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Digital Inclusive Finance and Corporate Technological Innovation

Yinghan Lu[1,a,*]

[1]*Department of Finance, Shandong University of Finance and Economics, Jinan, China*
a. 1022421883@qq.com
**corresponding author*

Abstract: As digital technology develops apace, digital inclusive finance has appeared before people's eyes. Its emergence has brought new technological innovation power for enterprises and provided new opportunities for the economic high-quality development of the nation. This paper carries out theoretical analysis and empirical analysis, and draws the following conclusions: The advancement of digital inclusive finance has a pronounced impact on fostering corporate technological innovation and this effect has regional heterogeneity; Human capital stock and urbanization level play a mediating role in this process. Finally, policy recommendations are made accordingly: firstly, the government should invest more in digital inclusive finance; secondly, it should pay attention to the positive roles played by human capital stock and urbanization level in promoting technological innovation of enterprises.

Keywords: digital inclusive finance, corporate technological innovation, human capital, level of urbanization.

1. Introduction

Now, strengthening scientific and technological innovation to create new momentum for the development of new quality productivity has become a new requirement for the stage of high-quality development.

The rapid advancement of digital technology has facilitated the widespread adoption of various technologies, including computers, the Internet, big data, and other information technologies, and it has become possible to transform and upgrade traditional industries through digital means. In order to invigorate the high-quality development of China's economy, the seamless integration of emerging digital technologies with traditional inclusive finance has given rise to the concept of digital inclusive finance. Digital inclusive finance encompasses the delivery of new, convenient, and cost-effective financial services through digital technology to individuals who are challenging to be covered by traditional financial services. These are usually people from relatively poor and remote areas of developing countries, micro and small entrepreneurs, and so on. By expanding the horizons of financial services, digital inclusive finance effectively enhances the functionality of financial services, improves service efficiency, and effectively solves the problems of the "last kilometer" and "last step" of financial services, bringing new opportunities for China's innovative development.

First, this paper draws on the theories and empirical analyses proposed by relevant scholars, promotes the development of research about the effect of digital inclusive finance on enterprise

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technological innovation, complements the research in related fields, and has theoretical significance for further understanding the relationship between the two. Secondly, the study of the mechanism will broaden the understanding of government departments of the two and their interrelationship, provides new ideas for the policy formulation of relevant departments, and has practical significance in promoting the coordination of policies.

2. Literature Review

In this day and age, digital inclusive finance has garnered considerable interest from scholars across different disciplines, leading to a wealth of research findings and theories in this field. Previous research on digital inclusive finance has focused on the impact of digital inclusive finance. The impact can simply divide into four levels: broadening financial services, improving financing efficiency, accelerating capital accumulation, and optimizing resource allocation. First, regarding to broadening financial services, digital inclusive finance improves processing efficiency and cost management capabilities through using digital technology, reduces the demand for private capital [1], and enhances the integration of finance and industry [2]. Secondly, in terms of improving financing efficiency, digital inclusive finance can reduce information asymmetry, thereby enhancing its capital inflow efficiency and alleviating the problem of enterprise financing constraints [3]. Then, with regard to accelerating capital accumulation, digital inclusive finance expands the financing channels of economic entities, thus promoting the formation of various types of capital. Ultimately, in optimizing resource allocation, through enhancing the reach and availability of financial products and services, digital inclusive finance can enhance the efficiency and precision of resource allocation in the financial sector.

There are many academic studies on enterprise technological innovation, and this paper synthesizes their influencing factors. Researches on the factors that influence enterprise technological innovation mainly focus on the market and the micro enterprise itself. In the market, market demand is an essential driving force for enterprise technological innovation, and enterprises realize technological innovation by continuously understanding and responding to market demand to adjust and improve their products and services. In the case of enterprises themselves, effective internal organizational structures and management mechanisms can facilitate information flow and collaborative innovation and improve innovation efficiency. In addition, the increased urbanization level of the region when the enterprise is located [4] will also promote technological innovation.

3. Theoretical Analysis

Small and medium-sized enterprises (SMEs) contribute more than 70% of technological innovation in China. The traditional financial market favors investment by large enterprises, making it difficult for SMEs to access the resources needed for technological innovation. However, through the expansion of financing channels and other means, digital inclusive finance has the capacity to mitigate the financing limitations experienced by SMEs, thus catalyzing enterprise technological innovation.

Based on the above analysis, this paper proposes the first hypothesis:

Hypothesis 1: Digital inclusive finance has a facilitating effect on enterprise technological innovation.

