A Study on the Impact of Intellectual Property Protection on Regional Innovation Efficiency Based on Mediation Effects: Evidence from China

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Abstract. In the context of escalating economic globalization, global scientific and technological endeavours have surged, catalyzing intensified competition among sovereign entities. Currently, human society is in the throes of transitioning to a new economic epoch characterized by a foundation in knowledge resources. Within this epoch, technological innovation and intellectual property emerge as pivotal in augmenting the core competitiveness of nations. This investigation, leveraging data spanning from 2011 to 2020 across 30 provinces, municipalities, and autonomous regions within China (excluding Tibet, Hong Kong, Macao and Taiwan), employs a moderating mediation effect model to scrutinize the mechanism by which the intensity of intellectual property protection influences regional innovation performance. The empirical findings elucidate that the enactment of pertinent policies not only reinforces the safeguarding of intellectual property, thereby amplifying regional innovation efficiency and the level of scientific and technological progress; however, it concurrently elevates the expenditures associated with scientific research and development. For small and medium-sized enterprises, the suboptimal ratio of investment return precipitates a deficiency in innovation impetus, subsequently exerting an adverse effect on regional R&D investment. Moreover, the influx of foreign direct investment (FDI) functions as a regulatory mechanism within this context, significantly moderating the correlation between intellectual property protection and innovation efficiency, in addition to exerting a positive moderative influence on the relationship between intellectual property protection and R&D investment.

Keywords: Intellectual Property Protection, Innovation Efficiency, Entropy Weight Method, Moderating Mediation Effect.

1. Introduction

The emergence of the knowledge economy marks a transition to an era where knowledge is central to economic growth, significantly impacting the global economy, politics, and society. With economic globalization, China focuses on developing its knowledge economy by enhancing its science and technology innovation system to boost competitiveness. The 20th National Congress report highlights China's commitment to reforming its science and technology system, diversifying science and technology investments, and strengthening intellectual property rights (IPR) protection to improve national innovation efficiency. This includes judicial reforms and better governance of IPR to encourage innovation. By the end of 2022, China led in patent applications and authorizations globally, demonstrating strong growth in invention, utility model, and design patents. The successful execution of an innovation-driven strategy requires balancing intellectual property protection to foster innovation while preventing negative effects like increased technology costs and reduced innovation motivation. Thus, determining the optimal level of IPP protection is crucial for advancing regional innovation efficiency under this strategy.

2. Literature review

According to the theory of regional innovation systems, intellectual property protection is an important part of the institutional environment and its strength has a significant impact on the efficiency of regional innovation.

