Digital Transformation and Enterprise Technology Innovation

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Abstract—The 14th Five-Year Plan clearly points out the importance of accelerating China's digital development, and the economic consequences of digital transformation have gradually become the focus of academic attention, whether this can improve the level of technological innovation in enterprises? This paper empirically examines the impact of digital transformation on enterprise technological innovation and its mechanism from the perspective of enterprises, using data of all A-share listed enterprises in manufacturing industry from 2010 to 2020. It is found that digital transformation significantly enhances the technological innovation level of Chinese manufacturing enterprises, and this finding still holds after a series of robustness and endogeneity tests. The mechanism analysis confirms that digital transformation alleviates the financing constraints of enterprises, which in turn promotes their technological innovation. Further study finds that the more competitive the product market is, the more obvious the promotion effect of digital transformation on enterprise technology innovation is. This paper reveals the mechanism by which digital transformation promotes enterprise technology innovation and extends the research related to digital transformation.

Keywords-digital transformation; financing constraints; enterprise technology innovation;

1. Introduction

In recent years, the rapid development of information technology has brought human society into the digital era, and the continuous emergence of big data, Internet, artificial intelligence and other technologies has promoted the digitalization process of enterprises. Digitalization technology mainly includes big data technology, information technology and Internet technology. The 19th Party Congress report points out the need to promote the deep integration of big data, the Internet, artificial intelligence and the real economy. The China Academy of Information and Communication's "White Paper on the Development of China's Digital Economy in 2021" shows that by the end of 2021, the scale of China's digital economy reached 45.5 trillion yuan, with a nominal growth of 16.2% year-on-year, accounting for 39.8% of GDP, of which the scale of digital industrialization and the scale of industrial digitization were 8.35 trillion yuan and 37.18 trillion yuan respectively, marking that China's digital economy is The digital economy in China is accelerating to take off against the trend, and is changing from quantitative expansion to qualitative improvement. The broad development prospect of digital economy has pointed out the direction for China's enterprises to carry out digital transformation. According to the China Enterprise Digital Transformation Index Report (2021), from 2018 to 2021, the average score of the Digital Transformation Index has increased from 37 to 54, indicating that enterprises in various industries in China are continuously promoting digital transformation.

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The 2022 government work report points out that we should deeply implement the innovation-driven development strategy, strengthen the main position of enterprise innovation, and continuously promote the key core technology research. According to the National Bureau of Statistics, China's innovation index in 2021 was 264.6, of which the innovation input index was 219.0, an increase of 4.4% over the previous year, and the total innovation input ranked second in the world. However, the problem of weak innovation capacity in China's manufacturing industry still exists, and the technological innovation level of enterprises is still low. At present, the digital transformation of enterprises in China mainly refers to the process of using digital technologies such as big data, Internet and artificial intelligence to transform the business model and production process of enterprises, and then optimize their operation methods and finally complete industrial upgrading. [1] Digital transformation is an important support point for China's economic transformation, and exploring the impact of digital transformation on enterprise technological innovation and its mechanism of action can help provide theoretical references for promoting the integration of digital transformation and the real economy.

Several studies have been conducted on the relationship between digital transformation and enterprise technology innovation. Combing the existing literature, it is found that current studies generally focus on the impact of big data, Internet, and information technology on enterprise innovation. J. Jun and C. Xue (2022) [2] pointed out that blockchain technology has characteristics such as traceability and authenticity and transparency, which makes information highly transparent, thus integrating supply chain resources and promoting enterprise innovation. G. Shen, and Z. Yuan (2020) [3] found that the application of Internet technology enables companies to grasp consumer demand in a timely and accurate manner, which reduces the cost of information search and matching, and thus promotes corporate innovation. J. Sun and J. Li (2022) [4] studied that the mining and analysis functions of data using big data technology can optimize enterprise innovation decisions, grasp customer needs, and improve innovation efficiency. Duan et al. (2019) [5] pointed out that artificial intelligence reshapes the innovation model of enterprises by facilitating the absorption of external knowledge and the wide dissemination and sharing of internal knowledge. Han et al. (2014) [6] found that as the level of information technology increases, the efficiency of enterprise innovation increases and then decreases. This paper provides further research on the impact of the degree of digital transformation on corporate technological innovation and explores the mediating role played by financing constraints in the relationship.