Digital inclusive finance may have promoting effect on human capital stock. In economically underdeveloped areas, due to the imperfection of the financial market, a lot of poor families cannot bear the cost of education through financing, resulting in a lack of human capital [5]. Digital inclusive finance, as part of the financial market, provides more possibilities for capital lending and borrowing, increases financial accessibility, and expands the opportunities for low-income groups to access educational and economic resources, thus increasing human capital stock. additionally, improving the

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proportion of technicians and the education level of employees can enhance technological innovation in enterprises, and increasing the education of personnel may enhance the efficiency of R&D capital utilization [6].

Based on the above analysis, this paper proposes the second hypothesis:

Hypothesis 2: digital inclusive finance promotes corporate technological innovation by facilitating the enhancement of human capital stock.

The second macro factor considered in the article is urbanization level.In the first place,Digital inclusive finance not only opens up numerous opportunities and channels for both the supply and demand aspects of funds through factor flows, industrial structure enhancement, and technological innovation but also plays a pivotal role in integrating finance with industry, thereby driving urbanization. Secondly, as the level of urbanization increases, the spatial layout of cities is improved, and enterprises gather together to form a community conducive to the functioning of the market economy. Various factors of production have been fully utilized and optimized, increasing the level of science and technology in the region. Urbanization can also promote technological innovation by enhancing capital accumulation, improving the quality of labor, or expanding the size of the city.

Based on the above analysis, this paper proposes the third hypothesis:

Hypothesis 3: Digital inclusive finance promotes technological innovation of enterprises by improving urbanization.

4. Mathematical Model Construction

This paper use panel data of 31 provinces in the country (excluding Hong Kong, Macao and Taiwan) from 2011-2022 to construct the regression model using two-fixed effects. Due to the large absolute differences between the data of the selected variables, all variables are treated as logarithmic.

The explanatory variable is enterprise technological innovation (INN). In this paper, we choose patent application authorization to measure enterprise technological innovation.

The explanatory variable is digital inclusive finance (ind). This paper used the 2011-2022 Peking University Digital Inclusive Finance Index [7] to measures digital inclusive finance development level.

Based on the transmission mechanism analysis detailed in the preceding theoretical section, human capital stock (hum) and urbanization level (urb) have been selected as mediating variables to investigate the specific pathways through which digital inclusive finance influences enterprise technological innovation. This paper employs the ratio of undergraduate students enrolled in general higher education institutions to the resident population at the year-end as a metric for assessing the human capital stock (hum). Additionally, the urbanization rate is determined by the ratio of the urban population to the overall resident population at the close of the year, serving as a gauge for the level of urbanization (urb). The data utilized in this study are sourced from the National Bureau of Statistics.

Considering the availability of data and based on relevant studies , this paper chooses more representative control variables. They are economic development (gdp), industrial structure upgrading (upg), open-up degree (ope) and government support (gov). The gdp is expressed through the per capita GDP of each province. The lnupg represents the level of development, which is quantified by the ratio of the combined value added from secondary and tertiary industries to the regional GDP. The variable lnope indicates openness, measured by the ratio of foreign direct investment to the region's GDP. Lastly, the variable lngov reflects governmental support, determined by the ratio of science and technology expenditure to the overall budgetary outlay. The above data are from the National Bureau of Statistics and provincial statistical yearbooks.

$$\mathrm{Lninn}_{\mathrm{I,t}} = \alpha_0 + \alpha_1 \mathrm{lnind}_{\mathrm{I,t}} + \alpha_2 \mathrm{lngdp}_{\mathrm{I,t}} + \alpha_3 \mathrm{lnupg}_{\mathrm{I,t}} + \alpha_4 \mathrm{lnope}_{\mathrm{I,t}} + \alpha_5 \mathrm{lngov}_{\mathrm{I,t}} + \mathrm{i.year} + \mathrm{i.province} + \varepsilon_{\mathrm{I,t}} \quad (1)$$

In this equation, the i and t represent the data for the ith province in year t. The symbol α_0 represents constant terms, lninn is the dependent variable, lnind is the primary independent variable,

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while lnupg, lnope, lngov, and lngov are the control variables in the model. The terms i.year and i.province capture the provincial and yearly effects, respectively, and $\varepsilon_{i,t}$ represents the error term accounting for random fluctuations in the data.

5. Empirical Analysis

5.1. Model Test

After logarithmic processing, missing data for some years in individual provinces were completed by interpolation and trend methods. The statistical descriptive results are shown in Table 1.

Table 1: Descriptive statistics of variables.

