capability theory to explore how digitalization affects firm performance (Jantunen et al., 2018; Qrunfleh & Tarafdar, 2014). In this paper, we analyze the association between digitalization and performance from a knowledge management perspective and are consequently able to offer a new mechanism that explains the link between the two. Second, similar to past research that asserts that knowledge inertia has a negative impact on innovation (Liao et al., 2008), in the context of the digital revolution, we reveal that knowledge inertia weakens the positive effect of digitalization on firm performance. Hence, this finding not only expands the areas in which knowledge inertia has been studied but also provides new insights into the performance puzzle of digitalization. Third, although the importance of organizational integration mechanisms in improving organizational ambidexterity has been acknowledged by scholars (Jansen et al., 2009), the influence of the two main types of

organizational integration mechanisms (formal and informal) on success in digitalization is still unclear. In this paper, we operationalize these two specific types as secondary moderators, thereby responding to the call of scholars for more detailed research in this field and providing another explanation for the digitalization puzzle.

Managerially, our study not only offers direct implications for how Chinese manufacturing firms can implement effective digital strategies but also provides a reference for firms in other countries that face a similar dilemma.

2. Theory and hypotheses

2.1 A knowledge management perspective on digitalization

Knowledge management refers to the construction of a knowledge system in an organization, in terms of both tasks and technologies (Ferraris, Santoro, & Dezi, 2017). The goal is continuous innovation through the process of obtaining, creating, sharing, integrating, recording, accessing, and updating knowledge (Hedlund, 1994). Typically, knowledge can be divided into *explicit* and *tacit* forms (Schniederjans et al., 2020). The former can be easily communicated in words and numbers (Huarng, Mas-Tur, & Moreno, 2018), whereas the latter is difficult to describe, communicate, and share (Anand, Ward, & Tatikonda, 2010).

According to Nonaka (1994)'s theoretical framework, socialization, externalization, combination, and internalization make up the circle for knowledge creation. *Socialization* focuses on the exchange of tacit knowledge among the members of an organization; *externalization* is the transformation of tacit knowledge into explicit knowledge; *combination* involves the conversion of explicit knowledge into more complex forms, whereas *internalization*

refers to the transition of explicit knowledge back into tacit form (Schniederjans et al., 2020). Conspicuously, the most intuitive effect of digitalization is the codification of explicit knowledge, that is, transforming analog data streams into discrete digital bits of 1s and 0s (Ritter & Pedersen, 2020). In relation to externalization and internalization, the use of some smart technologies, such as knowledge mining systems, business intelligence, virtual knowledge communities, and expert systems, provides a means to convert tacit knowledge to explicit knowledge, as well as the conversion of explicit knowledge into tacit knowledge (Cheng, Zhong, & Cao, 2020; Ferraris, Mazzoleni, Devalle, & Couturier, 2019). Given that digitalization can improve socialization, externalization, combination, and internalization to some extent, one of the most important functions of digitalization is to facilitate the creation of new knowledge (Ilvonen, Thalmann, Manhart, & Sillaber, 2018).

Furthermore, according to Carrión, González, and Leal (2004), technology, processes, and people are three pillars of knowledge management. In particular, knowledge management entails not just managers' and workers' technical ability, but also the use of social networks to plan, alter, and execute workflows, allowing for the free flow of information inside the firm (Schniederjans et al., 2020). In the digital era, actuators in manufacturing equipment can bypass the supercomputer's point-to-point control to communicate directly through sensor capabilities, thereby disclosing another function of digitalization, namely the decentralization of information sharing (Rey, Panetti, Maglio, & Ferretti, 2021).

Based on the above arguments, we believe that the creation and sharing of new knowledge are two mechanisms through which digitalization can improve firm performance. First, the

digitalization of business processes, particularly through the use of big data analytics and artificial intelligence, can continually offer new knowledge to inform firms' decision-making (Abou-foul, Ruiz-Alba, & Soares, 2021; Bresciani, Ciampi, Meli, & Ferraris, 2021; Khanra, Dhir, & Mäntymäki, 2020). For example, through the large amount of data collected from consumers, firms can now use advanced analytics to obtain new knowledge related to consumer characteristics and future consumer behavior, thus providing potential conditions for effective business decision-making (Cohen, 2018). Second, the application of some emerging digital technologies, particularly the Internet of Things and cloud computing, can not only capture real-time machine data but also disseminate data across the whole supply chain (Bresciani, Ferraris, & Giudice, 2018), allowing upstream and downstream supply chain partners to keep track of various activities (Ferraris, Monge, & Mueller, 2018). McKinsey (2020) reports that firms that use digital supply chain systems to frequently exchange information and expertise with suppliers have stronger growth, lower operational expenses, and higher profitability than their rivals. Hence, we propose:

Hypothesis 1. Digitalization has a positive relationship with firm performance.

2.2 The moderating effect of knowledge inertia

Inertia is a physics term that describes the condition of an item that is either immobile or moving uniformly (Liao et al., 2008). Organizational academics apply the concept to the context of knowledge management (Mol & Kotabe, 2011). *Knowledge inertia*, which includes procedural, experience, and learning forms, reflects a firm's cognitive tendency to solve new problems on the basis of prior knowledge and experience (Xie et al., 2016). Digitalization, however, necessitates

the abandonment of many outdated management concepts and organizational processes (Liang, Wang, Xue, & Ge, 2017). We, therefore, examine how the level of knowledge inertia may influence the effect of digitalization on firm performance.

