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Urban Intellectual Property Strategy and University Innovation: A Quasi-Natural Experiment from National Intellectual Property Model City

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Abstract: Colleges and universities play a crucial role in fostering innovation, making it essential to explore effective strategies for promoting innovation at the institutional policy level. This paper focuses on the establishment of intellectual property (IP) model cities as a starting point and conducts an empirical analysis using innovation data from 234 cities and 942 colleges and universities between 2007 and 2017. By constructing a multi-temporal double-difference model, this study reveals that the establishment of IP model cities effectively fosters innovation in colleges and universities. Further analysis demonstrates that this promotion effect is particularly significant in the western region, key cities, key colleges and universities, as well as in the fields of invention and utility model patents. These conclusions withstand a series of robustness tests, confirming their validity. In terms of the underlying mechanisms, it is found that the national IP pilot city policy has a substantial impact on university innovation by promoting research and development (R&D) investment and strengthening innovation cooperation. The insights provided by this study offer valuable policy recommendations for leveraging the innovation potential of the IP model city policy, thereby driving economic transformation, upgrading and fostering innovation development in China.

Keywords: IP strategy; national IP model city; university innovation；DID model

1. Introduction

The national innovation system places great importance on the relationship between government and universities. Universities, as one of the main components of the 'triple helix ', are increasingly becoming central institutions in modern society and crucial driver of knowledge-driven growth[1-2]. Universities are rich in human resources, offer a wide range of disciplines, conduct strong scientific research, engage in extensive external exchanges, and receive substantial public funding. They play a vital role in developing basic research, nurturing innovative talents, and promoting technological progress. As the primary force in scientific and technological work, universities have the obligation, responsibility, and capability to lead the 'innovation' movement and drive high-quality economic development, similar to the success of Silicon Valley. Moreover, the income generated through innovation activities can further support the growth and development of universities. Efficient innovation practices are also essential for their long-term sustainability. In recent years, the number of invention patents granted to Chinese universities has been steadily increasing, accounting for over 20% of all domestic invention patents granted. However, there is still a significant gap between the pivotal role of scientific and technological innovation in Chinese universities and their counterparts in Europe and America. Chinese universities have yet to become an indispensable bridge between the government and enterprises for innovation. They still have a long way to go before effectively fulfilling their role as the driving force behind endogenous innovation.

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Innovation plays a crucial role in driving development, with the protection of IP being essential for safeguarding innovation. Currently, China is transitioning from being a country that primarily imports IP to becoming a nation that generates its own IP. Consequently, the focus of IP work is shifting from quantity to quality. The implementation of the national IP pilot city policy is aimed at realizing the strategy of establishing China as a strong IP nation and fostering an innovative country. As a significant reform policy in line with China's innovation-driven development strategy, the national IP pilot cities have undergone six rounds of selection since 2012, encompassing 77 cities across 24 provinces. The primary objective of this policy is to enhance the creation, protection, and utilization of IP, strengthen the city's capacity and effectiveness in IP governance, and ultimately promote innovation-driven development. The policy encompasses various aspects, including improving patent quality, ensuring robust IP protection, expediting the development of IP operation and service systems, and continuously innovating IP financial services. It involves multiple stakeholders such as the government, industry, academia, research, and financial services, forming a comprehensive policy framework to foster innovation and development.

Institutional policies play a crucial role in facilitating active innovation activities in universities. Universities are instrumental in fostering scientific and technological achievements that bridge the gap between laboratories and markets. These achievements are given high priority by the policies of pilot cities for IP. For instance, the pilot policy emphasizes the promotion of high-value patent cultivation centers in universities and research institutes. This aims to achieve a coordinated match between the growth of patent applications, economic growth rate and the level of scientific and technological innovation. The policy also aims to facilitate the entire IP process, including layout and design, cultivation and incubation, trading and circulation, and transformation and implementation. Furthermore, it aims to promote IP operation and industrialization in key industries. National IP pilot cities have been implemented for several years, and their construction scope and influence have been continuously expanding. They have become a significant regional innovation policy pilot that cannot be ignored when considering the level of urban innovation. Therefore, it is important to investigate whether the innovation-driven policy of national IP pilot cities effectively promotes innovation in universities. Additionally, understanding the influence mechanism behind this policy and exploring potential differences in the innovation effects of universities in different cities are crucial. However, these questions have yet to be answered by theoretical framework or empirical evidence.