The possible marginal contributions of this paper are: First, it confirms whether financing constraints can play a mediating role between digital transformation and technological innovation in manufacturing firms, and further reveals the mechanism of the impact of digital transformation on technological innovation. Second, it expands the research on the relationship between digital transformation, financing constraints and technological innovation of firms, and provides a new research perspective to alleviate the financing constraints on technological innovation of listed manufacturing firms. Third, from the perspective of product market competition, we explore its moderating effect on digital transformation and corporate technological innovation, enriching the research related to digital transformation.

2. Theoretical Analysis and Research Hypotheses

2.1 Digital Transformation and Enterprise Technology Innovation

With the emergence of digital technologies such as Big Data, Internet of Things, Artificial Intelligence, Blockchain, etc. and their application in all aspects of enterprise production management, enterprises have started to pay attention to digital transformation. Digital technology has broken the boundaries of enterprises, and the cross-border integration of enterprises provides more possibilities for innovation activities. This paper argues that the impact of enterprise digital transformation on technological innovation is realized through the following three aspects.

First, digital transformation promotes the participation and collaboration of innovation subjects. The wide application of big data, cloud computing, and artificial intelligence expands the function of cyberspace and networked organization forms, which in turn realize the diversification of innovation subjects and networked innovation organizations and enhance the interaction and collaboration effect of innovation subjects [7]. Based on the innovation ecosystem view, technological innovation in enterprises relies on the multivariate collaboration of different participating subjects within the ecosystem (Ander and Kapoor, 2010) [8]. The openness of digital technologies such as big data and the Internet of Things can continuously input new ideas for enterprises [9], and enterprises can acquire knowledge elements across technological and organizational boundaries [10], and acquire knowledge and information needed for innovation through R&D collaboration [11] to achieve knowledge synergy, thus improving The relevance of digital technology provides enterprises with more channels of communication with the outside world, and the connection between enterprises and consumers is closer. With the help of digital technology to mine and analyze information resources, it helps enterprises enrich the information of consumers' preferences, grasp the changes of consumers' needs in a timely and accurate manner, and invest in R&D in a more targeted manner, and enterprises can even innovate together with consumers [12].

Second, digital transformation changes the organizational structure of enterprises [9]. The application of technologies such as big data and blockchain strengthens data sharing among enterprises and optimizes resource allocation, enterprise departments are more closely connected, organizational structure develops toward flattening, management's authority will tend to be decentralized, and enterprise employees will be given more authority, which not only helps to enhance employees' sense of participation and satisfaction and stimulate their potential innovation potential, but also promotes employees' need for self-actualization and active involvement in This will not only enhance employees' participation and satisfaction and stimulate their potential for innovation, but also promote their need for self-actualization and active participation in the innovation practice of the company.

Finally, digital transformation reduces the cost of innovation. Based on the knowledge base view, knowledge acquisition, application and creation are important drivers of enterprise innovation [13]. It is usually impossible for enterprises to have all the critical knowledge resources they need when conducting innovation activities, and about 1/3 of the new knowledge required for technological innovation needs to be acquired from outside. Digital transformation achieves low-cost penetration of knowledge. For example, using the Internet enterprises can more easily access relevant theories and learning resources and find various scientific research results. Enterprises using digital technology can speed up external knowledge search, save external

knowledge search costs for R&D departments, shorten the R&D process, and improve innovation efficiency. Accordingly, this paper proposes the hypothesis:

H1: Digital transformation promotes enterprise technological innovation.

