Research on the Impact of Digital Business Environment on Enterprises' Innovation Capability

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Abstract. This paper measures the development level of digital business environment in 30 provinces from 2015-2021, and examines the influence mechanism between digital business environment and enterprise innovation capability based on the perspective of innovation input and innovation output using a two-way fixed-effect model with data from Shanghai and Shenzhen listed A-share enterprises. The conclusions show that the digital business environment significantly enhances the innovation capability of enterprises, and improving the quality of internal control is a critical path for the digital business environment to enhance the innovation capability of enterprises. The findings of the study have implications for the government to optimize the digital business environment and for enterprises to enhance their innovation capabilities.

Keywords: digital business environment; innovation capability; internal control quality

1 Introduction

China's economic growth has embarked on a new journey, and innovation becomes the new engine. With the development of new technologies such as the big data and artificial intelligence, the traditional business environment can no longer support the needs of efficient innovative development of enterprises, and the digital business environment is now receiving more attention. The digital business environment includes the dual connotation of "digital + business environment" and "digital business + environment". The former represents the traditional market environment empowered by digital technology, the latter refers to the new business environment required for the innovative development of market players in the context of the digital economy[1].

The effect of the digital economy and the business environment on company innovation has already been studied. An improved external environment can increase the importance of IPR and technology research and development for enterprises[2]. A favorable business environment can significantly contribute to firm innovation by reducing policy uncertainty, improving the quality of internal controls and easing financing constraints[3]. The development of the digital economy may offer a digital platform for communication between firms, enabling knowledge and information to be transformed into

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innovation[4]; it effectively reduces market information asymmetries, broadens firms' access to finance, and helps enterprises to access consumer demand in a timely and accurate manner, thus improving the quality of innovation[5]. So what about the impact of the optimization of the digital business environment on the innovation capacity of enterprises Based on this, this paper develops a study, which has theoretical and practical significance for stimulating the innovation of enterprises.

2 Theoretical analysis and hypothesis

2.1 Digital business environment and enterprises' innovation capability

This paper argues that optimizing the digital business environment can create a more equitable and efficient external environment for enterprises to innovate and develop. Firstly, an improved digital business environment means a further improvement in the level of e-government services, which can reduce institutional transaction costs for enterprises, save time for product approval and improve the efficiency of enterprises' innovation. Secondly, digital business environment can force companies to accelerate data sharing, which can break down traditional market barriers, improve the mobility of innovation factors in the industry chain and match supply and demand, thus facilitating R&D cooperation between companies[6]. Finally, optimizing the digital business environment can provide abundant talent, technology and other innovation resources for enterprise innovation, thus contributing to the scale effect and technology effect and stimulating the innovation vitality of enterprises.

In summary, this paper proposes hypothesis H1: Optimization of the digital business environment can effectively enhance the innovation capacity of enterprises.

2.2 The mediating role of internal control quality

The quality of internal control can be effectively improved by the growth of the digital business environment. Firstly, the improvement of the digital business environment will enhance the transparency of information of enterprises and urge them to strengthen internal control and improve their internal system construction[7]. Secondly, an open digital business environment can also reduce information asymmetry, thus establishing an effective internal and external communication mechanism, eliminating the phenomenon of "information silos" and providing managers with complete information for decision-making. Finally, digital business environment places greater emphasis on "data for decision making and data for management", which places greater demands on the digitalization of internal controls. Utilizing digital technologies can shorten the corporate governance process and increase internal management flexibility[8]. A higher quality of internal control can increase communication and coordination between departments, and enhance resource allocation efficiency, thus improving innovation efficiency[9].

In summary, this paper makes the hypothesis H2: The digital business environment enhances enterprises' innovation capability by improving the quality of internal control.

