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Research on the influence mechanism of intellectual property protection on China's digital economy

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Abstract: In the context of accelerating the construction of the digital economy, it is of great practical significance to study the degree of intellectual property protection to improve the development of the digital economy to help the high-quality development of China's digital economy. The data of 273 cities in China from 2012 to 2021 were selected as samples, and the level of intellectual property protection was measured by the number of intellectual property cases, and the development of the digital economy was measured by the Internet infrastructure, Internet-related output, and digital financial inclusion. It is found that 1) The protection of intellectual property rights has significantly improved the level of development of the digital economy. 2) Intellectual property protection can promote the development of the digital economy by increasing the activity of innovation. 3) The impact of intellectual property protection on the digital economy is verified from the levels of different regions, city sizes and local financial resources, and it is found that the positive effect of intellectual property protection on the digital economy in the eastern region, Type II large cities and cities with high local financial resources is greater.

Keywords: Intellectual property protection; digital economy; influence mechanism

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1. Introduction

The G20 Digital Economy Development and Cooperation Initiative proposes to create an appropriate and effective intellectual property protection system to promote the development of the digital economy. The 14th Five Year Plan emphasizes the need to support the development of innovative consortia such as digital technology open source communities, improve open source intellectual property rights and legal systems. Intellectual property protection, as a strategic resource for national development, is a key element in regulating market order, promoting modernization of national governance, and enhancing national competitiveness. It provides a new breakthrough for the high-quality development of the digital economy.

In recent years, with the development of information networks and communication technologies, the digital economy has made historic breakthroughs, and its new business forms are rewriting the global competition pattern. In 2022, the total scale of China's digital economy reached 50.2 trillion yuan, ranking second in the world, an increase of 10.3% over 2021, accounting for 41.5% of GDP. However, China's digital economy also has many shortcomings, such as uneven technological development, mostly concentrated in the consumer field, and insufficient production fields such as system software and chip hardware. China's regulations on the protection of intellectual property rights in the digital economy mostly stipulate the storage of copyrighted works, software source code, electronic reproduction rights and copyrights in electronic form, and emphasize the protection of databases and trade secrets.

In the context of accelerating the construction of the digital economy, studying the degree to which intellectual property protection can enhance the development of the digital economy is of great practical significance for supporting the high-quality development of China's digital economy.

2. Theoretical Analysis and Research Hypotheses

2.1. The Direct Effect of Intellectual Property Protection on the Digital Economy

The main components of the digital economy are digital technology and creative content. The digital economy includes 5G, communication and Internet technologies, which are patent intensive industries; Creative content includes television, publications, music, etc., and belongs to the creative intensive industry. Therefore, the digital economy is an intellectual property intensive industry that is closely related to intellectual property protection. On the one hand, intellectual property protection can provide the necessary resources for the development of the digital economy, such as an improved business environment and entrepreneurial spirit [1], meeting the unique innovation, sharing, and virtuality of digital economy development. On the other hand, intellectual property protection can promote the high-end development of the digital economy. At present, the development of China's digital economy is uneven, with consumer sectors such as financial technology, e-commerce, and mobile payments in a dominant position, and production areas such as electronic chips and software systems lacking development [2]. Intellectual property protection can promote the development of digital technology in the production field, improve the situation where core technology in China is subject to human control, and provide a sustained driving force for the development of the digital economy. In summary, the following assumptions are proposed:

Assumption 1: Intellectual property protection has a promoting effect on the digital economy.

2.2. The Indirect Impact Mechanism of Intellectual Property Protection on the Digital Economy

Intellectual property protection can not only directly affect the digital economy, but also influence the digital economy through innovation activity.

Intellectual property protection can affect innovation activity, mainly manifested in three aspects. Firstly, reducing the possibility of innovation achievements being encroached upon and improving the innovation benefits of innovation entities. The digital economy has the characteristic of rapid information dissemination, while innovative achievements are non competitive knowledge products that cannot exclude the use of other stakeholders, making the acquisition of innovative achievements more convenient, fast, and low-cost [3]. The possibility of being occupied rapidly increases, and innovative entities face huge losses. The two most important aspects of intellectual property protection are the formulation of intellectual property laws and the level of enforcement of intellectual property protection [4]. Innovative entities can use the legitimate rights granted by intellectual property laws to protect their innovation rights and interests. Through authorization and technology licensing, innovative entities can obtain exclusive benefits for a period of time, creating a fair environment for innovation activities. At the same time, intellectual property protection can utilize legal and rights protection centers to provide channels for rights protection and address rights demands, to a certain extent, to prevent relevant stakeholders from stealing innovative achievements, prevent the spread of the "free riding" phenomenon, regulate market order with mandatory legal protection, enhance the interests of innovative entities, increase innovation benefits, and enhance their innovation motivation. The effectiveness of the previous round of intellectual property protection will affect the innovation momentum of the next round, forming a virtuous innovation cycle system. Secondly, reduce trial and error costs and improve innovation