High levels of knowledge inertia represent a barrier to any change in the firm's problem-solving methods (Yu et al., 2020). Digitalization aims to achieve the real-time, free, and orderly flow of data among information systems, automated equipment, and people, and yet many firms lack trust in such knowledge sharing because the information and knowledge obtained are not always right (Ghasemaghaei & Calic, 2020). That is, firms with a high level of knowledge inertia place less trust in digital information and more trust in past knowledge and experience to tackle new problems that arise during the course of business, rather than exploring potential digital solutions. Furthermore, it has been argued that digitalization can lead to information overload, and so cause organizational paralysis (Guo, Lu, Kuang, & Wang, 2020). By contrast, low levels of knowledge inertia mean that firms tend to embrace new ideas and knowledge, even though this may be risky (Yu et al., 2020). Such openness undoubtedly reduces the barriers to digital change. In fact, McKinsey (2018) has reported that if firm leaders encourage employees to continuously try new ideas and learn from their failures through methods like rapid prototyping, then a firm is more likely to thrive after digitalization. In accordance with the above arguments, we postulate:

Hypothesis 2. Knowledge inertia negatively moderates the relationship between digitalization and firm performance.

2.3 The secondary moderating effect of organizational integration mechanisms

One of the main causes of knowledge inertia is the lack of knowledge flow (Xie et al., 2016). Hence, to overcome knowledge inertia, it is vital to improve organizational integration mechanisms by boosting knowledge flow amongst employees and comprehensively utilizing the knowledge of all individuals. Motivated by the work of Jansen et al. (2009), we focus on two types of organizational integration mechanisms, namely cross-functional interfaces and connectedness. *Cross-functional interfaces* (e.g., liaison personnel, cross-functional teams, and task forces) are formal organizational integration mechanisms; they bring together employees from different departments with varying levels of competence to share in-depth information and knowledge. In contrast, *connectedness* is an informal organizational integration mechanism, often based on an organizational environment in which members with varying levels of experience and knowledge may freely discuss and exchange new ideas. Prior studies have examined the effects of organizational integration mechanisms on exploratory and exploitative innovation (Jansen et al., 2009). Given that, in most cases, innovation and inertia are diametrically opposed (Liao et al., 2008), in the following we examine how organizational integration mechanisms, both formal and informal, can change the effect of digitalization on firm performance by influencing knowledge inertia.

Organizational integration mechanisms can enable the emergence of new knowledge by linking previously disconnected sources of knowledge (Jansen et al., 2009). For example, cross-functional interfaces can assist members of an organization who would otherwise not be in regular contact to reach a consensus through in-depth conversation and exchange, thereby crossing the bounds of current knowledge (Prabhu, Chandy, & Ellis, 2005). Nahapiet and

Ghoshal (1998) suggest that, in addition, informal social relations (i.e., connectedness) may act as a cross-departmental information bridge for organizational members who want to obtain new knowledge in new areas. Furthermore, organizational integration mechanisms can produce knowledge synergies across multiple, otherwise separate functional divisions (O'Reilly & Tushman, 2008). It can, for instance, make it easier and simpler for members of the organization to communicate and collaborate across regions and time zones (Wang, Hong, Li, & Gao, 2020). Overall, the higher the level of a firm's organizational integration mechanisms, the more employees may be willing and able to share knowledge, thereby increasing the collective wisdom of the entire organization. Under such circumstances, firms are more likely to produce and implement new ideas or solutions rather than depending on outdated knowledge and experience. Therefore, high levels of organizational integration mechanisms may weaken a firm's knowledge inertia, and this is expected to promote the linkage between digitalization and firm performance, albeit indirectly. In fact, McKinsey (2018) reports that when a firm adopts at least one type of organizational integration mechanism (e.g., continuous learning or open work environments) to enable employees to come up with their own ideas on how digitalization may support the business, it will be more likely to achieve success than its peers. According to the above arguments, we propose:

Hypothesis 3a. The stronger the firm's cross-functional interfaces are, the weaker will be the negative moderation effect of knowledge inertia on the association between digitalization and performance.

Hypothesis 3b. The stronger the firm's connectedness is, the weaker will be the negative

moderation effect of knowledge inertia on the association between digitalization and performance.

Based on the above hypotheses, the theoretical model of this paper is depicted in Fig. 1.

Please insert Fig. 1 here.

3. Methods

3.1 Data collection

The reasons why we focus on Chinese manufacturing firms are that, first, China is the world's manufacturing engine and the country with the most technical innovation in emerging economies (Li, Ye, Dai, Zhao, & Sheu, 2019), and thus, investigation in China may serve as a reference for firms in other developing nations dealing with the same performance puzzle of digitalization. Second, because manufacturing firms are generally in the middle of the value chain (Islam, 2017), understanding how to properly apply digitalization for manufacturing firms may substantially increase the overall efficiency of the value chain. Third, many Chinese manufacturing firms have achieved different degrees of digitalization in their procurement, production, manufacturing, and sales processes (Zhang et al., 2016), thus providing a rich sampling pool for this study.