Zhang Lingzhi (2019) examines the effects of intellectual property (IP) protection from the perspectives of innovation capacity and quality. The research finds that the current IP protection policies in China, in conjunction with factor coordination, can enhance regional innovation capacity but have a negligible effect on improving regional innovation quality [1]. Dai Lihua and Lin Faqin (2020) use IP protection as a threshold variable to empirically analyze the threshold effect of IP protection on the impact of bidirectional Foreign Direct Investment (FDI) on regional innovation capacity. The results indicate a significant IP protection threshold effect on the influence of FDI and Outward Foreign Direct Investment (OFDI) on regional innovation capacity. Furthermore, compared to OFDI, the technological spillover effects of FDI are more pronounced. Additionally, the level of IP protection in most Chinese provinces is either low or high, limiting the innovative effects of bidirectional FDI, especially the technology spillover effects from OFDI [2]. Xu Pengyuan (2020) constructed a conceptual analytical framework covering government R&D subsidies, intellectual property protection, and regional innovation output, using a moderated mediation effect model to prove that regional R&D investment plays a significant mediating role between government R&D subsidies and regional innovation output. At the same time, the strength of intellectual property protection plays a positive moderating role in this process [3]. Li Xue and Wu Fuxiang, et al. (2021), through constructing a threshold effect model for research, found that overall, the strength of China's intellectual property protection is on the left side of the optimal level, conforming to the inverted U-shaped curve relationship between intellectual property protection and innovation. Increasing the region's R&D personnel and R&D funding also indirectly promoted regional innovation activities [4]. Liu Shiqi (2021), introducing the concept of technology spillover in the research process, found that the strength of intellectual property protection has a positive impact on technological innovation output and can promote the positive effects of enterprise-independent R&D, technology introduction, and foreign direct investment inflow technology spillover. However, its impact on reverse technology spillover from foreign direct investment is negative [5]. Lin Zhouzhou and Su Yi (2021) empirically analyzed the nonlinear relationship between dual-channel knowledge spillovers and regional innovation performance, using intellectual property (IP) protection as a threshold variable. The results show that the impact of dual-channel knowledge spillovers on regional innovation performance significantly exhibits complex nonlinear characteristics with IP protection serving as a dual threshold, and they share the same threshold intervals [6]. Xu Lei and Song Hongti (2021) explored the driving mechanisms of bidirectional Foreign Direct Investment (FDI) on regional innovation capacity from the perspective of IP protection, finding that IP protection plays an important regulatory role in this innovation-driving effect and shows a significant trend towards consistency [7]. Si Yujing and Cao Wei et al. (2022) utilized a bidirectional fixed-effects model to identify the mediating effect of innovation on the impact of IP protection on the development of the digital economy across the overall regional innovation and five dimensions, conducting heterogeneity tests over time and across different works. The results indicate that regional innovation plays a partial mediating role in promoting the empowerment of the digital economy through IP protection, with all five dimensions also playing a mediating role to some extent. The mediating effect of the innovation environment is the most significant, and there is a partial mediating effect in the lagged innovation performance. Furthermore, the mediating effect of innovation is most optimal in the eastern region, followed by the central region, and slightly evident in the western region [8]. Wei Dongming and Xu Yangyue, et al. (2023), taking national intellectual property demonstration cities as a research entry point, found that governance of intellectual property rights can significantly improve regional innovation efficiency, mainly through the transmission of technical efficiency. Meanwhile, this effect varies by geography, city size, and resources and has a wide range of spatial spillover effects [9].

Through a review of previous studies, it was found that the majority of empirical research indicates a positive impact of the strength of intellectual property protection on innovation output. Moreover, this impact relationship may be influenced by the mediating effects of other variables. However, a minority of literature points out the existence of an inverted U-shaped relationship between intellectual property protection and innovation output. In terms of indicator selection, the academic community widely adopts the GP index and legislative strength proposed by Ginarte and Park (1997) to estimate the strength of intellectual property protection [10]. Regional innovation output is commonly proxied by the number of patent applications per 10,000 people. In empirical analysis methods, the most common approach is to use the OLS method. Furthermore, scholars have also employed a variety of methods such as the PSM model, DID model, and spatial econometric models. Scholars have also noticed the nonlinear relationship between intellectual property and innovation output and have conducted studies using threshold models. In recent years, scholars in this field have studied the interrelationship and transmission mechanisms between intellectual property, regional R&D investment, and regional innovation output, and have identified the mediating effects of certain variables. This paper aims to apply these research methods to explore the interaction between intellectual property, regional R&D investment, and regional innovation output.

The paper's marginal contribution is as follows.

1. Adoption of Novel Indicators for Measuring Regional Innovation Efficiency.

Previous research in the domain of regional innovation efficiency predominantly utilized metrics such as the number of patent applications, the number of patent applications per 10,000 individuals, and the ratio of granted patents to patent applications as measures of innovation efficiency. However, the complex categorization of patents has resulted in the limited interchangeability of these variables. Consequently, this study employs the regional innovation capacity index for reevaluation. Furthermore, drawing upon the regional innovation system theory, which identifies human capital as a pivotal factor, this paper incorporates human capital into the control variables to examine its influence.