efficiency. Compared to independent research and development enterprises, payment imitation innovation enterprises reduce time costs to a certain extent, can quickly seize the market, reduce trial and error costs in the early stage, and effectively improve the efficiency of technological innovation. Moreover, enterprises can integrate existing and new technological innovations, digest and absorb newly introduced technologies, adjust new technologies based on the needs of the target market and product characteristics, and form breakthrough innovation outputs through technological innovation. Thirdly, increasing the cost of imitation innovation forces independent innovation. Due to the protection of intellectual property rights, non innovator enterprises need to pay high innovation imitation costs, establish entry barriers, and force them to change their innovation strategy, shift from imitation innovation to independent innovation, invest funds and talents in research and development, and obtain monopolistic innovation benefits after conquering key technologies.

The increase in innovation activity helps to promote the development of the digital economy. One is to accelerate the diffusion of knowledge. The higher the level of innovation activity, the more convenient the communication, and the faster the dissemination and diffusion of knowledge [5]. Innovation participants have a higher willingness to improve their ability to absorb and manage knowledge, which helps to create more digital economy business opportunities for the local area and empower the development of the digital economy [6]. In addition, the development of digital economy and network technology conforms to Metcalfe's law and has a strong multiplier effect on network externalities. When implementing intellectual property protection, by establishing knowledge spillover mechanisms and knowledge dissemination channels through innovation activity, digital economy enterprises, individuals, and information are interconnected, continuously creating larger local networks and digital economy markets. The second is to improve the business environment. The increase in innovation activity has formed a good innovation atmosphere and further optimized the innovation environment of the city. Improving the urban innovation environment can ensure the full play of the innovation market mechanism, stimulate the driving force of digital independent innovation for individuals, enterprises, and research and development institutions, and promote the development of the digital economy. On the other hand, a good business environment can attract capital inflows, enhance the risk-taking ability of digital economy development, and promote the development of the digital economy. The third is to correct information asymmetry. The increase in innovation activity and the development of digital technology, especially information and communication technology, have reduced the cost of obtaining information for market participants, making high-quality products and services recognized by the market, making competition between manufacturers more transparent, improving market transaction efficiency, and promoting the development of digital economy. For example, the Bitcoin distributed accounting technology with centralized and tamper proof features has corrected the previously widespread information asymmetry, promoted the flow of digital information, and solved the pain points of the digital economy. In summary, the following assumptions are proposed:

Assumption 2: Intellectual property protection can promote the digital economy by increasing innovation activity.

3. Research Design

3.1 Study Method

This article examines the overall impact of intellectual property protection on the digital economy by constructing a benchmark regression model. The model is as follows:

$$Dig_{it} = \alpha_0 + \alpha_1 IPP_{it} + \alpha_c X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

Among them, i and t respectively represent the city and year; Dig_{it} represents the digital economy; IPP_{it} represents intellectual property protection. The regression coefficient α_1 measures the impact of intellectual property protection on the digital economy. If intellectual property protection does indeed improve the development level of the digital economy, the coefficient α_1 should be significantly positive. X_{it} represents a set of control variables, including industrial structure, government support, financial development level, and foreign investment level. μ_i, δ_t and ε_{it} represent urban fixed effect, time fixed effect, and random disturbance term, respectively.

In order to examine the impact mechanism of intellectual property protection on the digital economy, based on the mediation effect test method, this article constructs the following regression model on the basis of equation (1):

$$Iact_{it} = \beta_0 + \beta_1 IPP_{it} + \beta_c X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

$$Dig_{it} = \gamma_0 + \gamma_1 IPP_{it} + \gamma_2 Iact_{it} + \gamma_c X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (3)$$

For the selected intermediary variable, innovation activity $Iact_{it}$, the following steps are taken to test: first, test whether the digital economy is influenced by the core explanatory variable, α_1 is expected to be significantly positive. Secondly, determine the relationship between intellectual property protection and intermediary variables, and if β_1 meets expectations, proceed to the next step of testing. Finally, if γ_2 is significant and significance of γ_1 decrease or coefficient is smaller than that in model (1), it indicates that the addition of innovation activity reduces the impact of the digital economy, and there is a partial mediating effect; If γ_1 is not significant, it indicates that intellectual property protection is fully mediated.

