The Impact of Digital Transformation on Enterprise Innovation Performance

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Abstract. As globalization becomes more and more obvious, digital transformation has become a necessity for business growth. Innovation, as the core driving force for sustainable development, is always pursued by enterprises. However, the way digital transformation drives innovation in firms is still a subject of scholarly disagreement. As scholars' understanding of digital transformation in academia was deepened and the measurement methods are similar, this paper will summarize the influence relationships of linear influence and inverted U-shaped influence in the current academia and outline the mediating and moderating roles affecting the two relationships. A well-calibrated degree of digitalization may contribute to improved innovation performance within enterprises. However, if the organization's collaborative management capacity fails to align with the degree of digital advancement, it may lead to adverse effects. In addition, the internal characteristics and the external environment of enterprises, as well as macro policies, will also moderate the relationship. In future studies in this area, it is necessary to be wary of incomplete and unrepresentative descriptions in the data construction process.

1 Introduction

Over the past few decades, advancements in transportation and information technologies—including widespread internet access, logistics innovations, and the rise of cloud computing—have significantly enhanced the global movement of goods and services, making globalization an increasingly prominent phenomenon. This has led to the fact that when facing increasingly fierce market competition, enterprises must efficiently use existing resources and technologies to integrate data to reduce costs and improve production efficiency.

To integrate resources efficiently and face global competition, companies are placing more importance on digital transformation and see it as a necessary path for future development. At the same time, innovation is the core element for enterprises to stand out in digital competition and is increasingly valued by business research [1]. In the process of digital transformation, enterprises will also encounter various problems, such as changes in organizational structure and adjustments in production methods, which will directly affect the innovation results of enterprises, that is, the measurement of the results achieved by enterprises in innovation activities, also known as innovation performance.While existing

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studies predominantly focus on how digital transformation is implemented in enterprise management practices, the academic discourse remains divided regarding its impact on corporate innovation performance. Some researchers argue that leveraging Internet technologies within business operations can substantially foster technological advancement. In contrast, some researchers argue that as the degree of informatization advances, innovation efficiency initially rises but subsequently declines, forming a nonlinear pattern—specifically, a non-linear (inverted U-shaped) relationship has been identified between enterprise digitalization efforts and their innovation outcomes. Therefore, a systematic review of this topic is particularly urgent.

This paper aims to systematically sort out the classification of different conclusions of existing research on this topic, investigate the mechanisms through which digital transformation influences enterprise innovation performance, and examine the influencing factors and moderating relationships from multiple perspectives. A horizontal comparison of relevant studies reveals that resource organization capability serves as a mediating factor in the relationship between digital transformation and enterprise innovation performance. While the external policy environment, internal enterprise characteristics and its organizational characteristics will also play a regulatory role in the relationship between the two. However, when the company's organizational capabilities do not match its digital investment, the company's excessive investment will lead to negative effects.

2 Definition of digital transformation

At present, there is no unified definition of digitalization in academia. According to VALENDUC, digitalization refers to the extensive integration of digital tools, information infrastructures, and online platforms across multiple domains of societal development, driving significant changes in both social structures and economic systems [2]. Contrasting with macro-level analyses, LEGNER takes a micro-level perspective, proposing that digitalization involves complex and interconnected socio-technical dynamics grounded in digital tools, which operate across individual, organizational, and societal domains. He further highlights that firms implement this transformation by leveraging IT solutions to refine and adjust their current business operations, thereby improving their responsiveness and operational performance [3]. Meanwhile, RITTER and PEDERSEN emphasize that digitalization involves firms employing digital technologies to reshape how they engage with other businesses, interact with market structures, and connect with customers [4]. This transformation redefines traditional communication channels and transactional patterns, fostering new modes of value creation. The three have given definitions of digitalization from macro to micro.