3 Study design

3.1 Study sample and data

Most of the data in this paper at the provincial level are sourced from China Statistical Yearbook, China Marketization Index, Peking University Digital Inclusive Finance Index. The e-government level is sourced from the survey report on the online service capability of provincial governments, and the enterprises' data are sourced from CNRDS and CSMAR databases. In this paper, listed A-share enterprises in Shanghai and Shenzhen from 2015-2021 are selected as the research sample. Following the convention, the samples of ST, *ST, financial sector and enterprises with missing data are excluded, and the continuous variables are treated with a 1% level of tail reduction.

3.2 Definition of variables

Based on the work of Hongmei Zhao[10], the evaluation indicator system of the digital business environment is reorganized, taking into account the characteristics of the external environment in which enterprises conduct their production and business activities in the digital economy, including five elements of the government and legal environment (the level of e-government, score for Government-Market Relations, score for the intermediary organization and legal system, etc.), financial environment (digital inclusive finance index, social financing scale, balance of deposits and loans of financial institutions/GDP, etc.), market environment (e-commerce sales, per capita disposable income of residents, total fixed investment/GDP etc.), human resources environment (percentage of employment in information software and research, etc.) and digital infrastructure environment (internet penetration rate, etc.). And the digital business environment scores are measured by principal component analysis (PCA).

Table 1 displays the names and symbols of all variables.

Table 1. Description of key variables

Variable type	Variable name	Symbols	Variable Description
Explained variables	Innovation inputs	RD1	Logarithm of total R&D investment is taken
	Innovative outputs	RD2	Logarithm of the number of patent applications for inventions is taken
Explanatory variables	Digital Business Environment	Env	Digital Business Environment scores
Control variables	Size of enterprise	Size	Logarithm of the number of employees is taken
	Age of enterprise	Age	Length of years from the date of establishment of the business to the year of enumeration
	Current ratio	CR	Current assets/current liabilities
	Return on total assets	ROA	Net profit/average total assets
	Asset liability ratio	Lev	Total liabilities /total assets
	Tobin's Q	TQ	Total market capitalization/assets
	Concentration of shareholding	Con	The sum of the shareholdings of the top 10 largest shareholders of the enterprise
	Chairman and Managing Director	Dual	1 if the chairman and managing director are the same person, 0 otherwise

3.3 Empirical model construction

Using the theoretical analysis presented above, the benchmark regression model for this paper is set as follows:

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

RD is the explained variable, which contains innovation inputs RD1 and innovation outputs RD2; Env is the explanatory variable; Controls is a set of firm-level control variables that will have an impact on enterprise innovation; the explanatory variable subscript i,t denotes the value of the ith sample unit in year t; ΣIndustry and ΣYear are the Industry fixed effects and Year fixed effects, and $\varepsilon_{i,t}$ is a random error term.

4 Analysis of empirical results

4.1 Benchmark regression results

The results of benchmark regression are displayed in Table 2. Columns (1) and (2) are the regression results without the inclusion of control variables, Columns (3) and (4) are the regression results after adding the control variables, these results show the regression coefficients of the explanatory variable are positive at the 1% or 5% significance level, demonstrating that the digital business environment significantly enhances the enterprises' capacity for innovation, and supporting hypothesis H1.

Table 2. Benchmark Regression results

	(1) RD1	(2) RD2	(3) RD1	(4) RD2
Env	0.334*** (0.020)	0.068*** (0.020)	0.292*** (0.014)	0.047** (0.019)
Size			0.792*** (0.009)	0.314*** (0.014)
Age			-0.010*** (0.002)	-0.014*** (0.002)
Cur			0.037*** (0.005)	0.039*** (0.007)
ROA			1.367*** (0.135)	1.208*** (0.085)
PPE			0.564*** (0.073)	0.312*** (0.085)
TQ			-0.013* (0.007)	0.003 (0.008)
Con			-0.002*** (0.001)	-0.003*** (0.001)
Dual			0.055*** (0.018)	-0.030 (0.025)
_cons	16.306*** (0.112)	0.513*** (0.073)	10.056*** (0.144)	-1.801*** (0.143)
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
N	13965	13965	13965	13965
R2	0.117	0.057	0.544	0.130

Robust standard errors in brackets, ***、**、* denote significant at 1%, 5% and 10% levels respectively.