3.2. Variable Declaration

3.2.1. Explained variable

The dependent variable of this article is the level of development of the digital economy (Dig). The key production factors of the digital economy are digital information and knowledge. In terms of measurement, this article draws on the digital economy indicators constructed by Zhao Tao et al. (2020) [7], including infrastructure construction, digital technology development, and inclusive development of digital finance. Among them, infrastructure can build data resources and modern information network architecture, measuring Internet penetration by the number of Internet users per 100 people, and measuring the number of mobile. The development of digital technology can develop resource sharing space on the original basis, measuring the number of Internet related employees with the proportion of computer services and software practitioners, and measuring Internet related output with the total amount of per capita telecommunications business. The focus of inclusive finance reform is digitization, and the digital inclusive finance index is used to measure the inclusive development of digital finance. On the basis of the above indicators, use the entropy method to calculate the digital economy development index.

3.2.2. Core explanatory variables

The explanatory variable of this article is Intellectual Property Protection (IPP). This article refers to the method of Shen Guobing and Huang Shuojun (2021) [8], and expresses the level of intellectual property protection by the ratio of regional intellectual property cases to regional GDP.

$$IPP_{it} = \left(\frac{Case_{it}}{Case_{ct}}\right) / \left(\frac{Gdp_{it}}{Gdp_{ct}}\right) \quad (4)$$

Among them, $Case_{it}$ represents the number of intellectual property cases in region i for year t, Gdp_{it} represents the gross domestic product of region i for year t, $Case_{ct}$ represents the number of national intellectual property cases in year t, and Gdp_{ct} represents the annual gross domestic product.

3.2.3. Mediating variables

The mediating variable in this article is innovation activity. Patent indicators, as an effective measure of innovation activity (Iact), are divided into the number of patent applications and the number of patent authorizations. Patent applications that have not been reviewed will lower the innovation threshold and amplify the level of innovation. Therefore, based on the research results of Gao Bicong (2023) [9], this article uses the natural logarithm of the number of patent authorizations in the region+1 as the mediator variable indicator.

3.2.4. Control variables

Referring to existing literature research [10], this article adopts the following control variables in the model: (1) Industrial structure (Ind), characterized by the ratio of the gross domestic product of the tertiary industry to the gross domestic product of the secondary industry; (2) Government support (Sup) is characterized by the proportion of government science expenditure to government fiscal expenditure; (3) Financial development level (Fin) is characterized by the proportion of deposit and loan balances of financial institutions to GDP; (4) The level of foreign investment (FDI) is determined by the proportion of the actual amount of foreign investment used in the current year to the regional GDP. The descriptive statistics of the above variables are shown in **Table 1**.

Table 1. Descriptive Statistics of Variables

Variables	Meaning	Size	Mean	Standard	Min	Max
Dig	Digital Economy	3,003	0.105	0.0424	0.0340	0.677
Ipp	Intellectual property protection	3,003	0.465	0.790	0	12.47
Iact	Innovation activity	3,003	7.020	2.127	0	12.54
Ind	Industrial structure	3,003	1.042	0.583	0.114	5.348
Sup	Government support	3,003	0.0174	0.0176	0.000568	0.207
Fin	Financial development level	3,003	2.536	1.309	0.588	21.30
Fdi	The level of foreign investment	3,003	0.00409	0.0399	7.58e-11	1.915

3.3. Data Sources

This article selects data from 273 cities in China from 2012 to 2021 as the research sample. In terms of cross-sectional selection, a large number of samples with missing data were removed, and 273 cities were selected as the research objects. The Digital Inclusive Finance Index is sourced from the Digital Finance Research Center of Peking University, while other stock data on the digital economy is sourced from the Digital Economy Industry Special Database. The number of intellectual property cases closed is sourced from the Peking University Treasure Judicial Case Database, which searches for intellectual property ownership, infringement disputes, and intellectual property contract disputes. The national number of intellectual property cases closed is sourced from the Judicial Protection of Intellectual Property in Chinese Courts, and other variables are sourced from the China Statistical Yearbook, China Urban Statistical Yearbook, and local statistical bureaus. For missing numbers, linear interpolation is used to fill in the missing data.