Prior to the formal distribution of the study questionnaire, we asked 30 MBA students with expertise in digital operations to assess the wording of its items and the time required to complete it, in a pre-test. In addition, we enlisted the help of three professionals in the field of digital operations management to refine it. The formal data-gathering was conducted in the second quarter of 2021. We partnered with a reputable survey organization in mainland China

since it had strategic ties with over 30,000 Chinese firms. We then randomly emailed the questionnaire, together with a cover letter describing the goals of the study and possible contributions of the respondent firms, to those firms in the sample pool of the survey organization. There were two screening questions to ensure that our final sample met our research purpose: the firms had to indicate both that they were in the manufacturing industry and that they used at least one digital technology (e.g., big data analytics, Internet of Things, artificial intelligence, cloud computing, and blockchain). The screening left a sample of 515 potential firms. Each of these firms needed to provide two key informants: a senior manager, to answer the questions on digitalization, knowledge inertia, and organizational integration; and a financial or market manager, to answer the questions related to firm performance. Each of these informants had also given their job title, age, and work experience (in terms of the number of years). These further requirements left a total of 192 valid responses, with a recovery rate of 37.28%. Table 1 depicts the profile of the sample firms. The majority of respondent firms were privately owned, had been in operation for more than 10 years, and employed more than 200 people. They were in a variety of manufacturing industries.

Please insert Table 1 here.

We examined non-response bias by comparing the first and last quarter of the responses with regard to the mean values of the number of employees and years established (Armstrong & Overton, 1997). The results of independent group *t*-tests demonstrated no significant differences between these two groups ($p > 0.10$). Moreover, although we collected the data from different informants, we still employed some statistical techniques to assess common method variance

(CMV). First, similar to the work of Li, Wang, and Wang (2020), we conducted Harmon's single-factor test, that is, loading all items in the exploratory factor analysis. The result of the unrotated factor analysis indicated that CMV was not a serious problem because the largest factor captured only 34.52% of the variance, which was much less than the cutoff point of 50% (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Second, we applied the marker-variable technique by setting the mobile phone brand of one of the informants as a marker variable (Lindell & Whitney, 2001). We found that the marker variable had non-significant correlations with the other study variables (see Table 2), and, more importantly, controlling for common method bias did not change the corresponding correlations of variables to statistical non-significance ($p > 0.10$). Hence, the above results also suggested that CMV did not pose a risk to our research.

3.2 Measures

All items were adapted from previous studies and were scored on a seven-point Likert scale, with 1 indicating strongly disagree and 7 strongly agree. First, four items for digitalization were adapted from Abou-foul et al. (2021); they captured how a firm uses digital technologies to understand customers, make operational decisions, increase the added value of products and services, and launch new business models. Next, similar to the work of Fu et al. (2021), knowledge inertia was measured by five items that demonstrated a firm's proclivity to address difficulties in the same way as previously, based on prior experience and knowledge. Five items for cross-functional interfaces were adapted from Jansen et al. (2009), and these items reflected how a firm employed liaison personnel, cross-functional teams, and task forces to promote

knowledge sharing within the firm. We also adapted another four items from Jansen et al. (2009) to measure connectedness, which captured the extent to which employees with varying levels of expertise and knowledge were able to freely share their ideas across the firm. Finally, four items adapted from Vickery, Jayaram, Droge, and Calantone (2003) were used to measure firm performance. Some control variables were also included in the questionnaire, including firm age (the number of years established, up to 2021), firm size (the number of employees), type ownership (public, private or collective, or foreign), and the specific manufacturing sector the firm operated in. The details of each item are presented in *Appendix A Fig. A1*.

4. Results

4.1 Validity and reliability

We employ confirmatory factor analysis (CFA) to test the validity and reliability of each latent construct (Li, Wang, Chen, & Wang, 2020) and present the results in *Appendix A Table A1*. The model fit indices are good, with χ^2 = 252.231, df = 199, χ^2/df = 1.287, NFI = 0.904, IFI = 0.978, TLI = 0.975, CFI = 0.978, and RMSEA = 0.037. All factor loadings range from 0.701 to 0.900, above the recommended threshold of 0.5, and the corresponding *p*-values are significant at the 0.01 level, thereby indicating good convergent validity (Fornell & Larcker, 1981; Nunnally, 1978). In addition, the average variance extracted (AVE) of all latent constructs is over 0.5, which further demonstrates convergent validity (Fornell & Larcker, 1981; Nunnally, 1978). Furthermore, the composite reliability (CR) and Cronbach's α values of each latent construct are greater than the critical value of 0.7, thus implying acceptable reliability (Li et al., 2019). Finally, we examine the discriminant validity by comparing the square roots of AVEs of all latent

constructs with the correlations between all pairs of latent constructs (Fornell & Larcker, 1981; Nunnally, 1978). As depicted in Table 2, all the square roots of AVEs are greater than the corresponding correlations, thus demonstrating adequate discriminant validity (Kim, Kumar, & Kumar, 2012).

Please insert Table 2 here.

4.2 Hypothesis testing

Following Song and Di Benedetto (2008), we first average all items belonging to each latent construct to obtain an overall value. We then perform collinearity diagnostics to alleviate multicollinearity issues. The variance inflation factors (VIF) of all variables are substantially below the crucial value of 10 (Hu, Mcnamara, & Piaskowska, 2017). After that, we analyze the data using hierarchical regressions and the PROCESS macro in SPSS 23.0 (Hayes, 2013). Following the logic of hierarchical regressions, we add all control variables into the first block and the independent variable into the second block, thereby obtaining an estimate of the direct impact of digitalization on firm performance. Next, we use MODEL 1 and MODEL 3 of the PROCESS routine to conduct moderation analysis and moderated moderation analysis by setting 5000 bootstrap samples and the 95% bias-corrected confidence interval (Hayes, 2013). The PROCESS macro has great advantages in handling multivariate mediation effects and multilevel moderation effects (Li, Wang, Li, & Liao, 2021a). Currently, in the field of management, many scholars, such as Diamantopoulos, Davydova, and Arslanagic-Kalajdzic (2019), Rialti, Zollo, Ferraris, and Alon (2019), and Li, Wang, Li, and Liao (2021b), have used such an estimator to test their theoretical models.