2.2 Digital Transformation, Financing Constraints and Enterprise Technology Innovation

Financing constraints are a major challenge for companies to undertake technological innovation. Digital transformation can alleviate financing constraints and thus facilitate enterprise technological innovation through the following ways. First, digital transformation enhances the transparency of enterprise information [14]. If enterprises carry out digital transformation, it is inevitable to use a lot of digital technologies such as big data and Internet in the daily production and operation process. Relying on the connection function of the Internet, the communication between internal and external enterprises is more efficient; using the ability of big data to collect and analyze information, enterprises can analyze the relevant situation within the enterprise more quickly and deeply, improve the quality of enterprise information disclosure, enhance Investors' confidence in the enterprise, reduce the expected risk, and thus reduce the financing cost of the enterprise.

Second, digital transformation reduces the agency costs of firms. Agency costs are one of the reasons why financing constraints arise [15]. On the one hand, digitally transformed firms attract analysts' attention [16], which, according to the information revelation hypothesis, can alleviate the agency problem between shareholders and management, curb management's surplus management activities, and thus reduce agency costs and alleviate financing constraints. On the other hand, the increase of analysts' attention increases the external regulatory pressure on firms, and firms will improve the quality of information disclosure accordingly, and high-quality information disclosure reduces agency costs [17], thus alleviating corporate financing constraints.

Finally, the digital transformation of enterprises follows the development trend of the digital economy era, responds to the national guidelines and policies, has great potential for development, and can even effectively improve market expectations, and media news coverage of such enterprises will gradually increase [16]. The increase in media news coverage will also disclose more information about the firm such as financial status and corporate governance to the outside world, thus alleviating the financing dilemma. Accordingly, this paper proposes the hypothesis:

H2: Digital transformation can promote enterprise technological innovation by alleviating financing constraints.

2.3 Digital Transformation, Product Market Competition and Enterprise Technology Innovation

As the main body of the market, the survival and development of enterprises are bound to face the fundamental problem of market competition. The advent of the digital era has changed the competition model of enterprises. Those enterprises that can quickly adapt to the market and environmental changes are able to stand out. On the one hand, digital transformation, as a new driving force to promote enterprise innovation and development, has greatly improved enterprise performance and value, and enterprises in this competitive environment are more willing to undergo digital transformation. On the other hand, the digital economy era has broken down the boundaries of enterprises, and when the competitive market environment in which

enterprises are located is relatively strong, even if they have carried out digital transformation, they still have to face potential entrants from many other enterprises in the industry as well as from outside the industry. Enterprises need to continuously develop new technologies, launch new products, form product differentiation or reduce costs in order to create competitive advantages, and in this case enterprises tend to pay more attention to increasing R&D investment. Accordingly, this paper proposes the hypothesis:

H3: The influence of digital transformation on enterprise technology innovation will be enhanced with the increase of product market competition.

3. Research Design

3.1 Sample Selection and Data Sources

This paper selects the data of all A-share manufacturing listed companies from 2010 to 2020 as the initial research sample and treats the data as follows: first, the data of financial and insurance companies are excluded; second, the sample of companies that are ST,PT during the observation period are excluded; third, the data of sample with incomplete main variables and delisted during the observation period are excluded; fourth, to reduce the influence of outliers, this paper applies 1% and 99% tailoring to all Fourth, to reduce the impact of outliers, all continuous variables at the micro level are subjected to 1% and 99% tailoring. Raw data are obtained from the Cathay Capital database (CSMAR)

3.2 Variable Design

3.2.1 Explained variable: Technology Innovation (RD): The current way to measure the level of technology innovation of enterprises is mainly divided into innovation inputs and innovation outputs. In this paper, we refer to Zhu et al. (2014) [18] and use the ratio of R&D expenditure to operating revenue of enterprises in the current year to measure the technological innovation of enterprises.

3.2.2 Explanatory variable: Digital Transformation (DT): Drawing on Wu et al.(2021) [16] measure of corporate digital transformation indicators, the frequency of specific keywords related to digital transformation such as blockchain technology, artificial intelligence technology, cloud computing technology, big data technology, and digital technology applications published in the annual reports of listed companies are summed and logarithmically processed to measure the degree of digital transformation.

3.2.3 Mediating variable: Financing constraint (FC): Referring to the method of Ju et al. (2013) [19] to measure the financing constraints of firms using SA index.