4. Results and Analysis

4.1. Benchmark Regression Analysis

The results of the benchmark regression are shown in **Table 2**. Under the fixed effects model, according to column (1), it can be seen that the estimated coefficient of the core explanatory variable intellectual property protection is significantly positive, indicating that the stronger the intellectual property protection, the higher the level of digital economy development at the city level. Furthermore, columns (2) to (6) sequentially added other control variables that affect the digital economy. It is easy to observe that the coefficient of intellectual property protection has changed, but the sign and significance of the

coefficient have not changed, indicating that the impact of intellectual property protection on the digital economy is relatively stable.

Table 2. Benchmark regression results of the impact of intellectual property protection on the digital economy

	Dig				
Variables	(1)	(2)	(3)	(4)	(6)
Ipp	0.016***	0.014***	0.008***	0.006***	0.006***
	(8.10)	(8.05)	(6.32)	(5.47)	(5.46)
Ind		0.019***	0.019***	0.008***	0.008***
		(7.52)	(8.83)	(5.50)	(5.49)
Sup			0.643***	0.576***	0.576***
			(13.47)	(10.88)	(10.89)
Fin				0.009***	0.009***
				(7.18)	(7.17)
Fdi					0.005
					(0.75)
Constant	0.098***	0.079***	0.071***	0.048***	0.061***
	(106.46)	(28.74)	(29.03)	(8.87)	(28.82)
N	3,003	3,003	3,003	3,003	3,003
Urban fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
R2	0.103	0.173	0.250	0.281	0.317
F	65.55	58.43	113.5	72.46	256.1

Note: The data in parentheses are robust standard errors, where *, * *, and * * * refer to significance levels of 10%, 5%, and 1%, respectively. The same applies below.

Further examination of the control variables shows that industrial structure, government support, and financial development level are significantly positive at the 1% level, indicating that the development level of the tertiary industry, technology expenditure, and financial level are important factors in promoting the development of urban digital economy. Industrial structure optimization can reasonably allocate resources, adjust market factors, and help the local digital economy sprout and grow; Government funding can improve performance; Financial development contributes to the accumulation and aggregation of capital, improves the efficiency of resource allocation, and enhances the efficiency of the digital economy.

4.2. Analysis of Impact Mechanisms

Based on the theoretical analysis in the previous text, it can be concluded that innovation activity is an important reason for the impact of intellectual property protection on the digital economy. This article analyzes the logical mechanism through the mediation effect model, and the results are shown in **Table 3**. Among them, column (1) once again confirms that intellectual property protection has a significant positive impact on the digital economy; Column (2) uses innovation activity as the explanatory variable, and the coefficient of intellectual property protection is significant at the 1% level, indicating that intellectual property protection can drive an increase in innovation activity. By incorporating the variables of intellectual property protection and innovation activity into the regression model, it can be found that the coefficient of innovation activity in column (3) is significant at the 1% level, indicating a significant positive impact on the development of the digital economy; The coefficient of the impact of intellectual property protection on the digital economy has decreased compared to column (1), indicating that innovation activity has played a partial intermediary role in the process of intellectual property promoting the development of the digital economy. In order to enhance the reliability of the conclusion, the ratio of R&D personnel to urban employment personnel is further used to

measure innovation activity. The regression results show that the conclusion that intellectual property protection promotes the digital economy by increasing innovation activity is still robust, further verifying hypothesis 2.

Table 3. Mechanism verification results

	Dig	Iact	Dig	Iact1	Dig
	(1)	(2)	(3)	(4)	(5)
Ipp	0.006***	0.447***	0.005***	0.129**	0.006***
	(5.46)	(7.56)	(5.26)	(2.23)	(5.38)
Iact			0.001***		
			(4.03)		
Iact1					0.001***
					(4.39)
Ind	0.008***	-0.008	0.008***	-0.158***	0.008***
	(5.49)	(-0.14)	(5.66)	(-11.01)	(5.55)
Sup	0.576***	47.869***	0.510***	22.795***	0.552***
	(10.89)	(10.46)	(9.73)	(9.02)	(10.96)
Fin	0.009***	0.063	0.009***	0.122***	0.009***
	(7.17)	(1.68)	(7.25)	(3.48)	(7.15)
Fdi	0.005	-0.319	0.006	0.181	0.005
	(0.75)	(-1.31)	(0.78)	(0.86)	(0.70)
Constant	0.061***	5.829***	0.053***	1.802***	0.059***
	(28.82)	(36.80)	(19.00)	(20.70)	(29.19)
N	3,003	3,003	3,003	3,003	3,003
Urban fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
R2	0.317	0.303	0.320	0.0812	0.319
F	256.1	183.6	347.2	68.02	514.6