Table 3 presents the results for the models with digitalization as the independent variable, knowledge inertia, cross-functional interfaces, and connectedness as the moderating variables, and firm performance as the dependent variable. Model 1 indicates that the relationships between all control variables and firm performance are non-significant. In model 2, although the F-statistic is non-significant, perhaps as a result of interference from the control variables, digitalization ($\beta = 0.217, p < 0.01$) still has a positive relationship with firm performance. In addition, when we remove all the control variables, the F-statistic increases to 9.408 ($p < 0.01$). Given that the relationship between digitalization and firm performance is significant even after removing the control variables ($\beta = 0.205, p < 0.01$), we argue that hypothesis 1 is supported.

Model 3 in Table 3 reports the results of the moderation analysis. As expected, the two-way interaction effect of digitalization × knowledge inertia ($\beta = -0.195, p < 0.001$) shows a negatively significant relationship with firm performance. To make comprehension easier, we visualize this moderating relationship in Fig. 2. As depicted in Fig. 2, when the knowledge inertia of a firm is low, an increase in digitalization can lead to a dramatic improvement in firm performance. In contrast, when the knowledge inertia of a firm is high, an increase in digitalization makes a limited contribution to better performance. These results thereby support hypothesis 2.

Models 4 and 5 show the estimated results of the analysis of moderated moderation. The three-way interaction effect of digitalization × knowledge inertia × cross-functional interfaces ($\beta = 0.120, p < 0.05$) has a significant relationship with firm performance, whereas, surprisingly, the three-way interaction effect of digitalization × knowledge inertia × connectedness ($\beta =$

$0.024, p > 0.10$) has a non-significant relationship with firm performance. Hence, these results support hypothesis 3a but reject hypothesis 3b.

To further understand the three-way interaction effect of digitalization × knowledge inertia × cross-functional interfaces, we first test for a conditional interaction effect at different values of cross-functional interfaces. As shown in Table 4, with an increase in cross-functional interfaces, the negative moderating effect of digitalization × knowledge inertia decreases. We visualize this three-way interaction in Fig. 3. It can be seen that when cross-functional interfaces are low, as the degree of digitalization increases, the performance gap between firms with high knowledge inertia and those with low knowledge inertia becomes larger. However, when cross-functional interfaces are high, although there is still a performance gap between firms with high knowledge inertia and those with low knowledge inertia, it is much smaller than in the case of low cross-functional interfaces.

Overall, as Table 5 indicates, most hypotheses are supported.

Please insert Table 3 here.

Please insert Table 4 here.

Please insert Table 5 here.

Please insert Fig. 2 here.

Please insert Fig. 3 here.

5. Discussion

Because of the inconsistent reported findings on the association between digitalization and performance (Kohtamäki et al., 2020; Papadopoulos, Gunasekaran, Dubey, & Wamba, 2017;

Papadopoulos, Singh, Spanaki, Gunasekaran, & Dubey, 2022), we investigate which factors affect the relationship between the two from a knowledge management perspective. We address two research questions: (1) How does knowledge inertia affect the relationship between digitalization and firm performance? (2) Which type of organizational integration mechanisms formal or informal, has the greater influence on the combined effect of knowledge inertia and digitalization on firm performance? From our analysis of 192 Chinese manufacturing firms, some important findings emerge.

First, similar to most previous studies (Abou-foul et al., 2021; De Luca, Herhausen, Troilo, & Rossi, 2021), we find that a higher degree of digitalization is likely to generate superior performance by the firm. This may be because digitalization promotes knowledge exchange and new knowledge creation at the intra- and inter-firm levels. Indeed, Imran, Iqbal, Aslam, and Fatima (2019) find that the application of social media first enhances employee communication and relationships, then advances knowledge exchange by encouraging knowledge sharing and transfer. Schniederjans et al. (2020) also suggest that to improve the efficiency of communication and knowledge exchange throughout the supply chain, firms should gather and disseminate data through digital technologies like cloud computing and the Internet of Things. Overall, our findings support the inferences drawn from previous studies in different scenarios.

Second, we find that the positive effect of digitalization on firm performance is determined by the firm's level of knowledge inertia. Although past studies have not directly examined this link, they do provide some indirect support. In particular, through an investigation of 485 companies in Taiwan, Liao et al. (2008) find that learning inertia (one type of knowledge inertia) is

negatively correlated with organizational learning and organizational innovation. Moreover, based on data from 145 Chinese manufacturing firms, Yu et al. (2020) reveal that firms with a higher level of knowledge inertia are less interested in discovering innovative ways for diverse participants to communicate economically. In the context of big data analytics, Mikalef et al. (2021) interview representatives of 27 European firms and assert that socio-cognitive inertia hampers the formation of a firm's dynamic capabilities, which leads to poor firm performance. These observations indicate that firms with high levels of knowledge inertia may not be inclined to change and innovate. Whilst digitalization brings many opportunities to firms, it also exposes them to risks, such as data leakage and loss of capacity (Ralston & Blackhurst, 2020). Moreover, the managerial insights that digitalization brings may not always be right (Cohen, 2018). For these reasons, firms with high levels of knowledge inertia may rely more on existing knowledge to solve problems in the business process instead of exploring potential digital solutions, and this may explain the negative moderating effect of knowledge inertia on the association between digitalization and performance.