2. The Mediating Role of R&D Investment and FDI Inflow in the Path of Influence.

In the realm of related scholarly works, research has primarily concentrated on probing the existence of an inverted "U"-shaped relationship between the intensity of intellectual property rights (IPR) protection and innovation efficiency, as well as the threshold effect of intellectual property rights on innovation efficiency. This study utilizes a mediation effect model to explore the potential impact of IPP protection on innovation efficiency via intermediary variables. It is found that R&D investment and foreign direct investment (FDI) inflow serve as mediators and moderators in this transmission mechanism.

3. Research Design

The paper's research hypothesis is presented in Figure 1.

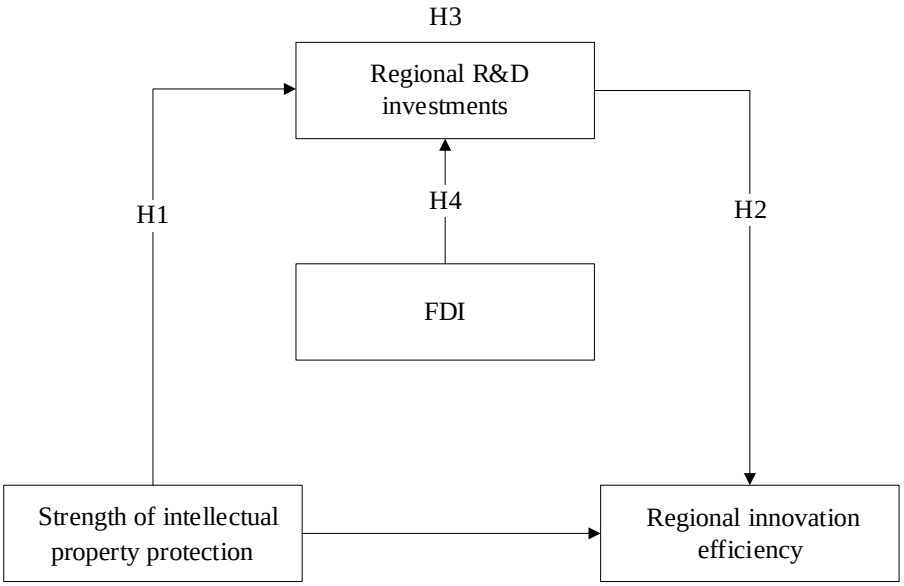

Figure 1. Research Hypothesisonte

3.1. Intellectual Property Protection and R&D Investment

Currently, concerning the enhancement of intellectual property protection strength, technology-exporting enterprises will receive robust protection, which may impose certain restrictions on technology importers. When the strength of intellectual property protection is intensified, it could inhibit the innovative vitality of imitation-oriented enterprises. As of the end of 2021, there were 48 million small and medium-sized enterprises (SMEs) in China. As the most dynamic group of enterprises, although they possess strong innovation capabilities, they do not have the financial resources to support R&D. Strengthening intellectual property protection will increase the imitation costs for these enterprises, thereby reducing their enthusiasm. Therefore, this article proposes the hypothesis:

H1: Under the current innovation characteristics in China, strengthening the intensity of intellectual property protection does not significantly increase R&D investment.

3.2. Intellectual Property Protection Intensity and Regional Innovation Efficiency

Strengthening intellectual property rights can recognize the compensability and exclusivity of intellectual labour results, stimulating invention and driving technological innovation by creating a social, legal, and institutional environment that admires and encourages innovation. Effective intellectual property protection can directly impact regional innovation output by enhancing the overall societal awareness of intellectual property rights, refining relevant laws and regulations, and strengthening law enforcement. Furthermore, intellectual property protection ensures the key resources needed for innovation, such as funding, talent, and technical services, are reasonably circulated and efficiently allocated among innovating entities, making innovation more achievable. Therefore, it can be considered that intellectual property protection is an important factor in improving regional innovation output, hence the hypothesis is proposed:

H2: The intensity of intellectual property protection has a direct positive impact on regional innovation efficiency.