4.3. Robust Test

This article uses a series of methods to test the robustness of regression results, as follows: (1) Using principal component analysis to recalculate the level of urban digital economy development from 2012 to 2021; (2) Measuring the level of intellectual property protection by the number of intellectual property cases per 10000 people; (3) Exclude provincial capitals and municipalities directly under the central government, enhance the universality of the data, and conduct regression tests again. The above test results are shown in **Table 4**, and the basic conclusion of this article still holds.

Table 4. Robustness test results

	Dig		
	(1)	(2)	(3)
Ipp	0.109***	0.004**	0.006**
	(6.21)	(2.74)	(2.59)
Ind	0.150***	0.008***	0.033***
	(5.34)	(5.52)	(6.94)
Sup	8.673***	0.456***	0.309***
	(8.57)	(5.89)	(2.91)
Fin	0.173***	0.009***	0.005
	(10.75)	(6.98)	(1.60)
Fdi	0.004	0.004	0.007
	(0.05)	(0.62)	(1.32)
Constant	-0.796***	0.065***	0.050***
	(-18.82)	(24.26)	(9.49)

Urban fixed effects	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
R2	0.373	0.354	0.253
F	1505	198.2	44.36

4.4. Heterogeneity Analysis

4.4.1. Regional heterogeneity

Due to differences in location advantages, resource factors, and institutional policies in each region, it may lead to regional heterogeneity in intellectual property protection and digital economy. To this end, 273 cities were divided into the eastern, central and western regions to test whether there is regional heterogeneity in the impact of intellectual property protection on the digital economy. The results from columns (1) to (3) of **Table 5** show that the regression coefficient of intellectual property protection is significantly positive in the eastern region, consistent with the national regression coefficient. 23.4% of the driving effect of intellectual property on the digital economy is achieved through innovation activity. This may be because the economy in the eastern region is more developed, blockchain, Internet and other technologies are more popular, intellectual property awareness is stronger, and the relevant legal system and implementation mechanism are more perfect, so strengthening intellectual property protection can significantly promote the development of the digital economy. According to columns (4) to (6) of **Table 5**, the results for the central and western regions are not significant. Only 6.37% of the driving effect of intellectual property on the digital economy is achieved through innovation activity, which proves the regional heterogeneity of the driving effect of intellectual property protection on the digital economy. The reason may be that intellectual property protection in the central and western regions is in the initial development stage, and the investment and enforcement efforts are far less than those in the eastern regions. However, even so, intellectual property protection in the central and western regions still plays a role in promoting the development of the digital economy.

Table 5. Estimation results of regional heterogeneity

	West			Middle and West		
	Dig	Iact	Dig	Dig	Iact	Dig
Ipp	0.005**	0.234**	0.004**	0.003	0.479***	0.003
	(2.57)	(3.10)	(2.51)	(1.13)	(7.24)	(1.04)
Iact			0.005***			0.000
			(3.75)			(1.16)
Ind	0.006**	-0.751***	0.010***	0.003*	-0.005	0.003*
	(2.33)	(-8.08)	(3.68)	(1.90)	(-0.09)	(1.90)
Sup	0.868***	28.604***	0.733***	0.197**	40.577***	0.181**
	(4.85)	(4.82)	(3.97)	(3.00)	(8.27)	(2.67)
Fin	0.012***	0.434***	0.010***	0.008***	0.034	0.008***
	(7.31)	(5.01)	(6.60)	(6.09)	(1.30)	(6.10)
Fdi	1.426	76.147**	1.067	-0.001	-0.128	-0.001
	(1.53)	(2.94)	(1.38)	(-0.10)	(-0.57)	(-0.09)
Constant	0.047***	6.928***	0.014	0.073***	5.623***	0.070***
	(25.60)	(62.26)	(1.79)	(33.12)	(41.78)	(29.61)
N	935	935	935	2,068	2,068	2,068
Urban fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.540	0.449	0.552	0.146	0.169	0.146
F	463.9	102.4	691.7	89.01	75.09	102.2

