

Investigating Relationship Between Digital Technology Application, Slack, and Enterprise Innovation Based on Mediating Effect Model

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Abstract: With the rapid penetration of emerging digital technologies such as big data, artificial intelligence, cloud computing and mobile Internet at all levels of the economy and society, human society is accelerating into the era of digital economy. The deep integration of digital technologies with the real economy and the resulting reconfiguration of value creation logic have provided new momentum for high-quality economic and social development. Under the new wave of industrial technology revolution, more and more enterprises are making digital transformation a core strategy for establishing a new competitive advantage and achieving sustainable organisational growth. The application of digital technology has led to a profound change in the way social resources are allocated. The application of digital technology has triggered profound changes in the way society allocates resources and has further influenced all aspects of innovation activities. So, based on the data of A-share manufacturing enterprises listed in China from 2016 to 2020, we constructed a mediating effect model to empirically test the digital technology application on enterprise innovation and the intermediary effect through the slack. The results show that the application of digital technology has a significant facilitating effect on innovation. Secondly, slack has a significant mediating effect on the relationship between digital technology applications and enterprise innovation. Thirdly, the mediating effect of the application of digital technology on enterprise innovation through slack is significantly lower than the direct effect.

Keywords: Digital Technology Application, Slack, Enterprise Innovation, Mediating Effect Model

1. Introduction

With the rapid development of digital technologies such as Big Data, AI, cloud computing, and 5G, human society is entering the era of the digital economy. Under the impact of the new industrial technology revolution, more enterprises are embarking on digital transformation to gain a new competitive advantage and achieve the core strategy of sustainable development of the enterprise. It has triggered profound changes in the distribution of social resources, thus affecting all aspects of corporate innovation activities. The profound impact of digital technology application on enterprises' innovation activities is mainly reflected in the following aspects. Firstly, digital technology helps enterprises make scientific innovation decisions by

processing massive non-standard information in real-time and accurately identifying the possible path of technological succession. Secondly, it promotes the fundamental transformation of business innovation by transforming technological paradigms, business processes, and organizational structures [1]. Finally, the application of digital technology based on the digital platform and innovation ecosystem improves the level of innovation within enterprises and promotes cross-enterprise innovation in different organizations and industries. Therefore, the application of digital technology to improve the innovation capability of enterprises has attracted general interest in both theory and practice.

Pervious studies have discussed the relationship between digital technology and business innovation in depth, and their perspectives fell into two categories. One is to examine business innovation driven by a particular digital technology from a single digital technology perspective. For example, Yang discussed the impact of AI on business innovation at a theoretical level [2]. Wen found that building a smart city significantly improves enterprise innovation and that the collaborative model of "group information interaction" has a significant positive impact on R&D input and innovation output [3]. The other is based on the comprehensive perspective of digital technology to investigate whether enterprises use it to promote enterprise innovation. For example, Chen found that the application of digital technology strongly promotes exploratory innovation and exploitative innovation of enterprises [4]. In the empirical study on the relationship between digital technology and enterprise innovation, Wang used the 0-1 dummy variable to know "whether the enterprise uses digital technology in the current year" to measure the application of digital technology, and found that the application of digital technology has a positive effect on innovation performance [5]. A careful review of the relevant literature shows that the use of digital technology is closely related to firms' innovation activities. However, empirical studies that include the use of digital technologies, the slack, and corporate innovation in the analytical framework are relatively rare.

Based on the above analysis, we discuss the following two aspects of the problem: how the application of digital technology affects innovation in companies and what the role of the slack is in the impact of digital technology application on business innovation. The main contributions of this study are as follows. At the theoretical level, the relationship between digital technology, slack, and enterprise innovation is clarified, and a mediating effect model is constructed and empirically tested. At the practical level, Chinese enterprises are at a critical stage of transitioning to high-quality development, and the conclusions of the study help enterprises make decisions regarding digital transformation and innovation.

