Empirical Test of the Impact of Digital Innovation on Firms' New Quality Productivity in China

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Abstract. In the era of digital economy, digital innovation has become the primary motive force for cultivating new quality productivity. Taking Chinese listed companies as the research sample, this paper identifies corporate digital patents to portray the level of digital innovation and explores the effect of digital innovation on corporate new quality productivity. The findings show that digital innovation significantly promotes the development of firms' new quality productivity. Heterogeneity analysis reveals that digital innovation has a more pronounced promotion effect in non-state-owned enterprises, enterprises in industries with higher degree of competition, and enterprises in the central and eastern regions. This paper deepens the understanding of the economic effects induced by digital innovation, and provides a practical reference for cultivating new productivity under the digital China strategy.

Keywords: Digital innovation; New quality productivity; Digital patents.

1 Introduction

With the extensive application of cloud computing, big data, artificial intelligence, blockchain and other advanced technologies, enterprises no longer rely solely on traditional factors of production to promote productivity development, but mainly rely on new factors of production represented by digital technology in order to optimize the production and operation process, reshape the business development model (Ganotakis et al., 2023) [1]and promote enterprises to move towards high-end, intelligent, green, and digital transformation. Therefore, it is of great practical significance to study the relationship between enterprise digital innovation and new quality productivity for the high- quality development of enterprises.

The possible innovations of this paper are as follows: First, this paper has important theoretical significance for deepening the research of digital innovation and exploring the new kinetic energy of new quality productivity. This paper deepens the understanding of the economic effects caused by the wide application of digital technology, and provides a theoretical basis for cultivating new quality productivity under the digital

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China strategy. Second, it breaks through the previous perceptual cognition and verify the impact of digital innovation on the formation of new quality productivity from the empirical results. While the discussion of new productivity in the literature focuses on the theoretical level, this paper constructs a scientific and reasonable evaluation index system of digital innovation and new productivity, examines the effect of digital innovation on new productivity, and provides empirical evidence for the role of digital innovation in promoting the formation of new quality productivity.

2 Theoretical Analysis

The essence of new quality productivity is a new technological and economic development paradigm dominated by innovation, with the promotion of total factor productivity as the core symbol. Digital innovation directly affects the development of new quality productivity mainly through the following mechanisms:

First of all, digital innovation creates data production factors and promotes the emergence of new quality productivity. Digital innovation promotes the participation of multiple subjects in the digitization process in order to create massive amounts of data, making data a key factor of production. At the same time, it promotes the integration of data production factors with other traditional factors of production, such as capital, labor and technology, and generates a multiplier effect. In turn, it effectively promotes the deep integration of the digital economy and the real economy, triggering a leap in productivity and promoting the formation of new quality productivity (Zhang and Liu, 2024) [2].

Secondly, digital innovation promotes enterprise innovation and development, changes the traditional paradigm and accelerates the formation of new quality productivity. Digital innovation is regarded as the innovation field that brings together the most innovation elements, and from the viewpoint of the enterprise's internal innovation environment, digital innovation empowers the innovation of process frameworks, product forms, service methods, organizational forms and business models in an all-round way (Xu, 2024) [3]. From the viewpoint of external access to innovation resources, digital innovation dilutes the subjective boundaries and spatial-temporal boundaries of enterprise innovation (Nambisan et al., 2017) [4], which encourages enterprises to build an interconnected and shared innovation ecosystem, break down information barriers and technology barriers, accelerate the R&D and application process, effectively improve the quantity and quality of innovation, and then accelerate the formation of new quality productivity.

Finally, digital innovation integrates and innovates with emerging industries, nurturing future industries and building a new high ground for the development of new quality productivity. Through cutting-edge technologies such as artificial intelligence, big data and cloud computing, digital innovation has spawned new formats and models, forming an endogenous driving force for the continued emergence of future industries.

According to the above analysis, this paper puts forward the research hypothesis that digital innovation can significantly promote the new quality productivity of enterprises.

3 Research Design

3.1 Variable Definition and Measurement

3.1.1. Explained Variable.

For the measurement of new quality productivity (Npro) of enterprises, this paper draws on Song et al. (2024) [5] to construct a new quality productivity indicator system based on the two-factor theory of productivity.