4.4.2. Heterogeneity of City Size

According to the 2014 urban size classification standards, cities with a permanent population of more than 5 million but less than 1000 are classified as mega cities. Cities with a permanent population of more than 3 million but less than 5 million are classified as Type I mega cities, while cities with a permanent population of more than 1 million but less than 3 million are classified as Type II mega cities. On this basis, examine the impact of intellectual property protection on the digital economy under different city scales. As shown in **Table 6**, the positive impact of intellectual property protection on the digital economy has been verified in cities of different scales, and the promotion effect decreases from type II large cities to mega cities to type I large cities. The reason may be that large cities have strong economic agglomeration effects, digital infrastructure and industrial integration are in a leading position, have more resource control and integration, and carry out innovative activities, Promote the development of the digital economy; At the same time, if the city size is too large, it will also have a crowding effect, playing the role of diminishing marginal factor revenge, resulting in lower resource utilization. Therefore, the effectiveness of intellectual property protection on larger cities depends on the greater or lesser of the two impacts.

Table 6. Estimation results of heterogeneity in urban scale

	Mega cities			Type I large cities			Type II large cities		
	Dig	Iact	Dig	Dig	Iact	Dig	Dig	Iact	Dig
Ipp	0.004***	0.162*	0.004***	0.004**	0.308***	0.003	0.007*	0.313**	0.006
	(4.41)	(2.18)	(3.83)	(2.35)	(4.29)	(1.74)	(2.11)	(2.98)	(1.78)
Iact			0.003**			0.003***			0.004***
			(3.09)			(3.93)			(4.59)
Ind	0.011**	-0.222**	0.012**	0.005	-0.184	0.005	0.005***	-0.079	0.006***
	(2.75)	(-2.29)	(3.06)	(1.18)	(-1.22)	(1.43)	(3.98)	(-0.84)	(4.52)
Sup	0.573***	40.042***	0.469***	0.411***	40.334***	0.283**	0.723***	44.980***	0.565***
	(8.96)	(7.15)	(7.26)	(4.02)	(10.27)	(3.05)	(4.03)	(4.49)	(3.32)
Fin	0.012***	0.345***	0.011***	0.007**	0.202**	0.006**	0.007***	0.164***	0.007***
	(7.56)	(6.20)	(6.36)	(2.74)	(2.29)	(2.68)	(7.85)	(4.80)	(7.43)
Fdi	-0.556**	67.145***	-0.732***	-0.004	0.213	-0.005	-0.005**	0.266	-0.006***
	(-2.43)	(4.92)	(-3.29)	(-1.62)	(1.00)	(-1.75)	(-2.78)	(1.63)	(-4.08)
Constant	0.047***	6.116***	0.031***	0.072***	5.841***	0.053***	0.070***	5.153***	0.052***
	(10.25)	(46.70)	(5.11)	(13.33)	(32.64)	(10.27)	(20.33)	(25.23)	(20.39)
N	983	983	983	822	822	822	918	918	918
Urban fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.515	0.434	0.523	0.162	0.362	0.174	0.201	0.220	0.221
F	208.7	127.9	179.2	11.16	72.20	22.49	98.74	103.0	575.7

4.4.3. Heterogeneity of local financial resources

The financial resources of different regions provide financial support for urban development and vary greatly. Therefore, this article believes that local financial resources will have heterogeneous effects on intellectual property rights. This article refers to the approach of Zhou Kexuan and Yu Linhui (2021) [11], selecting the proportion of local fiscal revenue to GDP as a measurement indicator to measure local financial resources. The mean is used as the division basis. Cities above the mean are identified as the high finan-

cial group, while cities below the mean are classified as the low financial group. The regression results are shown in **Table 7**. The estimated coefficient of intellectual property protection on the digital economy of cities with high financial resources is 0.006, which is higher than that of cities with low financial resources. This means that the impact of intellectual property protection on the digital economy varies depending on local financial resources. Compared to cities with low financial resources, the driving effect of intellectual property protection on the development of the digital economy of cities with high financial resources is more significant. This also to some extent indicates that if intellectual property protection is to play a better role, financial support and external financing are needed.

