Research on the impact of digital transformation on enterprise innovation

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Abstract. This paper selects A-share listed companies in China as a sample to explore the impact of digital transformation on enterprise innovation. And the time span of data is from 2016 to 2020. Empirical research shows that the innovation level of enterprises can be improved by digital transformation. Meanwhile, digital transformation can alleviate corporate financing constraints and improve the quality of their internal control. Hence, it can enhance the innovation level of enterprises.

Keywords: Enterprise innovation; Digital transformation; Financing constraints; Internal control.

1   Introduction

Recently, digital transformation has been a promoting means of high-quality economy in China. In this setting, for promoting economy at the micro level of enterprises, it is meaningful for exploring its impact on enterprises in the current post pandemic era. Simply put, digital transformation is a dynamic digital business model. It should be a major strategy for enterprises and gradually improve their digital infrastructure construction. On the other hand, innovation, as an important means to enhance the core competitiveness, is also an important foundation for enterprises to survive and cultivate. From the two perspectives, this paper will explore whether and how it can have an impact on enterprise innovation. Meanwhile, its impact path on enterprise innovation will also be explored through relevant intermediary variable assumptions. Engaging in digital transformation actively can enhance enterprises' ability to process data and accelerate the speed of internal information. In addition, it can also reduce asymmetric information and improve the quality of internal control. Therefore, this article is based on the theories of enterprise innovation, information asymmetry and internal control. It constructs a theoretical framework and connection between digital transformation, financing constraints, internal control and enterprise innovation. It is conducive to enriching related research and achievements. Moreover, it provides theoretical basis related to the innovation level of enterprises and digital economy.

2   Literature review

Significance of digital transformation on enterprise innovation has been extensively studied by different scholars at home and abroad from different perspectives.

Digital technology has innovated enterprise business models, created new value systems and improved innovation efficiency [1]. Through research and data analysis on manufacturing enterprises, it is believed that digital transformation can achieve significant results in enterprise innovation through the improvement of dynamic capabilities [2]. Meanwhile, digital transformation can increase the growth of innovation efficiency by strengthening organizational resilience [3].

Influenced by the differences in the industrialization process and digital economy in foreign countries, research on digital transformation has been conducted earlier in foreign countries than in China. Digital transformation makes the market more sensitive to new products [4]. Manufacturers can not only obtain knowledge and technology to improve products through digital channels, but also can endow products with new connotations. As a result, they can enhance their adaptability to the market. Digital transformation can promote the direct innovation process of cooperative members by reducing communication costs among network members, improving information exchange rates, and expanding communication scope [5]. In addition, digital transformation is the online and offline integration of enterprises' products and services [6]. It can not only stimulate market demand through the Internet digital information technology, but also accelerate the sharing of enterprise resource elements and thus reduce enterprise operating costs. What is more, it can also enhance sustainable competitiveness.

3   Theoretical analysis and research hypotheses

There are three hypotheses which are based on the three theories respectively.

According to the theory of enterprise innovation, the aim of companies to innovate is to obtain potential profits and maximize excess profits. The adoption of digital transformation by enterprises is itself an innovation. Digital transformation will affect the organizational structure and market foundation. By utilizing data resources, enterprises can generate new cooperation models, products, and services. In response to these new demands of new products and services, enterprises will be more willing to carry out innovation activities. For instance, they are to improve their business processes and related products, and thereby enhance their innovation level so as to give them more advantages in product market competition. These activities will also enhance the future value effect of innovation. Hence, this article proposes the following hypothesis:

Hypothesis1: By limiting other conditions, digital transformation enhances the innovation level of enterprises.

According to the theory of asymmetric information, external stakeholders of enterprises have biased attitudes towards innovation due to the impact of information asymmetry. In addition, the emergence of agency issues may hinder the normal progress of innovation activities. Enterprise innovation has long-term and risky characteristics. When faced with high financing constraints, enterprises often find it difficult to obtain

funds from investors, thereby hindering their innovation activities. In the digital era, companies can improve their information transparency by utilizing emerging technologies. As a result, they can provide more diverse information to external stakeholders. This helps external stakeholders fully understand the enterprise. Through this method, the information asymmetry issues can be alleviated. Additionally, investors' investment risks can be reduced. Hence, investors will have a greater willingness to invest in these enterprises. Consequently, financing constraints for the enterprise can be relieved. The enterprises can have more funds to invest in innovation activities and improve their own innovation level. Hence, this article proposes the following hypothesis:

Hypothesis 2: By limiting other conditions, digital transformation enhances the level of innovation of enterprises through reducing their financing constraints.

According to theory of internal control, digital transformation can increase the transparency of information, which not only alleviates the information asymmetry of external investors, but also helps heighten the quality of communication in the internal control of companies. As a result, it can timely and efficiently convey internal information and establish more efficient internal communication channels. Meanwhile, it helps internal managers objectively evaluate and manage innovation risks and achievements. It provides a good environment and reliable guarantee for the achievements of enterprise innovation activities. Hence, this article proposes the following hypothesis:

Hypothesis 3: By limiting other conditions, digital transformation enhances innovation level of the enterprises through ameliorating the quality of their internal control.