2. Materials and Methods

2.1. Theoretical Analysis and Hypothesis

Digital technology as a new factor of production greatly improves the efficiency of resource utilization. The enterprise explores the potential innovation value of existing resources through digital technology and discovers the innovation needs of users through the digital platform to promote technological upgrading, expand new functions of products and services, and create a larger development space for enterprises [6]. Specifically, the application of digital technology firstly enables enterprises to acquire, share, and reorganize innovative resources in a wide space-time range. This helps enterprises integrate innovation resources at a

lower cost and promote enterprise innovation by opening up new uses of resources and improving their use efficiency [7]. Second, the application of digital technology makes enterprises transform and improve existing technologies. This helps enterprises improve their innovation capability, achieve sustainable competitive advantages in the original technology, and build a foundation for enterprise development. Finally, the digital technology platform allows the product to be extended and updated based on user feedback after the design is complete. This provides new directions for enterprises to innovate and leads to new products that meet users' needs. Therefore, the following hypothesis is proposed.

H1: The application of digital technology promotes enterprise innovation activities.

The application of digital technology enables enterprises to acquire and reorganize resources, which favors the integration of resources for more cost-effective production. The application improves the timeliness and scientificity of decision-making and reduces the waste of resources to a certain extent, giving enterprises more financial freedom. In addition, the uncertainty of R&D investment significantly increases the risk of innovation decisions. Managers are influenced by many factors when faced with risky decisions. As an internal resource with high flexibility in handling risk, slack increases decision-makers' confidence in making risky decisions. Therefore, if a company has a large number of redundant financial resources, the company's managers promote high-risk innovative activities to maintain core competitiveness and achieve sustainable development. Thus, the following hypotheses are proposed.

H2: Slack plays a mediating role in the impact of digital technology applications on enterprise innovation.

2.2. Variable Selection

We investigate the mediating effect of slack on digital technology adoption and enterprise innovation by taking Chinese A-share listed manufacturing enterprises from 2016 to 2020 as the research object. To reduce the influence of outliers, we excluded ST and * ST companies and several samples with serious missing observation values of variables. At the same time, the data were winsorized by 1% up and down to avoid the influence of extreme outliers on the estimation results. After the above sorting, a total of 2200 observations were included in the estimation model. The application of digital technology, slack, and enterprise innovation was analyzed and compiled based on the annual labor and financial reports of Chinese listed A-share enterprises during the study period. The company-level data required for the empirical study were all obtained from the CSMAR database.

Explanatory variable (ADT): Defining and measuring the application of digital technology is the premise of this study. The scientific and appropriate measurement of the level of use of digital technology in companies is one of the difficulties of empirical research. Following the existing studies, the annual change rate of the digital

technology-related part of intangible assets is used as a proxy indicator of the level of digital technology application in enterprises [8].

Mediating variable (slack): Currently, scholars measure slack mainly from subjective and objective aspects. To ensure the authenticity and reliability of the study, objective indicators are used to measure slack. Following Sean's practice, slack is defined according to the surplus attribute of superfluous resources and industry characteristics as the internal financial resources with high liquidity of enterprises [9].

Explained variable (Inno): Research on business innovation has a long history, and there are many measurement methods for business innovation. In this study, the existing measurement methods are fully

considered, and the indicators of financial data are more compatible with the objective of this study. However, since the logarithm of R&D expenditure is used to measure enterprise innovation without considering the influence of enterprise size on enterprise innovation, the ratio of R&D expenditure to operating income is used to measure enterprise innovation [10].

Controlled variable: In order to better analyze the relationship between the application of digital technologies and enterprise innovation under the mediating effect of slack and ensure a high degree of authenticity and reliability of the empirical research results, the control variables include size [11], ROA [12], indratio [13], age [14], and SOE [15].

The measures of the specific variables are listed in Table 1.

Table 1. Definitions of main variables.