Table 7. Estimation results of local financial heterogeneity

	Low financial resources			High financial resources		
	Dig	Iact	Dig	Dig	Iact	Dig
Ipp	0.005***	0.465***	0.004***	0.006*	0.401***	0.006
	(5.11)	(5.00)	(4.63)	(1.85)	(3.62)	(1.76)
Iact			0.002***			0.001*
			(3.82)			(1.88)
Ind	0.010***	0.243***	0.010***	0.006**	-0.259**	0.006**
	(9.17)	(3.84)	(8.07)	(2.75)	(-2.97)	(2.81)
Sup	0.641***	45.638***	0.538***	0.445***	46.189***	0.419***
	(8.63)	(7.98)	(7.96)	(5.46)	(5.99)	(5.09)
Fin	0.010***	-0.017	0.010***	0.007**	0.066	0.007**
	(14.13)	(-0.33)	(14.64)	(2.62)	(1.30)	(2.62)
Fdi	0.004	-0.347	0.005	0.005	-0.391*	0.006
	(0.52)	(-0.34)	(0.51)	(0.72)	(-1.96)	(0.74)
Constant	0.055***	5.911***	0.042***	0.069***	6.052***	0.066***
	(21.36)	(26.97)	(9.24)	(15.53)	(30.92)	(16.04)
N	1,294	1,294	1,294	1,709	1,709	1,709
Urban fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R2	0.338	0.349	0.344	0.150	0.182	0.150
F	153.6	88.00	236.6	26.31	83.17	65.57

5. Conclusion and Advice

5.1. Conclusion

This article is based on data from 273 cities in China from 2012 to 2021, using the ratio of regional intellectual property cases to regional GDP to measure the level of intellectual property protection. The entropy method is used to measure the digital economy, and the intermediary effect model is used to empirically examine the impact of intellectual property protection on the digital economy. Research has found that: (1) Intellectual property protection has significantly improved the level of digital economy development, and this conclusion has not undergone substantial changes even after replacing the core dependent variable, explanatory variable, and excluding the robustness test of provincial capital cities and municipalities directly under the central government. Industrial structure, government support, and financial development level can promote the development of the digital economy; (2) Through the mediating effect, it is found that intellectual property protection can promote the development of the digital economy by enhancing innovation activity; (3) Verifying the impact of intellectual property protection on the digital economy from different regions, city sizes, and local financial levels, it was found that intellectual

property protection has a greater positive effect on the digital economy in the eastern region, type II large cities, and high local financial cities.

5.2. Advice

Firstly, strengthen the construction of intellectual property protection mechanisms and create a suitable institutional environment. The country should establish an intellectual property protection system that is suitable for China's national conditions and conforms to the laws of digital economy development. At the legislative level, it should fully establish the status of intellectual property protection as a "baton" and promote more cities to deeply integrate into the national intellectual property protection camp. Local governments should improve various detailed rules and designs, determine specific data indicators, and gradually build an efficient, integrated, shared, and beneficial intellectual property service platform for the development of the digital economy from the law enforcement level, forming a healthy and stable intellectual property ecological environment. At the same time, emphasis should be placed on the heterogeneity of intellectual property protection, which plays a different role in different regions, city sizes, and local financial resources. It is necessary to implement the same intellectual property strategy for different regions, adopt different levels of intellectual property protection, adopt dynamic and differentiated development plans, achieve reasonable resource allocation, and establish a positive interaction between intellectual property protection and the digital economy, Maximize the role of intellectual property protection.

Secondly, promote the integration of intellectual property protection and innovation activity, and form a driving force for the development of the digital economy. Each city should formulate special support policies and provide financial support for research and development innovation in the financial sector, with funding for micro innovation. Valuing innovative talents, cultivating innovation awareness and intellectual property protection awareness among R&D personnel, increasing efforts to enhance innovation vitality, enhance digital literacy, and empower the development of the digital economy.

Thirdly, strengthen regional cooperation and promote the coordinated development of the digital economy. The economies of various cities are widely interconnected, and there is a universal spatial spillover between economic variables. When formulating digital economy policies, government departments implement the national regional coordinated development strategy, strengthen regional coordination and cooperation, timely follow up on changes in digital economy policies in surrounding areas, promote the orderly flow of production factors (such as capital and technology) between regions, guide resource sharing, and jointly promote the development of the digital economy. The integration and development of digital industries in urban agglomerations will be an important factor in promoting the level of digital economy development. In this process, fully utilizing the promoting effect of intellectual property protection on the digital economy will have more space.

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