Third, with respect to the significant three-way interaction effect of digitalization × knowledge inertia × cross-functional interfaces, we can also obtain some enlightenment from past research. Specifically, through a longitudinal survey of 230 companies, Jansen et al. (2009) find that the structural differentiation of departments in an organization can positively enhance exploratory and exploitative innovation through the mediation effect of formal organizational integration mechanisms (i.e., cross-functional interfaces), rather than through informal organizational integration mechanisms (i.e., connectedness). Jansen et al. (2009) attribute the

difference in the effectiveness of the two different types of organizational integration mechanisms to the fact that cross-functional interfaces can deepen the flow of knowledge with other departments without interrupting internal communication between departments, whereas establishing and sustaining informal social relations (i.e., connectedness) amongst employees who work in various departments is difficult. Moreover, Bughin, Deakin, and O'Beirne (2019) argue that to generate better digitalization outcomes, firms should empower employees. Compared with connectedness, which fails to provide employees with new functions, cross-functional interfaces offer employees new working environments and conditions, thereby helping to inspire new knowledge (Wendelken, Danzinger, Rau, & Moeslein, 2014). We can therefore infer that cross-functional interfaces are likely to promote knowledge exchange and the creation of new knowledge within an organization, whereas connectedness is less likely to do so, if only because it is more difficult for the firm to establish. Given that one of the main causes of knowledge inertia is a lack of new knowledge input, cross-functional interfaces, rather than connectedness, can weaken the negative moderation effect of knowledge inertia on the association between digitalization and performance.

5.1 Theoretical implications

Our study makes theoretical contributions in the following three respects. First, we expand the scope of previous research related to digitalization to the perspective of knowledge management, which helps to better understand the role of digitalization in a firm. In particular, previous studies generally used dynamic capability theory to investigate the influence of digitalization or of some specific digital technologies (e.g., big data analytics, cloud computing, blockchain, and Internet

of Things) on firm performance (Côrte-Real, Ruivo, & Oliveira, 2020; Ivanov, Dolgui, & Sokolov, 2019; Loukis, Janssen, & Mintchev, 2019; Mikalef, Boura, Lekakos, & Krogstie, 2018). Although we do not deny that digitalization or the use of some digital technologies can greatly help firms improve their dynamic capabilities, the prerequisite for this to happen is that the individuals in the organization are able to fully understand and apply these emerging technologies. Moreover, in the digital era, as the amount of data grows, understanding how to acquire, share, and create knowledge becomes crucial. Because knowledge management involves the processing and transformation of large amounts of data into new knowledge, investigating the role of digitalization in a firm from a knowledge management perspective can provide deeper insights.

Second, we address the controversy over the effects of digitalization on firm performance from the perspective of knowledge inertia. Whilst most studies have found that firms that have implemented digitalization have performed better than those that have not (Eller, Alford, Kallmünzer, & Peters, 2020; Ferreira, Fernandes, & Ferreira, 2019; Martínez-Caro, Cegarra-Navarro, & Alfonso-Ruiz, 2020; Remko, 2020; Wamba & Akter, 2019; Zhou, Liu, Chang, & Wang, 2021), in the real world, fewer than one-third of global businesses have effectively enhanced and sustained their performance through digitalization (McKinsey, 2018). Kohtamäki et al. (2020) attribute this puzzle to the lack of servitization support; that is, they state that the effect of digitalization on firm performance relies on the degree of servitization. Unlike Kohtamäki et al. (2020), we study these effects from a knowledge inertia perspective and empirically explain the digitalization puzzle by showing that knowledge inertia weakens the

association between digitalization and performance. Hence, the findings of this paper provide a new explanation for the complicated link between digitalization and firm performance.

Third, we provide a new understanding of the relative influence of formal and informal organizational integration mechanisms on the outcome of digitalization. Past studies have focused on the role of organizational integration mechanisms in increasing innovation (Blindenbach-Driessen, 2015; Jansen et al., 2009; Love & Roper, 2009). However, remote communication across geographies and time zones is no longer an issue thanks to digital technologies, which also make formal and informal organizational integration mechanisms more convenient and simpler to implement. Accordingly, in the context of digitalization, it is critical to assess the impacts of different forms of organizational integration mechanisms on businesses. Considering that organizational integration mechanisms aim to promote knowledge sharing and exchange within an organization, which can greatly help the firm to overcome knowledge inertia, we mainly operationalize formal and informal organization integration mechanisms as secondary moderators. Overall, by revealing the distinct secondary moderating effects of formal and informal organization integration mechanisms on the association between digitalization and performance, our findings not only expand the scope of research on organizational integration mechanisms but also provide another explanation for the digitalization puzzle.

5.2 Managerial implications

We also provide some managerial implications for firms on how to achieve success in the digital era. First, we find that digitalization has a positive relationship with firm performance in most cases. Accordingly, to improve their performance, firms should implement true digitalization, not

just informatization and networking. We suggest that firms divide their digitalization processes into the following four steps. The first is an electronic business operation, that is, transforming routine manual and arduous tasks into machine tasks to increase work efficiency. The second step is business process informatization, that is, through management reorganization and management innovation, combined with the advantages of information technologies to solidify business processes to improve the efficiency of the entire organization. The third step is the digitalization of business and management, that is, through the application of digital technologies, the integration of procurement, production, marketing, financial, and human resources to improve planning, coordination, supervision, and control, thereby breaking the "information island". Moreover, firms should use descriptive, predictive, and declarative analysis to analyze available data for insights, patterns, and anomalies. The last step is smart business decision-making, that is, firms can intelligently create and mine new knowledge with the help of digital technologies, and use this new knowledge for business decision-making and daily management, thereby forming self-organizing, self-learning, and self-evolving organizations.