Based on different understandings of digitalization, scholars have even more different understandings of digital transformation. Schallmo, Williams, Boardman, and Verhoef et al. suggest that digital transformation leverages technological tools to process and structure enterprise data, converting it into actionable insights that contribute to organizational value creation. This serves as a foundation for evaluation and decision-making, while also facilitating the development of innovative digital business models that contribute to value creation, performance improvement, and greater market impact [5,6]. Some researchers further argue that digital transformation goes beyond simply adopting advanced technologies, emphasizing instead the importance of organizational change, strategic alignment, and capability development. It also includes increasing risk appetite, investing in digital opportunities for employees, and simplifying organizational structures to achieve agility, so that organizations are consistent with the requirements of the digital environment [7]. It is not difficult to see that the academic community's understanding of digitalization has gradually shifted from the simple application of technical tools to the "co-evolution" of

technology and organization. That is, when carrying out technological reforms, enterprises also need to adjust their organizational structures to adapt to the needs of digital development, which emphasizes the complexity of the management level. Meanwhile, the focus of digital transformation has progressively shifted away from merely upgrading technological tools within firms to the process of enterprises in various industries or even across industries using digital tools to integrate business processes and build digital platforms. In other words, digital technology has gradually evolved from "new tools" to "basic measures" to promote technology integration between industries, making enterprise operations more efficient and more able to detect market changes quickly. At the same time, changes in enterprise organizations also make internal communication and collaboration smoother, and employees' innovation potential is more easily stimulated, allowing enterprises to adapt to changes more quickly. In conclusion, digital transformation fundamentally involves leveraging technological capabilities to drive comprehensive changes that foster innovation within enterprises.

3 The impact of digitalization on corporate innovation performance

Based on the above understanding of digitalization and digital transformation, it also explains the problem that when scholars use different samples to analyze the relationship between them, the conclusions they draw are different due to the different research perspectives they adopt. Zhao and Xu used Chinese enterprises as samples and found that digital transformation has a greater effect on improving the innovation quality of non-state-owned enterprises and enterprises in the eastern region of China [8]. Huang Jiegen et al. used listed company data to find that the digitalization level of enterprises and innovation performance are positively correlated [9]. Shen and Yuan found that enterprises' application of the Internet has a significant promoting effect on technological innovation. At the same time [10]. Yu et al. used enterprise questionnaire survey data to find that there is an inverted U-shaped relationship between the digitalization level and innovation performance [11]. Li et al. also found the same conclusion, further emphasizing that the enterprise's risk-taking level positively regulates how digital transformation affects firms' innovative outcomes [12]. Drawing on empirical data from a broad set of EU-based firms, some researchers argue that digital technologies exert only a marginal effect on innovation outcomes, with R&D investment remaining the most consistent indicator of innovation capability. However, since there are too few papers that have reached this conclusion, this paper will not be considered for the time being. Therefore, based on the different results of the discussion on the relationship between the two in this field, this paper divides the research into two categories and reviews them separately.

3.1 Perspective 1: linear impact

Ferreira et al. studied the data of 938 Portuguese companies. They use binary variables to measure the company's digitalization level and apply the impact of the number of innovative activities on turnover to measure the innovation level. It was later found that digital transformation significantly promoted performance by improving corporate innovation capabilities and optimizing resource allocation. They fully affirmed the necessity of digital transformation. Peng and Tao compared the annual reports of 1,578 listed companies in China from 2012 to 2020 and then extracted the frequency of four key words such as "intelligent manufacturing to construct an information index to measure the degree of digitalization. In addition, invention patent counts were adopted as a proxy measure for

innovation output. After data processing, the studies further revealed the mechanism through which digital transformation promotes innovation—specifically, by reducing costs, enhancing benefits, and improving efficiency, thereby encouraging enterprises to engage in innovation activities. As enterprises deepen their digital transformation and become more proficient in transformation methods, the improvement of corporate performance has become more significant. Subsequently, Li et al. applied a similar analytical approach to examine data from privately listed firms in China over the period 2011–2020. Also, they found the same conclusion that the degree of digital transformation of the enterprise is higher lending to the more invention patents which can also represent as the better the innovation performance. At the same time, this article explores how external factors such as government innovation subsidies and regional environment affect their promotion. The innovation lies in using these external factors as moderating variables and explaining the promotion of the positive impact of external factors on both from a macro perspective.