3.3. R&D Investment, Intellectual Property Protection, and Regional Innovation Efficiency

The enhancement of intellectual property protection intensity can increase innovation incentives, encouraging enterprises to increase R&D investments. This protection increases the likelihood of enterprises gaining returns from their R&D investments, thereby motivating them to increase R&D inputs. The enhancement of intellectual property protection intensity raises the value of intellectual property. The higher the enterprise's perception of the value of intellectual property, the more inclined

they are to increase R&D investment to protect and enhance the value of their research and development outcomes. Moreover, the enhancement of intellectual property protection intensity can also help enterprises establish technical barriers and competitive advantages. By protecting unique technological innovations, enterprises can achieve competitive advantages in the market and earn higher profits. To achieve this goal, enterprises will increase their R&D investment to improve their innovation efficiency and the quality and quantity of their intellectual property. Therefore, this article proposes the hypothesis:

H3: R&D investment mediates the relationship between the intensity of intellectual property protection and regional innovation output.

3.4. Foreign Direct Investment Inflow, Intellectual Property Protection, and Innovation Efficiency

The inflow of foreign direct investment (FDI) usually accompanies the introduction and transfer of technology. Multinational corporations, when establishing subsidiaries or partnerships in the host countries, often transfer their advanced technology, management experience, and expertise to the target country. This technology introduction and transfer can enhance the target country's innovation capability and knowledge level, promoting an increase in regional innovation output. Simultaneously, the inflow of FDI often accompanies demands for intellectual property protection. Multinational corporations tend to invest in countries or regions with more comprehensive intellectual property protection systems to safeguard their innovation investments and technological outcomes. Therefore, the inflow of FDI prompts the host country to enhance intellectual property protection intensity, thus providing a better environment and motivation to protect innovation outcomes and intellectual property, leading to the following hypothesis.

H4: The inflow of foreign direct investment positively moderates the mediating effect of R&D investment on the relationship between the intensity of intellectual property protection and regional innovation efficiency.

4. Data

This paper analyzes data from 30 provinces, municipalities, and autonomous regions in China (excluding Tibet, Hong Kong, Macao, and Taiwan) for the years 2011-2020. The data was sourced from the China Statistical Yearbook, China Law Yearbook, China Science and Technology Statistical Yearbook, and Patent Statistical Annual Report of the State Intellectual Property Office (SIPO), among others.

4.1. Dependent Variable

Regional Innovation Efficiency (pat): Refers to the output of innovation investment in the process of knowledge generation. The academic community commonly uses the number of patent applications or grants as a measure of innovation efficiency. This study believes that the regional innovation capability index can effectively measure regional innovation efficiency.

4.2. Independent Variable

Intellectual Property Protection Intensity (ipp): Due to the current lack of data on the provincial intellectual property protection intensity index in China, the authors have adopted the GP index proposed by Ginarte and Park (1997) and measured it using the entropy weight method based on legislation and enforcement levels.

4.3. Mediating Variable

R&D Investment (rd): R&D investment can motivate enterprises, research institutions, and countries to enhance support for technological R&D and innovation activities. Investing human, material, and financial resources in scientific research, experimentation, and development can

improve technological innovation capabilities, and cultivate and attract high-quality R&D personnel, thus advancing scientific and technological progress and technological innovation. The academic field generally divides regional R&D investment into funding and personnel inputs. Funding inputs are usually determined by measuring internal expenditures on R&D in various regions, including investments by enterprises, research institutions, and higher education institutions. Personnel input is often quantified by the full-time equivalent of R&D personnel. However, given the significant correlation between the two, this paper only selects technology funding input as the research variable.

4.4. Moderating Variable

Foreign Direct Investment Inflow (fdi): In the context of economic globalization, technology tends to diffuse, and besides increasing their R&D investment, the inflow of foreign direct investment is another main pathway. This paper measures it by the inflow of foreign direct investment.