4   Research design

4.1   Sample selection and data source

China's digital transformation has entered a new stage of development in 2016, moving towards the current trend of platformization and intelligence [7]. Hence, this article analyzes data of Chinese A-share listed companies from 2016 to 2020 to explore the effect of digital transformation on enterprise innovation. This study will take listed companies which are in non-financial industries as samples. Digital transformation data is from annual reports. The data which can represent the standard of internal control in companies is from the DIB Internal Control Index. Patent data is from CNRDS database. ST listed companies and companies with missing empirical data will be excluded.

4.2   Variables

4.2.1 Explained variable

Enterprise innovation (INO) is chosen to be the explained variable. The total number of patents applied by a company in the current year is selected to represent its innovation level [8]. A company with a higher number of applied patents means that the level of innovation of it is better.

4.2.2 Explanatory variable

Choose digital transformation (DIG) as the explanatory variable. Taking the ideas of scholars as examples, this research calculates the frequency of the sub indicators of digital application in listed company reports [9]. After that, it takes the logarithm of the word frequency obtained. Ultimately, the variable index of enterprise digital transformation is obtained.

4.2.3 Intermediary variables

There are two intermediary variables. One is financing constraints (SA). Absolute value of SA index is chosen to measure the degree of corporate financing constraints. [10]. If the absolute value of one company is higher than that of other companies, it means that this company is under more severe financing constraints. The other is internal control (IC). DIB Internal Control Index is a disclosure index which is currently the most commonly used indicator to comprehensively measure the actual situation of internal control [11]. Thus, it is selected to represent the quality of internal control in enterprises. The larger the value, the better the internal control quality of the enterprise. Moreover, this article uses its natural logarithms as an alternative measure.

4.2.4 Control variables

Enterprise age, profitability and ratio of liabilities. The specific definitions of variables are shown in Table 1.

Table 1. Specific definitions of variables.

Type of variable		Symbol	Explanation
Explained variable	Enterprise Innovation	INO	Ln (1+ Total number of patents filed independently by the company)
Explanatory variable	Digital Transformation	DIG	Ln (1+ Frequency of keywords related to digital transformation)
Intermediary variables	Financing constraints	SA	Absolute value of the SA index
	Internal Control	IC	Ln (1+ DIB internal control index)
Control variables	Age of companies	AGE	Ln (1+Age of enterprises)
	Profitability	ROA	Return on assets
	Ratio of liabilities	LEV	Total liabilities divided by total assets
	Year	YEAR	Dummy variable
	Industry	IND	Dummy variable

4.3 Models

This paper proposes the following specific models to verify the research hypothesis.
Impact of digital transformation on enterprise innovation is analyzed by Model 1.

$$INO_{i,t}=\beta_0+\beta_1 DIG_{i,t}+\beta_2 SIZE_{i,t}+\beta_3 AGE_{i,t}+\beta_4 ROA_{i,t}+\beta_5 LEA_{i,t}+\varepsilon \qquad \text{Model 1}$$

To further test whether digital transformation can promote enterprise innovation through the two paths which are financing constraint and internal control, the following models are established:

$$SA/IC_{i,t}=\beta_0+\beta_1DIG_{i,t}+\beta_2SIZE_{i,t}+\beta_3AGE_{i,t}+\beta_4ROA_{i,t}+\beta_5LEA_{i,t}+\varepsilon \qquad \text{Model 2}$$

$$INO_{i,t}=\beta_0+\beta_1DIG_{i,t}+\beta_2SA/IC_{i,t}+\beta_3SIZE_{i,t}+\beta_4AGE_{i,t}+\beta_5ROA_{i,t}+\beta_6LEA_{i,t}+\varepsilon \quad \text{Model 3}$$

In Model 1, if β_1 is significantly positive, it represents that digital transformation can promote the enterprise innovation level, that is, hypothesis 1 is valid. Through the joint three models, the mediating role of financing constraints and internal control in hypothesis 2 and hypothesis 3 can be tested.

5   Empirical analysis

5.1   Descriptive statistical analysis

Table 2 below shows the results of the descriptive statistics. Square variance of the explained variable (INO) of the sample companies is 1.77. The least value of INO is 0 and its peak is 9.41. These data show that the innovation level of these companies is different. Moreover, the average of explanatory variable (DIG) is 1.76. Its standard deviation is 1.46. The least value of DIG is 0 and its peak is 5.03, indicating that the extent of digital transformation is uneven. In fact, some enterprises have not yet started their own digital transformation. The standard deviation of IC, SA, LEV, ROA and AGE are all less than 1.

Table 2. Descriptive statistical analysis.