Variable	Variable measurement
ADT	Percentage of changes in intangible assets related to digital technology
Inno	Ratio of r&d expenses to main business revenue
Slack	(Monetary funds + tradable financial assets + net notes receivable + 0.7 * net accounts receivable + 0.5 * net inventory - short term borrowings) / total assets
Size	Take the natural log of total assets
Age	Observation year minus the establishment time of the enterprise
SOE	The value is 1 for state-owned enterprises and 0 for other enterprises
ROA	The ratio of total profits and interest income to total assets
Indratio	Ratio of the number of independent directors to the number of directors

2.3. Model Specification

Based on the mediation effect test method summarized by Wen, we construct the mediation effect model of digital technology application-slack-enterprise innovation and empirically analyze the effects of digital technology application and slack on enterprise innovation. The specific model is as follows.

$$Inno_{it} = \alpha_0 + \alpha_1 ADT_{it} + \alpha_2 Size_{it} + \alpha_3 Age_{it} + \alpha_4 SOE_{it} + \alpha_5 ROA_{it} + \alpha_6 Indratio_{it} + e_0 \tag{1}$$

$$Slack_{it} = \beta_0 + \beta_1 ADT_{it} + \beta_2 Size_{it} + \beta_3 Age_{it} + \beta_4 SOE_{it} + \beta_5 ROA_{it} + \beta_6 Indratio_{it} + e_1 \tag{2}$$

$$Inno_{it} = \theta_0 + \theta_1 ADT_{it} + \theta_2 Slack_{it} + \theta_3 Size_{it} + \theta_4 Age_{it} + \theta_5 SOE_{it} + \theta_6 ROA_{it} + \theta_7 Indratio_{it} + e_2 \tag{3}$$

(α_i , β_i and θ_i are correlation coefficients, e_i is the random error interference term).

This paper introduces organizational slack into the research framework of digital technology adoption and firm innovation. The results as follows.

3. Results and Discussion

A review of previous literature reveals that there are two main perspectives on the innovative behaviour of digital technology applications on firms [16]. On the one hand, scholars argue that the application of digital technology enhances the efficiency of resource use and reduces the waste of resources, so that firms can invest more resources in innovation. On the other hand, studies have found that the application of digital technology can have a substitution effect on firms' innovation behaviour, which itself is a long-cycle and high-risk behaviour, and therefore digital technology application can have a negative impact on firms' innovation behaviour.

Previous studies have discussed the impact of digital technology adoption on enterprise innovation, but have not developed further discussion on how this impact

3.1. Descriptive Statistics

Table 2 shows the descriptive statistics of the main variables. The minimum value of enterprise innovation is 0, the maximum value is 0.199, and the mean value is 0.042, indicating that there is a large difference in the innovation level of enterprises. The minimum value of the application level of digital technology is -0.007 and the maximum value is 0.197, which means that several listed companies could reduce the stock of intangible assets of digital technology to avoid risks caused by overreliance on digital technology. The minimum value of slack is not 0, which confirms "there is no organization with zero slack." The maximum value, minimum value, and mean value of the slack vary widely, suggesting that the extent of slack also varies from organization to organization.

Table 2. Descriptive results.

	N	Mean	Sd	Min	Max
Inno	2200	0.042	0.035	0	0.199
ADT	2200	0.016	0.029	-0.007	0.197
Slack	2200	0.315	0.148	0.013	0.687
Size	2200	22.32	0.991	20.26	25.25
Age	2200	18.77	5.294	9	33.25
SOE	2200	0.236	0.425	0	1
ROA	2200	0.027	0.089	-0.475	0.211
Indratio	2200	0.381	0.065	0.267	0.600