4.5. Control Variables

Government Intervention (gov): On one hand, government intervention can affect the input of R&D funds, and on the other hand, it can also affect the implementation of innovation policies. Therefore, this paper measures it by the proportion of fiscal expenditure to GDP.

Economic Development Level (per_gdp): Regions with a higher level of economic development usually have more funds and resources to provide more support for innovation activities. Therefore, this paper measures it by GDP per capita.

Financial Development Level (fin): The development level of the financial industry affects the financial support and convenience of financing channels required for innovation activities, as well as the scale of innovation investment and the ability to undertake risks. A developed financial industry is significant for promoting innovation activities and economic development. Therefore, this paper measures it by the loan balance of financial institutions.

High-tech Development Level (hitech): The development level of the high-tech industry shows the region's progress and innovation capability in the field of technology. Therefore, this paper measures it by the proportion of the total output value of high-tech industries to the total industrial output value.

Market Capacity (indust): Market capacity represents the diffusion and dissemination ability of innovation outcomes. When the market capacity is large, new technological innovations are more likely to be accepted and applied, prompting intense competition among enterprises and continuously improving the quality and quantity of innovation. Therefore, this paper measures this variable by the number of industrial enterprises above a designated size in each region.

Telecommunications Development Level (net): A higher internet penetration rate means that more people can access and share information, resources, and knowledge. The internet penetration rate in a region affects the development and exchange of innovation activities, so this paper measures the telecommunications development level by the internet penetration rate.

Infrastructure (elec): Considering that a region's infrastructure construction may affect the region's innovation efficiency, this paper measures it by electricity consumption.

Regional Openness (trad): The level of regional openness determines the frequency of technology exchange, which is more conducive to patent output. This paper represents it by the proportion of each region's imports and exports to the region's GDP for the year.

Human Capital (human): College students usually possess high academic abilities and innovation potential. A larger number of college students means that the region has more intellectual resources and innovation drive. This paper measures it by the number of students enrolled in higher education institutions.

In empirical analysis, all variables are standardized. At the same time, to reduce the impact of heteroscedasticity, natural logarithms are taken for all variables except for some proportion variables. The descriptive statistics for each variable are as shown in Table 1.

Table 1. The descriptive statistics for each variable

Symbol	Variable	Mean	Std	Median	N
pat	Regional Innovation Efficiency	0.032	0.107	0.003	300
rd	R&D Investment	0.146	0.181	0.100	300
fdi	Foreign Direct Investment Inflow	0.056	0.099	0.035	300
ipp	Intellectual Property Protection Intensity	0.427	0.259	0.348	300
gov	Government Intervention	0.221	0.17	0.193	300
per_gdp	Economic Development Level	0.255	0.182	0.204	300
fin	Financial Industry Development Level	0.112	0.082	0.097	300
hitech	High-tech Industry Development Level	0.335	0.103	0.335	300
indust	Market Capacity	0.206	0.228	0.102	300
net	Telecommunications Development Level	0.428	0.181	0.428	300
elec	Infrastructure Construction Level	0.269	0.213	0.201	300
trad	Degree of Openness	0.046	0.098	0.017	300
human	Human Capital	0.348	0.217	0.294	300

5. Construction and Analysis of Econometric Models

5.1. Construction of the Econometric Model

5.1.1. Mediation Effect Model

To test whether the intensity of intellectual property protection affects regional innovation performance through R&D investment, this paper constructs the following models using a stepwise testing method:

Model 1

$$pat_{it} = \alpha_1 + \beta_1 ipp_{it} + \sum \gamma control_{it} + \sum province_i + v_i + \varepsilon_{it} \quad (1)$$

Model 2

$$rd_{it} = \alpha_2 + \beta_2 ipp_{it} + \sum \gamma control_{it} + \sum province_i + v_i + \varepsilon_{it} \quad (2)$$

Model 3

$$pat_{it} = \alpha_3 + \sigma rd_{it} + \beta_3 ipp_{it} + \sum \gamma control_{it} + \sum province_i + v_i + \varepsilon_{it} \quad (3)$$

In the above models, the following symbols represent the variables and effects:

pat represents the regional innovation efficiency,

ipp denotes the intellectual property protection intensity of the region,

$control$ stands for control variables,

$year$ signifies fixed effects of different years,

$province$ indicates fixed effects of different provinces,

ν represents unobserved individual effects that are constant over time,

ε is the random error term.