3.1.2. Core Explanatory Variable.

Digital patent index has become the most representative index to measure digital innovation, which is widely used in digital innovation literature (Hanelt et al. 2021) [6]. This paper obtains the number of digital patent applications of enterprises, and measures digital innovation after logarithmic processing.

3.1.3. Control Variables.

The specific variable descriptions are shown in Table 1.

Table 1. Variable descriptions.

Variable type	Symbol	Variable name	Interpretation
Explained variable	*Npro*	New quality productivity of enterprise	Based on the productivity factor theory, the entropy value method is used to construct a new quality productivity index system.
explanatory variable	*digit*	Digital innovation	Logarithmize the number of digital patent applications
Control variables	*lnasset*	Enterprise scale	Natural logarithm of total assets at the end of the period
	age	Enterprise age	Natural logarithm of difference between current year and listing year
	cash	Cash-to-assets ratio	Balance of cash and cash equivalents/total assets
	roa	Return on assets	Net profit/total assets
	lev	Leverage ratio	Total liabilities/total assets
	cr	Liquidity ratio	Current assets/total assets
	arnr	receivable assets ratio	Receivable assets /total assets
	mbratio	Book-to-market ratio	Total assets/market Value
	owncon	Ownership concentration	Concentration of shareholding ratios of the top ten shareholders
	lnGDP	Level of economic development	Natural logarithm of GDP
	industrial	Proportion of the secondary industry	Added value of secondary industry/GDP
	techexpend	Proportion of local fiscal expenditure on science and technology	Local fiscal expenditure on science and technology/GDP

3.2 Model Setting

In order to test the impact of digital innovation on the new quality productivity of enterprises, this paper sets the benchmark model as shown in (1):

$$Npro_{ijt} = \beta_0 + \beta_1 digit_{jt} + \theta_1 X_{it} + \theta_2 X'_{jt} + \mu_i + \lambda_t + \varepsilon_{ijt} \quad (1)$$

In the above model, the subscripts i, j, and t represent the enterprise, province, and year, respectively. X_{it} And X'_{jt} respectively represent the control variable sets at the enterprise level and the regional level that affect the new quality productivity of the enterprise, as described in Table 1. This article focuses on β_1.

3.3 Data Description and Statistical Description

The sample data sources used in this paper are as follows: The digital patent data is from the State Intellectual Property Office, and the other data are from CSMAR. Considering the time availability of data, this paper takes A-share listed companies from 2011 to 2022 as the research sample. The rapid development of China's digital economy began in 2010, and the sample interval is an "important window period" for a deep understanding and comprehensive grasp of digital innovation. On this basis, according to the general practice of data processing of listed companies, the samples with ST, PT, financial and insurance industries and missing core variables are deleted. At the same time, the continuous variables are winsorized at the top and bottom 1% to eliminate the influence of outliers. After screening, the maximum number of valid samples in this paper is 32000. The statistical description of the main variables is shown in Table 2.

Table 2. Statistical description results of variables.

Symbol	Mean value	Standard deviation	Minimum value	Maximum value
Npro	5.124	2.496	0.729	14.78
digit	0.788	1.225	0	4.927
size	22.14	1.205	19.11	25.71
lnage	2.121	0.823	0	3.367
cash	0.205	0.144	0.0170	0.736
roa	0.037	0.064	-0.243	0.273
lev	0.417	0.204	0.054	0.885
cr	0.575	0.198	0.115	0.968
arnr	0.147	0.116	0	0.549
mbratio	0.615	0.247	0.116	1.183
owncon	0.431	0.198	0.130	0.908
lnGDP	11.23	0.475	9.682	12.16
techexpend	0.006	0.003	0.002	0.013
industrial	0.399	0.090	0.159	0.620

Data source: The data was obtained by the author through Stata processing.

4 Empirical Results and Analysis

4.1 Digital Innovation and New Quality Productivity of Enterprises: Baseline Results

Does digital innovation contribute to the realization of new qualitative productivity development? Table 3 provides an answer to this question. Column (1) includes only the key explanatory variables digital innovation, firm fixed effects and time fixed effects in the regressions, while columns (2) and (3) further include firm control variables, and macroeconomic variables at the regional level. In all three models, the coefficients of digital innovation (digit) are significantly positive, indicating that digital innovation significantly drives firms' new quality productivity.