It can be found that Ferreira et al. emphasize leadership behavior and internal resource integration from the perspective of internal corporate behavior, especially from the perspective of corporate managers, such as whether to actively embrace digitalization and whether to promote process reengineering. Peng and Tao's research focuses on how enterprises complete digital transformation through the path of capability building. They explore how digitalization can enhance innovation from the perspective of organizational capability evolution and mechanism design. Li Chen et al. are more concerned with the impact of policy incentives and macro institutional arrangements on corporate behavior and performance. They are from "internal behavior of enterprises" to "capability building mechanism" and then to "policy and institutional arrangements", that is, from micro to macro, from internal to external. And they show a progressive relationship and are complementary to each other.

3.2 Perspective 2: an inverted U-shaped relationship

Yu Feifei et al. utilized questionnaire data from 283 Chinese firms to validate the non-linear association and further investigated the underlying moderating mechanisms influencing this dynamic.: in the early stage of digitalization, performance is improved through value chain and process optimization, while excessive digitalization leads to resource mismatch and increased coordination costs. The author also added organizational flexibility as a moderating variable in the study to explore whether companies with the ability to integrate internal and external resources and adjust strategies promptly to adapt to environmental changes can better cope with the negative effects of digital transformation. Finally, the study concludes that organizational flexibility strengthens the positive impact of digitalization on innovation during its growth stage, while mitigating negative effects in later stages, thereby exerting a dual influence on innovation performance. Guo and colleagues selected data from Chinese A-share listed firms spanning the years 2013 to 2020 as their research sample, conducting a detailed analysis of the outcomes. Their findings indicate that digital transformation plays a significant role in boosting total factor productivity (TFP).However, when the degree of digitalization is either insufficient or excessive, it leads to higher operating costs, lower total asset turnover, and decreased management efficiency, ultimately exerting a negative impact on corporate performance (ROA/ROE)—a phenomenon referred to as the "digital paradox." The study further underscores how managerial decision-making acts as a moderating factor, revealing that short-term thinking among executives can intensify the adverse effects that digital transformation may have on a company's performance. Drawing on data from publicly traded firms in Shanghai and Shenzhen's electronic equipment manufacturing sector spanning 2007 to 2020, Li et al. conducted a corresponding analysis believed that in the early stage of digital transformation, innovation performance (such as the number of patents)

improved through technology integration, but after exceeding the threshold, performance was suppressed due to organizational inertia [12]. By defining the risk-bearing capacity of enterprises, it was found that the impact of digitalization on innovation was stronger in enterprises with high risk-bearing capacity. This was reflected in the early stage of digital transformation. Enterprises with high risk-bearing capacity were more likely to achieve better innovation performance, but at the same time, the negative impact brought about by their falling into the "digital paradox" was more significant.

It is noted that all three studies focus on Chinese firms as research subjects and adopt longitudinal analysis to investigate the underlying mechanism of the non-linear (inverted U-shaped) linkage between digitalization efforts and firms' innovation outcomes. All studies acknowledge that enterprise digitalization can effectively enhance innovation by streamlining value creation processes and boosting the efficiency of technological integration. Nevertheless, they also point out that an overemphasis on digitalization may result in issues such as resource misallocation and inflexible management structures. The root cause of these problems is that the organizational management capabilities within the enterprise have failed to keep up with the digitalization process. So they cannot meet the demand for efficient data processing capabilities after the digitalization level is improved, that is, the enterprise is "over-digitalized". At the same time, managers with management myopia are more likely to maximize short-term results and make large digital investments in the short term. In this way, it can make it easier for enterprises to have problems with digitalization and management organization mismatch. Under the requirement of high efficiency, enterprises are more likely to blindly apply technology. Therefore, after the blind increase of digital investment, the high requirements of management are also likely to cause more problems. Moreover, due to organizational inertia, decision-makers tend to draw upon past success-based insights when responding to present-day problems, which may ultimately restrict a firm's ability to innovate. All three studies emphasize the moderating role of internal organizational factors (management capabilities, risk-taking, and enterprise flexibility) on it. Therefore, the critical factor underlying the inverted U-shaped pattern is the suitability of the transformation process itself. Enterprises must find a proper balance between digital investment and managerial capacity—such as risk appetite and structural adaptability—to prevent the emergence of a “digital paradox.”