Variable names	Sample size	Average	Standard Deviation	Minimum	Maximum
lninn	372	10.16	1.630	4.796	13.68
lnind	372	5.331	0.673	2.786	6.133
lnhum	372	-4.441	0.336	-5.250	-3.592
lnurb	372	-0.550	0.229	-1.485	-0.110
lngdp	372	10.86	0.462	9.682	12.15
lnupg	372	-0.104	0.0592	-0.299	-0.00220
lnope	372	-4.602	1.362	-9.705	-2.112
lngov	372	-4.093	0.688	-5.800	-2.695

5.2. Baseline Regression Analysis

To initially ensure the robustness of the model, this paper chose to make the control variables added one by one for regression.

Table 2: Baseline regression results.

	(1) lninn	(2) lninn	(3) lninn	(4) lninn	(5) lninn
lnind	0.696***	0.545***	0.572***	0.584***	0.586***
	(0.136)	(0.158)	(0.159)	(0.162)	(0.159)
lngdp		0.889*	0.712*	0.716*	0.652
		(0.508)	(0.395)	(0.391)	(0.441)
lnupg			4.701**	4.601**	4.496**
			(2.171)	(2.073)	(2.022)
lnope				0.020	0.016
				(0.040)	(0.034)
lngov					0.046
					(0.114)
CONS	6.645***	-2.072	0.223	0.210	1.036
	(0.478)	(5.002)	(3.813)	(3.768)	(4.560)
Regional fixed effect	YES	YES	YES	YES	YES
Annual fixed effect	YES	YES	YES	YES	YES
N	372.000	372.000	372.000	372.000	372.000

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Table 2: (continued).

R^2	0.902	0.907	0.911	0.912	0.912
Adjusted R^2	0.899	0.904	0.908	0.908	0.908

The specific regression results are presented in Table 2. In Table 2, the coefficient of the explanatory variable is found to be highly significant at a 1% confidence level, indicating a strong positive relationship between digital inclusive finance and corporate technological innovation. Thus, hypothesis 1 is proven, and the model is initially judged to be robust. As indicated by the regression results in Column (5), holding the other relevant variables constant, a one percent rise in the level of digital inclusive finance is associated with a 0.586 percent increase in the technological innovation of enterprises. The adjusted R^2 shows a rising trend as additional control variables are incrementally included, suggesting an enhanced fitting effect of the regression model and improved explanatory power for the dependent variable.

Subsequently, this study examines the model's robustness by replacing variable, shrinking the tail, and excluding samples. Among them, the replacement variable chooses to replace the explanatory variable for the domestic patent application acceptance (lnreinn), and the explanatory variable lagged by one period of treatment, while the shrinking treatment shrinks the continuous variable by 1% up and down, and the exclusion sample takes into account the new crown epidemic and excludes the samples from 2020 to 2022. In Table 3(1)-(4), the results are shown.

Table 3: Robustness Tests.

	(1) lninn	(2) lnreinn	(3) lninn	(4) lninn
L.lnind	0.645***			
	(0.166)			
lnind		0.605***	0.637***	0.420**
		(0.163)	(0.157)	(0.167)
Control variables	YES	YES	YES	YES
CONS	0.470	-0.013	0.758	4.038
	(5.115)	(5.624)	(4.436)	(5.114)
N	341.000	372.000	372.000	279.000
R^2	0.908	0.857	0.912	0.856
Adjusted R^2	0.904	0.850	0.908	0.849

(1), (2), (3), and (4) show the regression results after lagging the explanatory variable (lnind) by one period of treatment, replacing the explanatory variable, shrinking the tail by 1%, and excluding the sample, respectively. The coefficients of the explanatory variable (lnind) are highly significant at a 1% confidence level, which is consistent with the results of baseline regression, suggesting that the model passes the robustness test.

To explore regional heterogeneity, this study stratifies the 31 provinces into 4 primary regions: the eastern, central, western, and northeastern areas, for a comprehensive analysis of regional disparities. The regression outcomes are displayed in Table 4, with columns (1), (2), (3), and (4) denoting the eastern, central, western, and northeastern regions correspondingly.

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Table 4: Heterogeneity Analysis Regression.