3.2.4 Moderating variable: Product Market Competition (HHI): Drawing on Yang and Yin (2015) [20], the Herfindahl index (sum of squares of the company's operating revenue/industry's total operating revenue) is used for measurement. The smaller this index is, the more competitive the product market is.

3.2.5 Control variables: Drawing on the study of Qi et al. (2020) [11], this paper selects firm characteristic variables that may affect technological innovation as control variables. Firm characteristics variables: (1) Firm size (Size): the natural logarithm of the firm's total assets at the

end of the period; (2) Gearing ratio (Lev): net profit/net assets; (3) Board independence (Ine): the proportion of the number of independent directors to the total number of board members; (4) Equity concentration Top1 (Top1): the proportion of shares held by the first largest shareholder; (5) Two positions in one (Doal). 1 if the chairman and general manager are both appointed, otherwise 0; (6) Nature of ownership (Soe). 1 if it is a state-owned enterprise, and 0 if it is a non-state-owned enterprise.

3.3 Model Design

In order to test the impact of digital transformation on enterprise technological innovation, a multiple linear regression model (1) is constructed in this paper.

$$RD_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \sum Controls + \sum Year + \varepsilon_{i,t} \quad (1)$$

In order to test the mediating role of financing constraints in digital transformation on enterprise technological innovation, multiple linear regression models (2) and multiple linear regression models (3) are constructed.

$$FC_{i,t} = \beta_0 + \beta_1 DT_{i,t} + \sum Controls + \sum Year + \varepsilon_{i,t} \quad (2)$$

$$RD_{i,t} = \gamma_0 + \gamma_1 DT_{i,t} + \gamma_2 FC_{i,t} + \sum Controls + \sum Year + \varepsilon_{i,t} \quad (3)$$

In order to test the moderating effect of product market competition on digital transformation and firm technological innovation, a multiple linear regression model (4) is constructed.

$$RD_{i,t} = \theta_0 + \theta_1 DT_{i,t} + \theta_2 HHI_{i,t} + \theta_3 DT_{i,t} \times HHI_{i,t} + \sum Controls + \sum Year + \varepsilon_{i,t} \quad (4)$$

4. Analysis of Research Results

4.1 Variable Descriptive Statistics

The results of descriptive statistics are shown in Table 1. The mean value of technological innovation is 5.132, and the minimum and maximum values are 0.09 and 25.92, indicating that there is a relatively large difference in the level of technological innovation of enterprises. The minimum value of digital transformation is 0.693 and the maximum value is 4.736, which indicates that the degree of digital transformation of manufacturing enterprises varies widely. The maximum value of financing constraint is 4.424 and the mean value is 3.787, which indicates that the financing constraint of listed manufacturing companies in China is relatively high. Among the control variables, the mean value of company size is 22.044, the maximum value is 25.659, and the minimum value is 19.940. the average value of liabilities of the sample companies is 38.5% of the company's assets.

Table 1 Descriptive Statistics of Main Variables

Variable	N	mean	sd	median	min	max
RD	8743	5.132	4.142	4.110	0.090	25.920
DT	8743	1.897	1.026	1.792	0.693	4.736
FC	8743	3.787	0.236	3.787	3.229	4.424
HHI	8743	0.071	0.055	0.056	0.015	0.302
Size	8743	22.044	1.158	21.905	19.940	25.659
Lev	8743	0.385	0.189	0.374	0.058	0.903

Variable	N	mean	sd	median	min	max
Top1	8743	33.679	13.986	31.317	8.882	72.718
Ine	8743	37.896	5.591	36.360	33.330	60.000
Soe	8743	0.271	0.413	0	0	1
Doal	8743	0.351	0.477	0	0	1

4.2 Regression Analysis of Digital Transformation and Corporate Technology Innovation

To test the impact of digital transformation on firms' technological innovation, this paper performs a multiple regression on model (1). As shown in Table 2, in column (1), this paper first performs regression analysis without including control variables, and the results show that the regression coefficient of digital transformation is 0.841 and passes the statistical significance test at 1%; Column (2) further includes control variables, and the regression coefficient of digital transformation is 0.833 and significant at the 1% level, indicating that digital transformation and enterprise technological innovation is positively correlated. H1 is verified.