Table 3. Regression results of digital innovation and new quality productivity of enterprise.

Variables	(1)	(2)	(3)
digit	0.092***	0.077***	0.074***
	(0.021)	(0.020)	(0.020)
Control variables	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
R^2	0.186	0.303	0.305

Notes: Figures in parentheses are robust standard errors; *, * * and * * * represent significant at the 10%, 5%, and 1% level, respectively. The same below.

Data source: The data was obtained by the author through Stata processing.

4.2 Robustness Test

In order to alleviate the endogeneity problem that may be caused by two-way causality, this paper adopts the instrumental variable method for research, and the selection of instrumental variables is as follows: Firstly, this paper chooses the penetration rate of fixed telephone in 1984 multiplied by the digital innovation value of a lag period as the instrumental variable. Secondly, this paper uses the strategy of lagging instrumental variables, and selects the digital innovation variable with a lag period as the instrumental variable. Finally, the third power of (digital innovation - mean digital innovation across all firms in all years) is used as the instrumental variable, which has the advantage that the heteroscedasticity information of the error can be used to obtain the effective instrumental variable without introducing external variables. The regression results are shown in Table 4, which are consistent with the baseline regression.

Table 4. Robustness test

Variables	(1)	(2)	(3)
digit	0.380***	0.249***	0.207***
	(0.075)	(0.053)	(0.024)
Control variables	Yes	Yes	Yes

Individual FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
First-stage results	0.358	0.271	0.066
	(0.018)	(0.011)	(0.001)
KP-LM test	283.894	478.779	1253.339
	(0.000)	(0.000)	(0.000)
KP-F test	418.330	614.602	4019.114
	(16.380)	(16.380)	(16.380)
R^2	0.245	0.258	0.300

Data source: The data was obtained by the author through Stata processing.

4.3 Heterogeneity Test

4.3.1. Heterogeneity Test based on Enterprise Attributes.

Based on the property of ownership, the degree of industry competition and geographical location, the paper conducts heterogeneity tests. The results are shown in Table 5. Digital innovation has a more pronounced promotion effect in non-state-owned enterprises, enterprises in industries with higher degree of competition, and enterprises in the central and eastern regions.

Table 5. Heterogeneity test results.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	State-owned	Non-state owned	Low degree of competition	High degree of competition	Central East	The West
digit	0.096	0.079***	0.064***	0.111***	0.086***	-0.008
	(0.078)	(0.019)	(0.021)	(0.029)	(0.020)	(0.060)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.211	0.313	0.271	0.330	0.310	0.278

5 Conclusions and Suggestions

5.1 Conclusions

The results show that: Firstly, the current situation analysis shows that the unbalanced development of digital innovation and new quality productivity in enterprises still exists. Secondly, digital innovation significantly promotes the development of firms' new quality productivity. Thirdly, the heterogeneity analysis finds that the promotion effect of digital innovation on the development of enterprises' new quality productivity is more obvious in non-state-owned enterprises, enterprises in industries with higher degree of competition and enterprises in the central and eastern regions.

5.2 Suggestions

Firstly, give full play to the enabling effect of digital innovation to help the generation and development of new quality productivity. On the one hand, integrate digital innovation fully into the frontier field of scientific and technological innovation representing new quality productivity. Integrate digital innovation with advanced manufacturing, advanced materials, low altitude economy and other fields to promote deep changes in economic patterns and industrial forms, thus leading to more emerging and future industries driven by digital innovation. On the other hand, relevant departments should promote the upgrading of the economic structure through the deep integration of digital innovation and the real economy.

Secondly, based on the heterogeneity of digital innovation effects, differentiated development programs should be formed. On the one hand, The government should improve the market mechanism, change the disadvantageous position of non-state-owned enterprises in terms of resource acquisition and policy support, and then improve the level of new quality productivity in those firms. At the same time, the government should build a moderate competitive environment. On the other hand, the regional differences of digital innovation are very large, and its driving effect on the new quality productivity of enterprises also shows obvious regional differences. Development programs therefore need to be tailored to local conditions.

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