	(1) lninn	(2) lninn	(3) lninn	(4) lninn
lnind	0.332	1.803	0.490**	-0.398
	(0.496)	(1.143)	(0.184)	(0.563)
Control variables	YES	YES	YES	YES
CONS	21.477	-4.645	3.202	-28.665
	(13.186)	(12.707)	(9.819)	(20.130)
N	120.000	72.000	144.000	36.000
R^2	0.931	0.946	0.917	0.982
Adjusted R^2	0.921	0.931	0.907	0.966

Column (3) shows that the level of digital inclusive finance is positively correlated with firms' technological innovation at the 5% significance level in the sample data from the western region, while in other regions, i.e., columns (1) (2) and (4), it presents a non-significant correlation. The findings suggest that the influence of digital inclusive finance on enterprise technological innovation is more pronounced in the western region compared to other regions. Conversely, technological innovation in enterprises within the remaining regions shows limited responsiveness to variations in digital inclusive finance levels. Therefore, this study concludes that there exists regional heterogeneity in the impact of digital inclusive finance on enterprise technological innovation.

5.3. Mechanism Testing

In this paper, we consider the two-step method [8] to test the mediating effect of human capital stock and urbanization level. Construct the following mediation effect model, and the regression results are shown in Table 5.

$$\mathrm{lninn}_{i,t} = \alpha_0 + \alpha_1 \mathrm{lnind}_{i,t} + \alpha_2 \mathrm{lngdp}_{i,t} + \alpha_3 \mathrm{lnupg}_{i,t} + \alpha_4 \mathrm{lnope}_{i,t} + \alpha_5 \mathrm{lngov}_{i,t} + \mathrm{i.year} + \mathrm{i.province} + \varepsilon_{i,t} \quad (2)$$

$$\mathrm{lnhum}_{i,t} = \beta_0 + \beta_1 \mathrm{lnind}_{i,t} + \beta_2 \mathrm{lngdp}_{i,t} + \beta_3 \mathrm{lnupg}_{i,t} + \beta_4 \mathrm{lnope}_{i,t} + \beta_5 \mathrm{lngov}_{i,t} + \mathrm{i.year} + \mathrm{i.province} + \varepsilon_{i,t} \quad (3)$$

$$\mathrm{lnurb}_{i,t} = \beta_0 + \beta_1 \mathrm{lnind}_{i,t} + \beta_2 \mathrm{lngdp}_{i,t} + \beta_3 \mathrm{lnupg}_{i,t} + \beta_4 \mathrm{lnope}_{i,t} + \beta_5 \mathrm{lngov}_{i,t} + \mathrm{i.year} + \mathrm{i.province} + \varepsilon_{i,t} \quad (4)$$

Table 5: Mechanism Test Results

	(2) lninn	(3) lnhum	(4) lnurb
lnind	0.586***	0.189***	0.189***
	(0.159)	(0.063)	(0.034)
Control variables	YES	YES	YES
CONS	1.036	-5.782***	-3.784***
	(4.560)	(1.842)	(0.940)
N	372.000	372.000	372.000
R^2	0.912	0.803	0.901
Adjusted R^2	0.908	0.795	0.897

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The results shown in Table 5 demonstrate that the coefficients of the explanatory variable are statistically significant and positive in models (2), (3), and (4), suggesting a favorable impact on enterprise technological innovation, human capital stock, and urbanization level.According to related research, human capital can promote enterprise technological innovation by increasing the technological potential of technological innovation sources and technology adopters [9]. And, urbanization shows a significantly positive effect on technological innovation [10]. Thus, we can judge that human capital stock and urbanization level can improve technological innovation of enterprises. The mediating effects of human capital stock and urbanization level tested by the two-step method is established, and hypothesis 2 and 3 are proved.

6. Research Conclusions and Policy Recommendations

In conclusion, the research reveals that digital inclusive finance exerts a significant positive influence on enterprise technological innovation, with observed regional disparities. Specifically, the western region displays a heightened sensitivity to digital inclusive finance in fostering technological innovation within enterprises, contrasting with the relatively subdued impact in other regions. Furthermore, the study underscores the role of digital inclusive finance in advancing enterprise technological innovation through the augmentation of human capital accumulation and urbanization level.

Building on the findings above, this paper puts forward the following policy recommendations:

To begin with, it is recommended that the government enhance its funding allocation towards digital inclusive finance, tailor incentive policies to align with regional nuances, and enhance interregional collaboration and synergy. Particularly in the western region, there is a need for heightened government investment in digital inclusive finance initiatives to drive awareness and adoption throughout the region.

Secondly, the positive role of human capital stock and urbanization level should be emphasized. The government can increase investment in education and deepen the reform of the skill training model. At the same time, the government should strengthen urbanization regulation and infrastructure construction, support the urbanization process, and enhance urban industrial structure upgrade.

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