α is the constant term, β and γ are coefficients to be estimated. i represents different regions (30 provinces and autonomous regions), and t indicates the time, with the data spanning from 2011

to 2020. The key to this analysis is to verify whether the coefficients β_2 and σ are simultaneously non-zero. If this is the case, then the mediation effect exists.

5.1.2. Mediation Effect Model with Moderation

To test the moderating role of FDI inflows in the mediation process of Intensity of IPP Protection - Regional R&D Input - Regional Innovation Performance and distinguish the mediating effect from the direct moderating effect, we have designed the following model:

Model 4

$$pat_{it} = \alpha_4 + \beta_4 ipp_{it} + \lambda_1 fdi_{it} + \theta_2 \left(ipp_{it} \times fdi_{it}\right) + \sum \gamma control_{it} + \sum year_t + \sum province_i + v_i + \varepsilon_{it} \tag{4}$$

Model 5

$$rd_{it} = \alpha_{5+} \beta_5 ipp_{it} + \lambda_2 fdi_{it} + \theta_2 \left(ipp_{it} \times fdi_{it}\right) + \sum \gamma control_{it} + \sum year_t + \sum province_i + v_i + \varepsilon_{it} \tag{5}$$

In the model, inflows are the only variable that differs from the model above in terms of meaning.

5.2. Results Analysis

5.2.1. Analysis of Mediation Effect Regression Results

This paper uses the stepwise testing method proposed by Baron and Kenny (1986) to test hypotheses H1 to H4. The results are shown in Table 2.

Observing Model 1 in the table, the test for coefficient β_1 is significant at the 95% confidence level (with a value of 0.0856), indicating that the intensity of intellectual property protection can significantly and positively promote regional innovation efficiency. This means hypothesis H2 is supported, and the next step of testing can proceed.

Observing Model 2 in the table, the test for the coefficient β_2 when regional R&D investment is the mediating variable is significant at the 95% confidence level (with a value of -0.147). This suggests that intellectual property protection has a negative impact on regional R&D investment, thus confirming hypothesis H1. This could be because, in the current context of China's innovation characteristics, an increase in the intensity of intellectual property protection might lead to a decrease in the innovative enthusiasm of imitation-type industries, thereby reducing investment in R&D.

Observing Model 3 in the table, the test for the coefficient σ to be 0, with regional R&D investment as the mediating variable, is significant at the 99% confidence level (with a value of -0.289). However, the coefficient β_3 is not significant. This indicates that there is a mediation effect of regional R&D investment on the impact of intellectual property protection intensity on regional innovation efficiency, and it is a complete mediation effect. Therefore, hypothesis H3 is supported.

The analysis shows a nuanced interaction between intellectual property protection, R&D investment, and innovation efficiency, which is critical for policy formulation and business strategy in the context of China's innovation ecosystem.