Second, considering that the effect of digitalization on firm performance is diminished by knowledge inertia, firms should seek ways to reduce the latter. According to our study, a formal organizational integration mechanism (i.e., cross-functional interfaces) is an effective solution. To this end, firms should actively promote knowledge exchange between different departments through liaison personnel, cross-functional teams, and task forces. In fact, knowledge inertia may not be reduced through dissemination, but communication and sharing can increase the collective wisdom of the entire firm. If only the growth of personal knowledge is emphasized, the overall

competitive advantage of the firm cannot be maximized and the tacit knowledge in the minds of the organizational members cannot be converted into the knowledge assets of the firm. Conversely, emphasizing collaboration between members of the organization and realizing the sharing and flow of knowledge between them can quickly increase the total knowledge and collective wisdom of the firm, thereby enhancing its competitiveness. Finally, firms should note that a formal organizational integration mechanism is difficult to implement if there is no open and transparent firm culture and without the full support of senior leaders. Hence, having intelligent and imaginative senior leaders in an organization may go a long way toward decreasing knowledge inertia. Additionally, firms should be committed to addressing some of the challenges involved with implementing formal organizational integration mechanisms, such as increasing the efficiency of cross-functional communication and clarifying the job responsibilities of cross-functional personnel.

6. Conclusions

Existing research and empirical evidence on the relationship between digitalization and firm performance have yielded conflicting results. To unravel this puzzle, we develop a moderated moderation model from the perspective of knowledge management. Through the analysis of 192 Chinese manufacturing firms, we demonstrate that whilst digitalization has a positive link with firm performance, this link is negatively moderated by knowledge inertia. Furthermore, we show that cross-functional interfaces, which represent a formal organizational integration mechanism, can mitigate the negative moderator effect of knowledge inertia. In contrast, connectedness, which represents an informal organizational integration mechanism, does not show such an effect.

Overall, we contribute to the digitalization literature by articulating the roles of knowledge inertia and organizational integration in influencing the relationship between digitalization and firm performance. Our study thus provides insights for firms to prosper in the digital era.

Despite the major contributions, three aspects of the study warrant further research. First, although we show the positive effect of digitalization on firm performance from the perspective of knowledge management, we do not rigorously demonstrate the mediation mechanisms. Hence, future research can incorporate some variables related to knowledge management as mediating variables in the model to verify our arguments. Second, our data are sourced from China, and, thus, the generalizability of our findings may be limited in a geographical sense. Future work in other nations or developed economies would allow cross-cultural comparisons and test the generalizability of our findings (Ferraris, Giudice, Grandhi, & Cillo, 2019). Third, our study takes an intra-organizational perspective to explain the puzzle over the relationship between digitalization and firm performance, and it would be of interest for future research to explore this puzzle from an inter-organizational perspective.

CRediT authorship contribution statement

Lixu Li: Writing-original draft, Methodology, Formal analysis, Writing-review & editing. **Fei Ye:** Project administration, Conceptualization, Methodology, Writing-review & editing. **Yuanzhu Zhan:** Supervision, Writing-review & editing. **Ajay Kumar:** Supervision, Writing-review & editing. **Francesco Schiavone:** Supervision, Writing-review & editing. **Yina Li:** Supervision, Writing-review & editing.

Declaration of Competing Interest

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.

Appendix A

Please insert Fig. A1 here.

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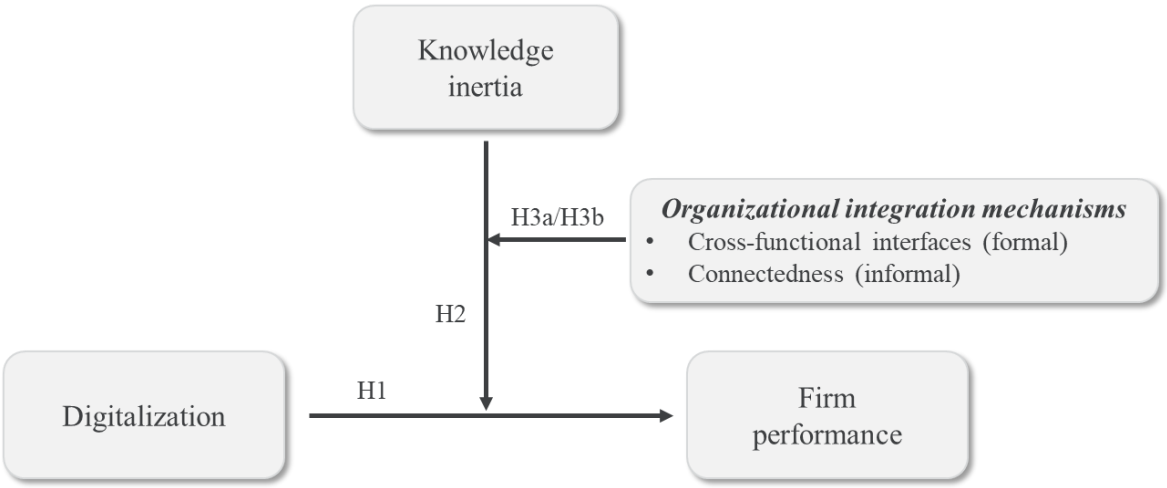