Table 2 The Regression Results of Digital Transformation and Corporate Technology Innovation

Variables	(1)	(2)
	RD	RD
DT	0.841***	0.833***
	(8.63)	(9.23)
Size		-0.506***
		(-5.96)
Lev		-3.591***
		(-6.86)
Top1		-0.031***
		(-5.41)
Ine		0.031**
		(2.09)
Soe		0.420*
		(1.85)
Doal		0.448***
		(2.65)
cons	4.426***	15.487***
	(10.91)	(8.37)
Year	Control	Control
N	8743	8743
R^2	0.053	0.135

a. Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

4.3 Regression Test of the Mediating Effect of Financing Constraints

Table 3 is the regression result of model (2) and (3). The results of testing the channel mechanism of financing constraints are shown in Table 3. Column (1) is the baseline regression of this paper. Column (2) is the regression of financing constraints on digital transformation, and the regression coefficient of digital transformation is -0.01 and significantly negative at the 5% statistical level, indicating that digital transformation alleviates the financing constraints of enterprises. The coefficient of digital transformation is 0.811 and passes the 1% significance test. H2 is verified.

Table 3 The Regression Results of Digital Transformation, Financing Constraints and Corporate Technology Innovation

Variables	(1)	(2)	(3)
	RD	FC	RD
DT	0.833***	-0.010**	0.811***
	(9.23)	(-2.32)	(9.09)
FC			-2.233***
			(-5.89)
Size	-0.506***	0.006	-0.494***
	(-5.96)	(0.88)	(-5.89)
Lev	-3.591***	0.096***	-3.377***
	(-6.86)	(3.51)	(-6.56)
Top1	-0.031***	-0.001***	-0.033***
	(-5.41)	(-2.83)	(-5.77)
Ine	0.031**	-0.002*	0.027*
	(2.09)	(-1.76)	(1.84)
Soe	0.420*	0.088***	0.617***
	(1.85)	(6.59)	(2.71)
Doal	0.448***	-0.030***	0.380**
	(2.65)	(-3.06)	(2.26)
cons	15.487***	3.415***	23.115***
	(8.37)	(24.27)	(10.04)
Year	Control	Control	Control
N	8743	8743	8743
R^2	0.135	0.216	0.148

b. Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

4.4 Regression Test of the Moderating Effect of Product Market Competition

The regression results of the moderating effect of product market competition are shown in Table 4. Column (1) is the baseline regression of this paper. The coefficient between product market competition and digital transformation and enterprise technology innovation in column (2) is -7.267 and passes the 1% significance test, indicating that product market competition has a negative moderating effect on the relationship between digital transformation and enterprise technology innovation. Since product market competition is an inverse indicator, that is, the

smaller the indicator is, the more intense the product market competition is, therefore, the increase of product market competition will significantly enhance the positive impact of digital transformation on enterprise technology innovation, and the more intense the product market competition is, the greater the promotion effect of digital transformation on enterprise technology innovation. H3 is verified.

Table 4 The Regression Results of Product Market Competition

Variables	(1)	(2)
	RD	RD
DT	0.833***	0.714***
	(9.23)	(8.67)
DT×HHI		-7.267***
		(-5.70)
HHI		-13.808***
		(-9.29)
Size	-0.506***	-0.468***
	(-5.96)	(-5.59)
Lev	-3.591***	-3.456***
	(-6.86)	(-6.71)
Top1	-0.031***	-0.025***
	(-5.41)	(-4.58)
Ine	0.031**	0.027*
	(2.09)	(1.90)
Soe	0.420*	0.359
	(1.85)	(1.62)
Doal	0.448***	0.418**
	(2.65)	(2.55)
cons	15.487***	16.074***
	(8.37)	(8.72)
Year	Control	Control
N	8743	8743
R^2	0.135	0.167

c. Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

5. Robustness and Endogeneity Tests

First, the explanatory variables were replaced. Referring to the study by Zhang et al. (2017) [21], the number of patent applications, including utility model patents, invention patents and design patents, were used as proxy indicators of firms' technological innovation, and the regression

results were tested on the original model, as shown in column (1) of Table 5, and the findings remained robust.

