The Innovation Effect of Information Infrastructure—Based on the Mediating Effect of Human Capital and Technology Diffusion

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Abstract. As the carrier and support of digital technology, information infrastructure is of great significance to promote innovation level. This paper empirically analyzes the effect and mechanism of information infrastructure on innovation, using the panel data of 30 provincial-level regions in China. The research shows that information infrastructure can promote innovation from quantity and quality. Information infrastructure can promote innovation level by promoting human capital accumulation and accelerating technology diffusion.

Keywords: information infrastructure, quantity of innovation, quality of innovation, human capital, technology diffusion

1 Introduction

Information infrastructure is important to digital economy. Global Innovation Index 2022 demonstrates that, China ranked first in patent applications, while the total brand value and intellectual property income representing the high-quality development of intellectual property rights ranked 18th and 35th respectively. China is still facing the innovation dilemma.

In terms of scholars' research, some focus on the connotation of information infrastructure, and believe that information infrastructure, using Internet data resources as a key factor of production, is an important pillar to promote new industrialization and greening and support the digital transformation and development of economic society [1]. Most scholars have chosen the pilot policy [2], or carried out word frequency analysis on the relevant content in the government work report to measure information infrastructure [3]. Rampersad and Troshani studied its influence on innovation in rural areas, and its effect was initially proved [4]. Zhao Xing tested the technological innovation effect of new infrastructure, and further explored the heterogeneity of government attention period and human capital level [5].

There is still much room in the research of information infrastructure. In terms of measurement, information infrastructure not only carry out information and digital processing on the consumer

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side, but also go deep into the production side. In terms of the innovation effect of information infrastructure, most of the research focuses on the number of innovative patents, and there are relatively few studies on the quality of innovation. The quality of innovation is related to increase product added-value, reduce energy consumption and pollutant emissions, and reduce R&D risks and optimize resource allocation [6]. In this context, Whether the information infrastructure has innovative effect and the effect mechanism are the problems to be solved.

2 Theoretical mechanism and research hypothesis

Information infrastructure can exert its own innovation effect from two aspects. First, information infrastructure helps to change the combination and connection of resources, cut down costs in the process of creation, save R&D costs, and enhance technology absorption and re-innovation, thus directly promoting technological innovation and increasing the quantity of innovation [7]. Second, information infrastructure greatly lift the transmission speed of information and high-end research results, and is conducive to substantive innovation output. Digital technology enables market players not only to know the data on the demand side, but also to master the data on the supply side [8]. At the same time, energy saving and consumption reduction has become an effective way to improve competitiveness, so market players will seize the opportunity to promote green technology patent research and development; the agglomeration of innovative elements such as data and knowledge to regions with high levels of information infrastructure will also attract universities, scientific and technological research institutes and high-tech enterprises, which is conducive to collaborative innovation.

Hypothesis 1: Information infrastructure is positively affecting the quantity and quality of innovation.

This paper believes that there are two paths for information infrastructure to improve the level of regional innovation. First, regional innovation can be improved by human capital accumulation because information infrastructure will increase the demand for highly skilled talents of enterprises. High-quality human resources can make theoretical innovation more quickly into the innovation of real products, so as to obtain more significant innovation results. Second, it can boost regional innovation by accelerating technology diffusion. Information infrastructure can improve communication efficiency. The technology diffusion can boost the sharing speed, so that participants can obtain cutting-edge technology more easily and upgrade the level of technological innovation.

Hypothesis 2: Information infrastructure improves regional innovation level by promoting human capital accumulation.

Hypothesis 3: Information infrastructure improves regional innovation level by accelerating technology diffusion.

3 Research design

3.1 Model settings

This article uses a panel data bidirectional fixed effects model to test hypothesis 1, which estimates the impact of information infrastructure on regional innovation capacity. The specific model settings are as follows:

$$y_{it} = \beta_0 + \beta_1 \cdot fra_{it} + \beta_2 \cdot X_{it} + \rho_i + \theta_t + \varepsilon_{it} \quad (1)$$

β is the parameter to be estimated, the subscripts i and t represent the province and the year, respectively. Regional innovation is represented by y. information infrastructure is represented by *fra*. X represents the control variable.

3.2 Variable selection

This paper measures the level of innovation from quantity and quality. Patents can better reflect regional innovation. Therefore, according to the patent classification of the State Intellectual Property Office, this paper uses the sum of the number of inventions, utility model and design patent applications per 10,000 people in the province to measure the number of regional innovations. This paper divides innovation quality into substantive, green and collaborative innovation.

The core explanatory variable is the level of information infrastructure construction. Based on the concept definition of information infrastructure in the previous text and referring to the research ideas of Hongwei Meng et al. [9], this article selects two dimensions of traditional information infrastructure and neotype infrastructure construction to reflect the status of information infrastructure. The Entropy Weight Method is used to calculate the level of information infrastructure. The specific evaluation index system is shown in Table 1.

Table 1. Index system of information infrastructure.

Target	Dimension	Index
Information infrastructure	Traditional information infrastructure	Number of web pages per 10,000 people
		Number of Internet access ports per 10,000 people
	Neotype infrastructure	The proportion of 3G and 4G users
		Long-distance optical cable line density

The control variables mainly include:Proportion of science expenditure in total public budget(tec); Ratio of deposits and loans of financial institutions to local GDP (fin); Proportion of total foreign direct investment to regional GDP(fdi);Ratio of fixed property investment to GDP (gp); Proportion of education spending in total public budget (edu); Ratio of regional GDP to government budget(mar).