Fig. 1. Research framework

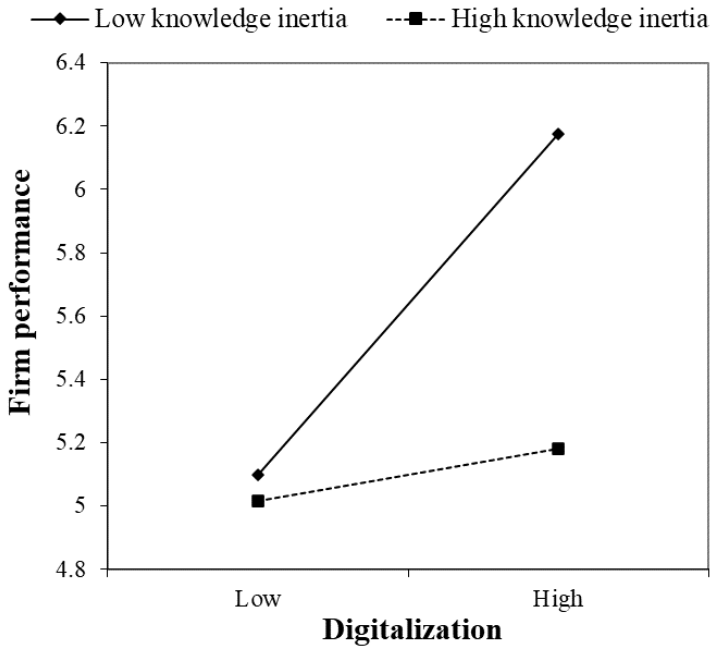

Fig. 2. Two-way interaction effect

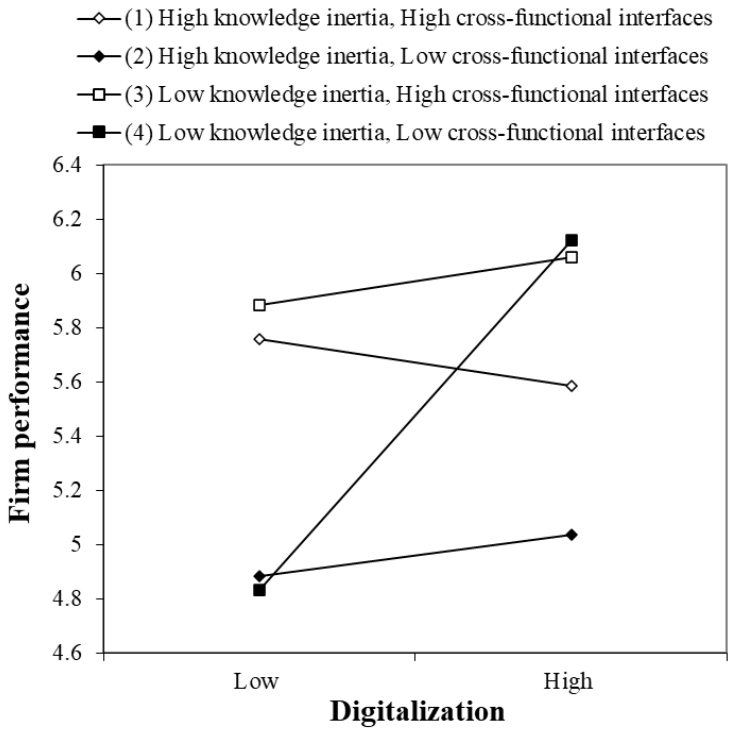

Fig. 3. Three-way interaction effects

Digitalization (Abou-Foul et al., 2021)	We use digital technologies to understand our customers better. We use digital technologies to make better operational decisions. We use digital technologies to increase the added-value of our existing products and services. We use digital technologies to launch new business models.
Knowledge inertia (Fu et al., 2021)	During the daily operations, we do not actively seek new knowledge to solve problems. During the daily operations, we are used to taking knowledge from the same source. During the daily operations, we rely on past knowledge and experience. During the daily operations, we are discouraged from trying new ideas and trading methods. During the daily operations, we don't use new methods to solve problems.
Cross-functional interfaces (Jansen et al., 2009)	Employees are regularly rotated between jobs in our organization. There is regular talk about possibilities for collaboration between units. Our organization coordinates information sharing between units through a knowledge network. We have cross-functional teams to exchange knowledge between departments. Our organization uses temporary workgroups for collaboration between units on a regular basis.
Connectedness (Jansen et al., 2009)	In our organization, there is ample opportunity for informal "hall talk" among employees. In our organization, employees from different departments feel comfortable calling each other when the need arises. People around here are quite accessible to each other. In this organization, it is easy to talk with virtually anyone you need to, regardless of rank or position.
Firm performance (Vickery et al., 2003)	My organization's growth in sales is better compared to major competitors. My organization's growth in profit is better compared to major competitors. My organization's growth in ROI is better compared to major competitors. My organization's growth in return on sales is better compared to major competitors.