Second, the explanatory variables are treated with a lagged first-order treatment. Given that the digital transformation of enterprises will promote technological innovation, and the increase in the level of technological innovation will create more revenue for enterprises and make them have more funds for digital transformation, which may result in reverse causality, therefore, this paper treats the digital transformation of enterprises with a lag of first order, which can attenuate the interference of mutual causality to a certain extent. The regression results are shown in column (2) of Table 5, and the coefficient of DT with one lag is 0.835 and remains significant at the 1% statistical level, and the study findings remain unchanged.

Finally, due to the possible endogeneity problem caused by sample self-selection, PSM test is conducted in this paper. The median value of digital transformation is taken as 1 for firms with digital transformation greater than or equal to the median, and 0 for the opposite. Firm size, gearing ratio, shareholding ratio of the first largest shareholder, board independence, dual-positioning, and nature of ownership are selected as covariates for pro-matching. After the test, it was found that the standard deviations of most of the variables in the experimental and control groups after matching were lower than those before matching, and the absolute values of the standard deviations were less than 10%. Moreover, the results of the t-test showed that there were no significant differences in all characteristic variables after matching. After one-to-one nearest pro matching of the samples, the PSM-treated samples were regressed again, and the results are shown in column (3) of Table 5, where the coefficient of DT is 0.780 and significantly positive at the 1% level, and the study findings remain unchanged.

Table 5 Regression Results of Robustness and Endogeneity Tests

Variables	(1)	(2)	(3)
	RD	RD	RD
DT	0.141***		0.780***
	(2.84)		(8.34)
L.DT		0.835***	
		(7.81)	
Size	0.305***	-0.537***	-0.524***
	(4.46)	(-5.12)	(-5.70)
Lev	-0.410	-3.680***	-3.273***
	(-1.35)	(-5.78)	(-5.98)
TOP1	0.006	-0.031***	-0.030***
	(1.64)	(-4.42)	(-4.94)
Ine	0.004	0.036**	0.018
	(0.49)	(1.98)	(1.16)
Soe	-0.213	0.496*	0.318
	(-1.53)	(1.77)	(1.37)
Doal	-0.040	0.529**	0.425**
	(-0.39)	(2.48)	(2.33)

cons	-4.760***	16.550***	16.210***
	(-3.19)	(7.05)	(8.15)
Year	Control	Control	Control
N	2399	5648	4796
R^2	0.045	0.134	0.128

d. Standard errors in parentheses * p < 0.1, ** p < 0.05, *** p < 0.01

6. Conclusion

Deep integration of digital technology with real enterprises has significant driving force for China's innovation-driven development strategy. This paper investigates the impact of digital transformation on enterprise technology innovation, and empirically examines the impact and mechanism of effect of digital transformation on technology innovation when enterprises carry out digital transformation with the help of data of manufacturing Chinese listed companies from 2010-2020, and draws the following main research conclusions: firstly, the higher the degree of digital transformation, the higher the level of enterprise technology innovation; secondly, further examining the digital transformation on enterprise technology innovation Second, further examination of the impact path of digital transformation on enterprise technology innovation reveals that digital transformation can alleviate financing constraints, which in turn promotes enterprise technology innovation. Finally, product market competition plays a moderating role in the promotion process of digital transformation on enterprise technology innovation.

Digital transformation has become the new trend of future enterprise development, and is an important propeller for enterprises to achieve high quality. In order to continue to play the driving role of digital technology on enterprise technology innovation and improvement, manufacturing enterprises should increase the relevant digital transformation capital investment, carry out comprehensive digital transformation, build digital platform, such as digital transformation of existing information systems and information equipment. At the same time, the government should increase the incentive policy to create a good external environment for the digital transformation of enterprises, and actively guide the digital transformation of enterprises.