4.2 Robustness test

Robustness tests are conducted by several methods： (1) Changing the explained variables. This paper replaces the measurement of innovation inputs with the ratio of R&D investment to operating revenue, and the number of patents granted with a one-period lag is used to measure innovation outputs. (2) Adjusting the sample interval. This paper eliminates the sample of enterprises with zero invention patent applications to avoid its impact on study results. (3) Using explanatory variables with a one-period lag. The one-period lag of digital business environment ie used for the regression to reduce lag effect. Table 3 displays the results. As can be observed, the digital business environment's regression coefficients are both statistically significant positive at the 1% level, further supporting hypothesis H1.

Table 3. Robustness test regression results

	(1) RD1_1	(2) RD2_1	(3) RD2	(4) RD1	(5) RD2
Env	0.004*** (0.000)	0.097*** (0.016)	0.087*** (0.022)	0.293*** (0.015)	0.048*** (0.021)
_cons	-0.014*** (0.002)	-2.381*** (0.180)	-2.381*** (0.180)	10.057*** (0.154)	-1.857*** (0.152)
Oth-ers	YES	YES	YES	YES	YES
N	13965	11970	8278	11970	11970
R2	0.271	0.123	0.181	0.548	0.133

4.3 Mechanism test

According to the theoretical analysis in the previous section, the digital business environment can promote enterprise innovation through the path of improving the quality of internal control. Referring to Huayou Duan[8], the quality of internal control (IC) is measured using the enterprise internal control index published in the Shenzhen DIB database. And the models are constructed as follows:

$$RD_{i,t} = \beta_0 + \beta_1 Env_{i,t} + \beta_1 Controls + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (2)$$

$$IC_{i,t} = \beta_0 + \beta_1 Env_{i,t} + \beta_1 Controls + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (3)$$

$$RD_{i,t} = \beta_0 + \beta_1 Env_{i,t} + \beta_2 IC_{i,t} + \beta_1 Controls + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (4)$$

The findings are displayed in Table 4. Column (1) shows a significant positive relationship between digital business environment and internal control quality at 1% level of significance, and the coefficients of Env and IC in columns (2) and (3) are both significantly positive, suggesting that the internal control quality improvement plays a partially intermediary role, which verifies hypothesis H2. At the same time, the results of the Sobel test and Bootstrap test also demonstrate the mediating effect of internal control quality, so hypothesis H2 is again tested.

Table 4. Results of the path mechanism test

	(1) IC	(2) RD1	(3) RD2
Env	0.131*** (0.019)	0.284*** (0.014)	0.038** (0.019)
IC		0.066*** (0.007)	0.067*** (0.007)
_cons	5.131*** (0.165)	9.716*** (0.148)	-2.141*** (0.149)
Others	YES	YES	YES
N	13965	13965	13965
R2	0.172	0.548	0.135
Sobel Z		5.737***	5.235**
Indirect effects		[0.0060,0.0124]	[0.0058,0.0119]
Direct effects		[0.2575,0.3085]	[0.0022,0.0808]

5 Conclusions

The study finds that the optimization of the digital business environment not only stimulates enterprises' willingness to innovate and increase their investment in innovation, but also promotes high-quality innovation output, improves the current situation of "quantity over quality" and effectively enhances the innovation capability of enterprises. The quality of internal control plays a partially mediating role in this effect.

The findings have implications for how governments and enterprises can improve their capacity for innovation. The government needs to fully utilize digital technology to create an efficient and transparent digital government to reduce the transaction costs of enterprises, enhance digital financial services to ease corporate financing constraints, and enhance the pertinent digital legislation and focus on intellectual property protection to stimulate the vitality of business entities. Enterprises, as subjects of innovation, should also seize the convenience and opportunities by the development of digital business environment, use digital technology to improve the quality of internal controls, and foster the deep integration of digital technology and innovation factors to continuously improve their innovation capabilities.

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