3.3 Data description

This paper uses the region-level data in China except Tibet and Hong Kong, Macao and Taiwan, and the time range is 2013-2020. Green innovation and industry-university-research collaborative innovation indicators draw on the ideas of Peizhen Jin et al [6]., and use the search formula to manually collect and organize them on the patent search and analysis website. The data on the level of information infrastructure construction are from the Broadband Development Alliance. The remaining data are mainly from China Statistical Yearbook, China City Statistical Yearbook.

4 Empirical results

4.1 Baseline regression

As indicated in Table 2, information infrastructure can improve regional innovation from quantity and quality. With the raise of information infrastructure, the number of innovations, substantive, green, substantive and industry-university-research collaborative innovation has enhanced significantly.

Table 2. Baseline Regression.

Variable	Innovation	Innovation Quality		
	patent	invent	green	iurc
fra	1.474***	0.982***	0.231***	0.030***
	(0.142)	(0.131)	(0.029)	(0.002)
Control Variable	Yes	Yes	Yes	Yes
N	240	240	240	240
R^2	0.688	0.568	0.708	0.642
Fixed Effect	Yes	Yes	Yes	Yes

4.2 Impact mechanism test

This paper establishes the following mediating effect model to examine the internal mechanism of information infrastructure to improve regional innovation capability.

$$y_{it} = \alpha_0 + \beta_3 \cdot station_{it} + \beta_4 \cdot X_{it} + \rho_i + \theta_t + \varepsilon_{it} \quad (2)$$

$$M_{it} = \alpha_1 + \beta_5 \cdot station_{it} + \beta_6 \cdot X_{it} + \rho_i + \theta_t + \varepsilon_{it} \quad (3)$$

$$y_{it} = \alpha_2 + \beta_7 \cdot station_{it} + c \cdot M_{it} + \beta_8 \cdot X_{it} + \rho_i + \theta_t + \varepsilon_{it} \quad (4)$$

In the formula, M is intermediary variable, that is, human capital and technology diffusion, and remaining formula variables are consistent with the previous benchmark model. This paper uses the ratio of high-skilled and low-skilled labor to measure human capital (AHC), and uses the proportion

of technology market transactions in GDP as a proxy variable for technology diffusion (TD). The mediating effect model is used by referring to the methods of Zhonglin Wen and Baojuan Ye [10].

Table 3 shows the regression results with human capital as the intermediary variable, in which stages one, two and three correspond to formulas (2), (3) and (4) respectively. This shows that information infrastructure enhance regional innovation by boosting the accumulation of high-tech talents to.The regression results of technology diffusion as an intermediary variable are shown in table 4. Information infrastructure construction has significantly accelerated the diffusion of technology. In Step 3, the mediating effect of technology diffusion on the impact of information infrastructure on substantive innovation has not passed the Bootstrap test, and the rest have partial mediating effects. This shows that information infrastructure improves innovation by effectively speeding up the spreading of technical knowledge. In summary, the test results of the two intermediary mechanisms basically verify hypothesis 2 and hypothesis 3.

Table 3. Test results of human capital accumulation mechanism.

Variable	Stage one				Stage two	Stage three			
	pat	invent	green	iurc	AHC	pat	invent	green	iurc
fra	1.474*	0.982*	0.231*	0.030***	0.035***	0.935*	0.712*	0.145*	0.008
	(0.142)	(0.131)	(0.029)	(0.002)	(0.002)	(0.328)	(0.085)	(0.050)	(0.007)
AHC						15.601	7.820*	2.504*	0.651*
						(6.513)	(2.617)	(1.136)	(0.138)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	240	240	240	240	240	240	240	240	240
R2	0.688	0.568	0.708	0.642	0.844	0.706	0.600	0.722	0.710

Table 4. Test results of technology diffusion mechanism.

Variable	Stage one				Stage two	Stage three			
	pat	invent	green	iurc	TD	pat	invent	green	iurc
fra	1.474*	0.982*	0.231*	0.030***	0.0006**	1.338*	0.968*	0.212*	0.027*
	(0.142)	(0.131)	(0.029)	(0.002)	(0.0001)	(0.178)	(0.116)	(0.032)	(0.003)
TD						216.30	23.45	29.532	5.177*
						(106.0	(45.89	(16.42	(2.001)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bootstrap							P=0.65		
N	240	240	240	240	240	240	240	240	240
R2	0.688	0.568	0.708	0.642	0.582	0.702	0.567	0.716	0.659

5 Conclusion

China urgently needs information infrastructure construction to generate new development momentum and achieve high-quality development driven by innovation. Based on the existing theoretical and empirical research, this paper constructs a comprehensive index of information infrastructure from the traditional and new dimensions, analyzes its effect and mechanism on regional innovation.

Information infrastructure can significantly promote the improvement of regional innovation level. Enhance the construction of information infrastructure such as big data, artificial intelligence, etc., while grasping the social needs of the evolution of traditional infrastructure functions, and creating a system integrating equipment perception, data processing, and network communication.

Information infrastructure can enhance regional innovation by human capital accumulation and technology diffusion. The government should value the talent training, formulate more attractive policies for personnel. At the same time, we should improve the technology market trading system and establish a reasonable intellectual property protection mechanism to provide a stronger driving force for the diffusion of technical knowledge.

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