References

[1] F. He and H. Liu (2019). Assessment of the performance enhancement effect of digital change in real enterprises from the perspective of digital economy[J]. Reform, (04): 137-148.

[2] J. Jia and C. Xue (2022) Research on the impact of blockchain application on the relationship between customer relationship governance and enterprise innovation [J]. Soft Science,36(08): 123-129.

[3] G. Shen and Z. Yuan (2020) The impact of corporate internetization on Chinese enterprise innovation and exports [J]. Economic Research,55(01): 33-48.

[4] J. Sun and J. Li (2022) Big data application, financing constraints and corporate innovation efficiency[J/OL]. Securities Market Herald. http://kns.cnki.net/kcms/detail/44.1343.F.20221109.1710.002.html

[5] Y. Duan, J. Edwards and Y. Dwivedi (2019) Artificial intelligence for decision making in the era of big data evolution challenges and research agenda. International Journal of Information Management, (48): 63-71.
[6] X. Han, N. Hui and W. Song (2014) Can informatization improve the efficiency of technological innovation in China's industrial sector[J]. China Industrial Economics, (12): 70-82.
[7] X. Zhang (2019) Research on the evolution of innovation models under the conditions of the digital economy[J]. The Economist, (07):32-39
[8] R. Ander and R. Kapoor (2010) Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations[J]. Strategic Management Journal, 31 (3): 306-333.
[9] Y. Qi and X. Xiao (2020) Business management changes in the digital economy[J]. Management World, 36(6): 135-152+250.
[10] Z. Yang and D. Li (2010) Innovation in Chinese Manufacturing Firms: Industry Competition, Cluster-Embedded Social Capital and Technology Strategy Options[J]. Finance and Trade Economics, (6): 98-105+136.
[11] H. Qi, X. Cao, and Y. Liu (2020) The impact of digital economy on corporate Governance -- From the perspective of information asymmetry and managers' irrational behavior [J]. Reform, (4): 50-64.
[12] E. Autio (2017) Strategic entrepreneurial internationalization: Anormative framework[J]. Strategic Entrepreneurship Journal,11(3): 211 -227.
[13] J. Zhang, Q. Xu and S. Zhang (2014) Research on the relationship between corporate knowledge management and innovation capability in a dynamic environment[J]. Research Management,35(4): 59-67.
[14] Y. Zhang, X. Li, and M. Xing (2021) Enterprise Digital Transformation and Audit Pricing[J]. Audit Research, (3): 62-71.
[15] Q. Gu and S. Zhai (2013) Information Disclosure Quality, Agency Costs and Corporate Financing Constraints-Empirical Evidence from the Shenzhen Stock Market[J]. Economic and Management Research, (5): 43-48.
[16] F. Wu, H. Hu, H. Lin, and X. Ren (2021) Enterprise digital Transformation and capital market performance--Empirical evidence from stock liquidity[J]. Management World, 37(7): 130-144+10.
[17] X. Du, and Z. Zhou (2009) An empirical study of information disclosure quality and agency costs--Empirical evidence based on information disclosure assessment of Shenzhen Stock Exchange[J]. Business Economics and Management, (12): 76-82+90.
[18] N. Zhu, L. Zhu, Y. Kong, and Y. Shen (2014) Study on the synergistic impact of technological innovation investment, social responsibility commitment on financial performance[J]. Accounting Research, (2): 57-63+95.
[19] X. Ju, D. Lu, and Y. Yu (2013) Financing Constraints, Working Capital Management and Corporate Innovation Sustainability[J]. Economic Research, 48(2): 4-16.
[20] X. Yang, and X. Yin (2015) Industry concentration, competitive position of enterprise and the competitive effect of cash holdings[J]. Economic Science,37(6): 78-91.
[21] Z. Zhang, D. Cao, and S. Xiang (2017) Institutional context, chairman tenure, and corporate technology innovation performance[J]. China Soft Science, (10): 114-127.