3.2. Estimated Results of Digital Technology Application and Enterprise Innovation

Stata14 is used to regress Eqs. (1), (2), and (3), and the estimation results of the mediating effect of application of digital technology on enterprise innovation are obtained (Table 3). In Model 1, the estimated coefficient of the influence of ADT on Inno is significantly positive at the 1% significance level, indicating that the application of digital technology significantly promotes enterprise innovation. In Model 2, the

estimated coefficient of the impact of ADT on slack is significantly positive at the 5% significance level, indicating that the application of digital technology also has a significant promoting effect on slack. In particular, the estimated coefficients of the impact of the application of digital technology and slack on enterprise innovation in Model 3 are significantly positive at the 5% and 1% significance level, respectively. The Sobel statistic significantly rejects the null hypothesis that there is no mediation effect at the 1% significance level, indicating that the mediation effect exists. This means that the application of digital technology promotes enterprise innovation through slack. The total effect of the application of digital technology on slack is 0.092093, and the mediation effect is 0.010085, accounting for 0.109509 of the total effect. The direct effect was 0.082008, accounting for 0.890491 of the total effect. This shows that the application of digital technologies plays a weak role in promoting enterprise innovation through slack and that the mediating effect of slack has not been fully effective.

Table 3. Estimated results of digital technology application and enterprise innovation.

	Model1	Model2	Model3
ADT	0.0914*** (3.58)	0.315** (3.09)	0.0828** (3.29)
Slack			0.0320*** (6.06)
Size	-0.0000655 (-0.08)	-0.028*** (-8.57)	0.00149 (1.85)
Age	-0.000242 (-1.60)	-0.0003 (-0.46)	-0.000269 (-1.80)
SOE	-0.000342 (-0.18)	0.0354*** (4.64)	-0.00144 (-0.76)
ROA	-0.0624*** (-7.17)	0.519*** (15.34)	-0.066*** (-7.52)
Indratio	0.0134 (1.15)	-0.0494 (-1.07)	0.0125 (1.10)
Sobel	0.0063*** (2.73)		Significant mediating effect
Ind-EFF	0.010085		Tot-EFF ratio 0.109509
Dir-EFF	0.082008		Tot-EFF ratio 0.890491

Notes: *, **, *** significant at the level of 10%, 5% and 1%. respectively, inside the parentheses is the T statistic, in the Sobel test, the parentheses are Z statistics, the same as below.

3.3. Robustness Test

Considering that sample selection and estimation methods introduce bias in estimation results, the bootstrap method of repeated sampling is used to test the robustness of the mediation effect model. The bootstrap self-sampling method is used to perform random repeated sampling of the existing samples. 1000 samples are elected, and the sample size of each sample is equal to the original sample size. Then, the regression analysis of the mediation effect is conducted with the selected group samples to further test the robustness of the regression results of the benchmark model. The regression results are shown in Table 4. The digital technology is applied to the direct effect of enterprise innovation and the mediation effect of slack estimates, which are significantly below a certain significance level. The direct effect and the indirect effect corresponding to the confidence intervals do not contain zero. This implies that the application of digital technology directly has a promoting effect on enterprise innovation and plays a significant mediating role through financial slack. The robustness of the regression results of the benchmark model is further verified.

Table 4. Mediation effect test of Bootstrap repeat sampling.

Effect	Estimated value	Confidence interval
Dir-Eff	0.082008	[0.026238, 0.147989]
Ind-Eff	0.010084	[0.026238, 0.147989]
Tot-Eff	0.092092	

4. Conclusion

The application of digital technology has a significant facilitating effect on innovation, and the slack has a significant mediating effect on the relationship between digital technology applications and enterprise innovation. The mediating effect of the application of digital technology on enterprise innovation through slack is significantly lower than the direct effect.

The result has implications for manufacturing enterprises to increase the application of digital technology and improve enterprise innovation. Investment in enterprise innovation has characteristics such as a long payback period and uncertainty. Digital technology applied to a certain extent helps avoid part of the uncertainty, improve the scientific nature of the decision to create a rich slack, and promotes the

innovation of the enterprise. To some extent, the technology helps enterprises build a competitive force and achieve sustainable development. So, manufacturing enterprises appropriately improve the application level of digital technology according to their situation, and use the rich slack to carry out enterprise innovation activities to help enterprises achieve core competitiveness and promote sustainable development of enterprises.

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