Table 2. Stepwise Testing Method Mediation Effect Regression Results

Variable	Model 1	Model 2	Model 3
	pat	rd	pat
ipp	0.0856*	-0.147*	0.0302
	-2.21	(-2.51)	-0.83
gov	-0.00747	0.152*	0.0277
	(-0.17)	-2.3	-0.69
per_gdp	0.950***	0.447***	1.048***
	-11.09	-3.46	-13.2
fin	-0.00112	-0.0135***	-0.00361*
hitech	0.00676	-0.324***	-0.0720**
	-0.25	(-8.22)	(-2.70)
indust	-0.330***	0.0011	-0.159*
	(-4.65)	-0.41	(-2.30)
net	-0.0372	0.0818	-0.0251
	(-1.27)	-1.86	(-0.94)
elec	-0.00057	-0.00427	-0.00179
	(-0.36)	(-1.74)	(-1.22)
trad	0.132***	0.0387	0.139***
	-3.49	-0.67	-4.02
human	-0.00051	-0.00171	-0.00106
	(-0.31)	(-0.67)	(-0.69)
rd			0.289***
			(-7.18)
_cons	-0.102**	0.138**	-0.0797**
	(-3.11)	-2.79	(-2.65)
Time Fixed Effects	Control	Control	Control
Individual fixed effects	Control	Control	Control
N	300	300	300
R2	0.8466	0.9147	0.8744

Note: p<0.05, ** p<0.01, *** p<0.001 and t-values are shown in parentheses (same below)

Meanwhile, Table 3 shows that the mediating effect of regional R&D input on the impact of regional innovation efficiency is 0.0045 when used as a mediating variable. This accounts for 52.57% of the total effect. The intensity of intellectual property protection is not a significant factor in this mediating effect. Increasing the intensity of intellectual property protection has a greater impact on regional innovation efficiency through R&D input than its direct impact. Therefore, increasing regional R&D input while increasing the intensity of intellectual property protection will enhance regional innovation activity and enthusiasm, ultimately improving regional innovation efficiency.

Table 3. Mediating and direct effects

		ipp&pat
	Total effect	0.0856
R&D as a mediating variable	Direct effect	0.0811
	Intermediation effect	0.0045
	Percentage of mediating effect	52.57%

5.2.2. Analysis of regression results with moderated mediated effects

Drawing on the test of mediated effects with moderation proposed by Wen Zhonglin and Ye Baojuan (2014) - the product coefficient method to test to conduct the correlation test of the mediated effects with moderation model. The results are shown in Table 4.

Table 4. Regression results with moderated mediated effects

Variable	Model 4	Model 5
	pat	rd
ipp	0.126**	-0.162***
	(-3.622)	(-4.285)
fdi	0.013	-0.246
	(-0.062)	(-1.089)
ipp*fdi	0.091*	0.516*
	(-0.387)	-1.985
gov	0.088*	0.024
	(-2.406)	-0.595
per_gdp	0.601***	0.288***
	(-17.466)	-8.36
hitech	-0.026	-0.221***
	(-0.687)	(-5.410)
indust	-0.164**	0.747***
	(-3.321)	(-23.183)
net	-0.162***	0.002
	(-6.225)	(-0.079)
fin	-0.001	-0.004
	(-0.009)	(-1.413)
elec	-0.001	-0.003
	(-0.394)	(-1.502)
human	0.002	0.001
	(-0.912)	(-0.315)
rd	-0.143**	
	(-2.670)	
_cons	-0.049*	0.053
Time Fixed Effects	Control	Control
Individual fixed effects	Control	Control
N	300	300
R2	0.735	0.884
Adjusted_R2	0.715	0.875

As demonstrated in Model 4 of Table 4, the interaction between IPP protection intensity and FDI inflow has a significant positive effect on regional innovation efficiency (η_1 =0.091, p <0.05). Additionally, Model 5 in the table shows that the interaction between the two also has a significant positive effect on regional R&D input promotion (η_2 =0.516, p <0.05). The results suggest that FDI inflow moderates the relationship between IPR protection intensity and innovation-driven efficiency, as well as the relationship between IPR protection intensity and R&D input. Hypothesis H4 is supported.

6. Conclusion

The intensity of intellectual property protection can significantly and positively promote regional innovation efficiency.

The level of intellectual property protection has a significant positive impact on regional innovation efficiency. This suggests that the implementation of state policies aimed at protecting intellectual property rights has a positive effect on regional innovation efficiency, which in turn enhances the level of local scientific and technological development.