Variables	Observations	Mean	Standard deviation	Min	Max
INO	13,484	2.973083	1.767687	0	9.405579
DIG	13,484	1.757588	1.455178	0	5.030438
SA	13,484	3.857845	0.24823	2.112596	5.277581
IC	13,484	6.369167	0.824587	0	6.848334
LEV	13,484	0.415761	0.198198	0.008359	3.512951
ROA	13,484	0.035379	0.087596	-1.91911	0.785865
AGE	13,484	2.977272	0.278305	1.609438	3.988984

5.2   Regression analysis

In Model 1, the explained variable is INO and the explanatory variable is DIG, controlling for industry and year. Table 3 below shows the regression results of Model 1. From the results of empirical analysis, the regression coefficient of DIG is 0.018. In addition, this result is significant at the 5% level, showing that enterprise digital transformation can improve its innovation level.

Table 3. Regression analysis of DIG and INO.

Variables	INO
DIG	0.018**
LEV	2.273***
ROA	2.458***
AGE	-0.126***
Constant	0.846***
Control year	YES
Control industry	YES
Observations	13484
R^2	0.310

Note: ***, ** and * are significant at 1%, 5% and 10% levels respectively, similarly herein-after.

Regression results of Model 2 and Model 3 are shown in the following two tables.

In Table 4, column (1) and (2) are the regression analysis results of Model 2 and Model 3, respectively. In column (1), the regression coefficient of DIG is negative, indicating that enterprises can ease their financing constraints through digital transformation. In column (2), the regression coefficient of SA is significantly negative, showing that the financing constraints can lower the innovation level of enterprises. Moreover, the coefficient of DIG is significantly positive, meaning that it has passed the intermediary effect test. This shows that the hypothesis 2 is true.

Table 4. Regression analysis of financing constraints

Variables	(1) SA	(2) INO
DIG	-0.000	0.017*
SA		-2.241***
LEV	-0.103***	2.042***
ROA	-0.072***	2.295***
AGE	0.764***	1.585***
Constant	1.646***	4.534***
Control year	YES	YES
Control industry	YES	YES
Observations	13484	13484
R^2	0.719	0.338

In Table 5, column (1) and (2) are the regression analysis results of Model 2 and Model 3, respectively. In column (1), the coefficient of DIG is positive, which shows that the internal control of enterprises can be promoted by their measures related to digital transformation. In column (2), the regression coefficient of IC is significantly positive, meaning that internal control can increase innovation level of the enterprise. DIG coefficient is significantly positive, indicating that it has passed the intermediary effect test. This shows that the hypothesis 3 is true, which means that digital transformation enhances the innovation level of enterprises through perfecting internal control.

Table 5. Regression analysis of internal control.

Variables	(1)	(2)
	IC	INO
DIG	0.002	0.018**
IC		0.124***
LEV	-0.452***	2.295***
ROA	1.658***	2.186***
AGE	-0.915***	-0.122**
Constant	9.349***	0.068
Control year	YES	YES
Control industry	YES	YES
Observations	13484	13484
R^2	0.040	0.313

6   Conclusion

This paper selected the relevant data of Chinese A-share listed companies from 2016 to 2020. It tested the impact of enterprise digital transformation on their innovation level through empirical analysis. After this analysis, the results indicate that engaging in digital transformation can enhance the innovation level of enterprises through reducing their financing constraints and improving their internal control.

References

1. Chen, J., Yang, W., & Yu, F. (2019). Ecological collaborative innovation strategy in digital transformation: Based on Huawei Business Group (EBG) China region strategic discussion. *Tsinghua Business Review, (06)*, 22-26.
2. Wang, C. (2021). Research on the mechanism of digital transformation on enterprise innovation performance. *Contemporary Economic Management, 43*(03), 34-42.
3. Wang, H., Xia, T., Ma, Y., & Lin, X. (2021). How can digital transformation improve innovation efficiency for middle and small-sized enterprises? Survey based on empirical sampling method. *Science and Technology Management Research, 41*(18), 168-174.
4. Candi, M., & Beltagui, A. (2019). Effective use of 3D printing in the innovation process. *Technovation, 80*, 63-73.
5. Lyytinen, K., Yoo, Y., & Boland, R. (2015). Digital Product Innovation within Four Classes of Innovation Networks. *Information Systems Journal, 26*(1), 47-75.
6. Mergel, I., Edelmann, N., & Haug, N. (2019). Defining Digital Transformation: Results from Expert Interviews. *Government Information Quarterly, 36*(4), 101385.
7. Li, W., & Li, X. (2022). Global digital transformation process, trend and Chinese promotion path. *Economist, (05)*, 36-47.
8. Wu, F., Hu, H., Lin, H., & Ren, X. (2021). Corporate digital transformation and capital market performance: Empirical evidence from equity liquidity. *Journal of Management World, 37*(07), 130-144+10.

9. Huang, D., Xie, H., Meng, X., & Zhang, Q. (2021). Digital transformation and enterprise value: Empirical evidence based on text analysis methods. *Economist,* (12), 41-51.
10. Xu, L. (2023). Research on the impact of digital transformation on enterprise innovation. *Communication of Finance and Accounting,* (16), 78-83.
11. Gao, B. (2023). Enterprise digital transformation and internal control effectiveness. *Friends of Accounting,* (04), 127-133.