4 Conclusion

Based on existing papers, this study reviews the relationship between them two and the mediating and moderating factors. As many firms remain in the initial to intermediate phases of digitalization, their innovation performance is noticeably enhanced, largely because their managerial and organizational strengths are well aligned with the current level of technological transformation. However, how digital transformation affects firms' innovative outcomes is not single, but a dynamic, multidimensional and complex system shaped by differences in internal capabilities, regional environments, firm characteristics and transformation stages. The positive effect relies on a healthy match between resource organization and capabilities and the external environment, which requires enterprises to improve the degree of digitization while improving the firm's managerial and organizational capabilities to make them match. The inverted U-shaped paradox refers to that companies' over-investment in digitalization can cause adverse financial outcomes or reduced gains from over-investment and managers' decision-making errors. In other words, as digital transformation continues to deepen, the investment in people will also increase as an additional demand, but the company's management capabilities cannot match the powerful digital technology. Excessive technological disparities and capability gaps will lead to digitization's inhibitory effect on innovation performance.

In existing research, firms' digitalization levels are primarily measured using continuous variables. Specifically, researchers evaluate the extent of digital transformation by analyzing how often digitalization-related language appears in corporate annual disclosures. Meanwhile, patent application counts are commonly employed as a proxy for measuring innovation output. Such methods, with high subjectivity in measuring digitization level, possibly ignore words that actually reflect digitization level, and are susceptible to subjective manipulation by companies. Moreover, the number of patents couldn't reflect the quality and value of patents, nor could it fully represent innovation performance. In addition, the sample type of the existing literature was insufficient, including only the data of manufacturing industry and some listed companies, and lacking data of some SMEs and different industries other than manufacturing, especially SMEs that were more likely to face more significant transformation thresholds due to a lack of resources. As a result, it was unable to comprehensively analyse the interplay between the two, which may lead to differences in the impact relationship due to the different industries or sizes of the companies. In the future, the research data can be further expanded, and better measurement methods can be proposed.

References

1. M. Baker, J. Wurgler, Investor sentiment and the cross-section of stock returns. J. Finance **61**, 1645-1680 (2006)
2. S.Y. Stander, A news sentiment index to inform international financial reporting standard 9 impairments. J. Risk Financ. Manag. **17**, 282 (2024)
3. A. Atak, Beyond polarity: How ESG sentiment influences idiosyncratic volatility in the Turkish stock market. Borsa Istanbul Rev. (2024)
4. V. Baklanova, A. Kurkin, T. Teplova, Investor sentiment and the NFT hype index: to buy or not to buy?. China Financ. Rev. Int. **14**, 522-548 (2024)
5. J. Deveikyte et al, A sentiment analysis approach to the prediction of market volatility. Front. Artif. Intell. **5**, 836809 (2022)
6. N. Pillada, S. Rangasamy, An empirical investigation of investor sentiment and volatility of realty sector market in India: an application of the DCC-GARCH model. SN Bus. Econ. **3**, 55 (2023)
7. T.T. Thanh, Measuring dynamic interlinkages between energy uncertainty, investor sentiment and financial market volatility: Fresh insights from the R^2 decomposed linkage method. Energy Rep. **13**, 363-377 (2025)
8. D. Anastasiou, A. Ballis, K. Drakos, Constructing a positive sentiment index for COVID-19: Evidence from G20 stock markets. Int. Rev. Financ. Anal. **81**, 102111 (2022)
9. S. Kogan, D. Levin, B.R. Routledge, J.S. Sagi, N.A. Smith, Predicting risk from financial reports with regression. Proc. Hum. Lang. Technol. Conf. North Am. Chapter Assoc. Comput. Linguist. 272-280 (2009)
10. H. Ph, A. Rishad, An empirical examination of investor sentiment and stock market volatility: evidence from India. Financ. Innov. **6**, 34 (2020)
11. X. Gong et al, Investor sentiment and stock volatility: New evidence. Int. Rev. Financ. Anal. **80**, 102028 (2022)
12. L.H. Pedersen, S. Fitzgibbons, L. Pomorski, Responsible investing: The ESG-efficient frontier. J. Financ. Econ. **142**, 572-597 (2021)