Fig. A1. Measurement items

Table 1. Characteristics of the sample firms (N = 192)

	Frequency	Percentage
Years established (as of 2021)		
<10	22	11.46%
10-19	83	43.23%
20-29	67	34.90%
>30	20	10.42%
Number of employees		
<100	15	7.81%
100–199	22	11.46%
200–499	50	26.04%
500–999	46	23.96%
1000–4999	47	24.48%
>5000	12	6.25%
Ownership		
State-owned	34	17.71%
Collective-owned	10	5.21%
Privately owned	134	69.79%
Foreign	14	7.29%
Manufacturing sector		
Automobile	11	5.73%
Chemical	18	9.38%
Electronics	37	19.27%
Food	15	7.81%
Machinery	52	27.08%
Pharmaceutical	14	7.29%
Steel	15	7.81%
Textile	19	9.90%
Others	11	5.73%

Table 2. Correlation matrix and discriminant validity

	1	2	3	4	5
1. Digitalization	**0.787**				
2. Knowledge inertia	-0.426**	**0.888**			
3. Cross-functional interfaces	0.325**	-0.282**	**0.718**		
4. Connectedness	0.296**	-0.295**	0.455**	**0.730**	
5. Firm performance	0.217**	-0.353**	0.584**	0.378**	**0.752**
6. Marker variable	0.055	-0.081	0.059	-0.070	0.018

Notes: ** $p < 0.01$; the square roots of AVEs are in the diagonal.

Table 3. Estimated results

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	5.480***	4.079***	0.836	-19.257*	1.360
Control variables					
Firm age	0.002	-0.001	-0.002	0.002	-0.002
Firm size	0.033	0.062	0.071↑	0.066↑	0.094*
Ownership:					
State-owned	-0.058	-0.008	-0.177	-0.236	-0.362
Privately owned	0.046	0.079	-0.056	-0.034	-0.126
Foreign	-0.059	-0.029	-0.029	-0.049	-0.158
Manufacturing sector:					
Machinery	-0.063	-0.061	-0.139	-0.244	-0.133
Electronics	-0.422	-0.340	-0.310	-0.338↑	-0.393↑
Pharmaceutical	-0.177	-0.172	-0.196	-0.217	-0.182
Steel	-0.385	-0.392	-0.349	-0.379	-0.201
Food	0.194	0.225	0.310	0.129	0.365
Chemical	-0.283	-0.283	-0.291	-0.345	-0.206
Textile	-0.063	0.017	-0.133	-0.123	-0.036
Automobile	-0.363	-0.441	-0.346	-0.416	-0.241
Moderating variables					
Knowledge inertia (KI)			0.940***	4.388*	1.178
Cross-functional interfaces (CFI)				3.831**	
Connectedness (CON)					0.046
Direct effect					
Digitalization		0.217**	0.864***	4.051**	0.660
Interaction effects					
Digitalization×KI			-0.195***	-0.835*	-0.298↑
Digitalization×CFI				-0.610**	
KI×CFI				-0.641↑	
Digitalization×KI×CFI				0.120*	
Digitalization×CON					0.009
KI×CON					-0.068
Digitalization×KI×CON					0.024
Degrees of Freedom	13,178	14,177	16,175	20,171	20,171
R^2	0.059	0.107	0.364	0.514	0.433
F value	0.853	1.508	6.252***	9.036***	6.536***
N (sample size)	192	192	192	192	192

Note: ***, **, *, and ↑ represent significance at the 0.001, 0.01, 0.05, and 0.1 levels, respectively.

Table 4 Test for conditional interaction at different values of cross-functional interfaces

Cross-functional interfaces	Effect (Digitalization * Knowledge inertia)	F	df1	df2	P
4.924	-0.247	10.345	1	171	0.002
5.625	-0.163	15.543	1	171	0.000
6.326	-0.079	6.729	1	171	0.010

Note: the selected values of the cross-functional interfaces are the mean and +/- one standard deviation from the mean.

Table 5 Summary of hypotheses

Hypotheses	**Results**
Hypothesis 1: Digitalization has a positive relationship with firm performance.	supported
Hypothesis 2: Knowledge inertia negatively moderates the relationship between digitalization and firm performance.	supported
Hypothesis 3a: The stronger the firm's cross-functional interfaces are, the weaker will be the negative moderation effect of knowledge inertia on the association between digitalization and performance.	supported
Hypothesis 3b: The stronger the firm's connectedness is, the weaker will be the negative moderation effect of knowledge inertia on the association between digitalization and performance.	rejected

Table A1. Results of confirmatory factor analysis

Items	Mean	Standard deviation	Standardized loadings	CR	AVE	Cronbach's α
DIG1	5.870	0.943	0.823	0.867	0.620	0.865
DIG2	5.760	1.076	0.764			
DIG3	5.750	0.987	0.747			
DIG4	5.839	0.938	0.814			
KI1	2.417	1.522	0.883	0.949	0.788	0.949
KI2	2.552	1.614	0.892			
KI3	2.380	1.485	0.876			
KI4	2.583	1.495	0.900			
KI5	2.661	1.557	0.886			
CFI1	5.427	0.929	0.731	0.842	0.515	0.841
CFI2	5.703	0.892	0.702			
CFI3	5.797	0.803	0.722			
CFI4	5.667	0.956	0.701			
CFI5	5.531	0.897	0.733			
CON1	5.323	0.954	0.705	0.820	0.533	0.818
CON2	5.708	0.959	0.714			
CON3	5.646	0.949	0.711			
CON4	5.479	1.130	0.786			
FP1	5.578	0.935	0.742	0.839	0.565	0.837
FP2	5.406	0.977	0.736			
FP3	5.490	1.018	0.749			
FP4	5.573	0.901	0.780			

Note: DIG, KI, CFI, CON, and FP are the abbreviations of digitalization, knowledge inertia, cross-functional interfaces, connectedness, and firm performance, respectively.