However, it should be noted that the intensity of IPR protection has a negative impact on regional R&D investment.

The intensification of intellectual property protection in China's current innovation form is not conducive to regional R&D investment. Based on these results, this paper suggests that the increase in the intensity of intellectual property protection may cause an increase in the learning cost of scientific and technological R&D. This increase in cost makes it difficult for small and medium-sized enterprises to achieve a satisfactory input-output ratio, resulting in insufficient internal drive for innovation, which in turn reduces R&D investment.

This is supported by the fully mediated effect of regional R&D investment.

Increasing the intensity of IPR protection has a greater impact on regional innovation efficiency through regional R&D input than through its own direct impact. This suggests that increasing regional R&D inputs and strengthening IPR protection will enhance regional innovation activity and motivation, thereby improving regional innovation efficiency.

Additionally, FDI inflows play a moderating role in this mechanism of action.

FDI inflow moderates the relationship between IPR protection intensity and regional innovation efficiency, as well as the relationship between IPR protection intensity and R&D investment. This paper argues that the inflow of foreign direct investment (FDI) causes small and medium-sized enterprises (SMEs), which import technology for innovation activities, to reduce their investment in research and development (R&D) in order to obtain funds to support technology patents. This, in turn, enhances the innovation enthusiasm and vitality of these enterprises and improves regional innovation efficiency.

References

[1] Zhang, Lingzhi. "The Relationship Between Intellectual Property Protection, Regional Innovation Capability, and Regional Innovation Quality: An Empirical Study Based on Provincial Panel Data from 2007-2017" [J]. International Economic Cooperation, 2019, (06): 43 - 52.

[2] Dai, Lihua, and Lin, Faqin. "Threshold Effect Study on the Impact of Bilateral FDI on Regional Innovation Capability from the Perspective of Intellectual Property Protection" [J]. Journal of Sun Yat-sen University (Social Science Edition), 2020, 60 (04): 171 - 182.

[3] XU Pengyuan. Study on the impact of government R&D subsidies and intellectual property protection on regional innovation output (Doctoral dissertation, Beijing Jiaotong University) [D], 2020.

[4] LI Xue, WU Fuxiang, ZHU Lile, et al. Internetization, intellectual property protection, and regional innovation output [J]. Science & Technology Progress and Policy, 2021, 38 (18): 46 - 55.

[5] LIU Shiqi. Study on the impact of intellectual property protection intensity on the technological innovation output of Chinese enterprises [D]. Harbin Institute of Technology, 2021.

[6] Lin, Zhouzhou, and Su, Yi. "The Relationship Between Knowledge Spillover and Regional Innovation Performance from the Perspective of Knowledge Source Heterogeneity: An Analysis Based on the Threshold Effect of Intellectual Property Protection" [J]. Journal of Systems Management, 2021, 30 (02): 227 - 237+252.

[7] Xu, Lei, Song, Hongti, and Xu, Liang. "Study on the Regional Innovation Driving Mechanism of Bilateral FDI from the Perspective of Intellectual Property Protection" [J]. Journal of Yunnan University of Finance and Economics, 2021, 37 (10): 24 - 36.

[8] Si, Yujing, Cao, Wei, and Zhao, Wei. "An Empirical Test of Intellectual Property Protection Empowering the Development of the Digital Economy: Based on the Mediating Effect of Regional Innovation" [J]. Finance and Economy, 2022, (05): 62 - 71.

[9] Wei Dongming, XU Yangyue. Does intellectual property governance promote regional innovation efficiency improvement? —A quasi-experiment based on national intellectual property demonstration cities [J]. World Economy Studies, 2023, No.273 (02): 14 - 30.

[10] Ginarte J C, Park W G. Determinants of patent rights: A cross-national study [J]. Research Policy, 1997, 26: 283 - 301.