There is a general consensus among academics that moderate IP protection can significantly promote innovation. IP protection for enterprises can discourage technology imitators from infringing, encourage enterprises to engage in R&D activities, grant enterprises exclusive rights to innovation results, reduce the spillover of R&D knowledge, alleviate financing constraints for enterprises, and ensure the legitimate benefits of enterprise innovation results[3-4]. Previous studies have examined the economic and innovation effects of IP model city policy, focusing on dimensions such as urban innovation quality[5], industrial structure upgrade[6], and enterprise innovation level[7]. However, research on IP protection has primarily focused on the regional, industrial, and enterprise levels, with limited exploration at the university level. The introduction of the Bayh-Dole Act in the United States in 1980 significantly boosted innovation activities in universities by promoting decentralization of IP [8-9]. While studies have confirmed the impact of IP on university innovation, most of them rely on theoretical frameworks and questionnaire survey data, lacking micro-level large-sample data from universities and observations of IP policy interventions.

This paper utilizes national IP pilot cities as a quasi-natural experiment to assess the impact of establishing IP model cities on university innovation. It achieves this by constructing double-difference and triple-difference models based on innovation data from 942 Chinese universities in 234 cities between 2007 and 2017. The main contributions of this paper are as follows: (1) It empirically tests the impact of IP pilot city construction on university innovation, focusing on the university perspective rather than the traditional enterprise perspective, thus enhancing existing research. (2) It examines the heterogeneity of the effect of IP pilot cities on university innovation from four different aspects: city-level, regional, university-level, and patent-type heterogeneity. (3) It analyzes and investigates the effect of IP pilot cities on university innovation by exploring the promotion of R&D

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investment and the strengthening of innovation cooperation, thereby exploring the path of the pilot policy.

2. Theoretical Mechanism and Hypothesis

2.1. IP City Policy and University Innovation

The pilot policy on IP cities is a system that focuses on the development and use of knowledge resources. It is designed to enhance China's capacity for independent innovation through targeted, integrated, and dynamic approaches. The main focus of this policy is on IP, aiming to improve the city's ability to create, apply, and protect IP. This, in turn, promotes regional knowledge innovation, and contributes to the overall quality and efficiency of the regional economy. It is important to note that the pilot policy on IP cities differs from policies implemented at other city levels. For instance, a low-carbon city policy aims to promote overall low-carbon development through energy efficiency, improvements energy structure adjustments, and energy industry transformations. On the other hand, a smart city policy aims to transform urban governance through information technology, enabling intelligent urban management, services, and lifestyles. Secondly, one of the key requirements for the establishment of IP pilot cities is to give IP work a strategic role in urban development. This involves integrating IP work into the overall context of urban economic and social development, supporting the creation of a favorable environment for IP pilot cities, and creating new opportunities for the upgrading of the urban industrial structure. Thirdly, IP pilot cities are managed by the State IP Office, with a three-level assessment and management mechanism that connects the State, provinces and municipalities. If a city fails to meet the review standards after three years, it will lose its IP pilot city status.

The establishment of IP model cities can tserve as a valuable strategy to mitigate innovation externalities through government funding. Basic research often yields positive knowledge externalities[10-11], which can be enhanced by a robust property rights system that incentivizes innovation behavior [12-13]. The construction of IP pilot cities focuses on improving IP administration, enhancing IP protection, and providing great convenience for the creation, application, and protection of IP in universities. This, in turn, ensures that technological innovation can yield corresponding economic benefits such as patent authorization and technology transfer. Such supporting IP policies can incentive universities to engage in more research and development, leading to increased knowledge innovation. Based on these arguments, this paper proposes the following hypothesis:

H1: The implementation of IP model cities positively impacts university innovation.

2.2. R&D Investment Intensity and University Innovation

Solow(1956) clearly pointed out that 87.5 percent of economic growth is driven by technological progress[14]. R&D investment, as a crucial measure and driver of technological innovation activities, plays a significant role in promoting economic growth. It effectively stimulates enthusiasm for R&D and innovation subjects[15]. Resource dependence is a key characteristic of universities, and the impact of R&D innovation, where inputs determine outputs, is particularly evident. R&D inputs typically include human capital and physical capital, with the latter mainly sourced from the government and market. It has been established that when university R&D input exceeds a certain threshold, it can drive the improvement of R&D quantity and quality. Therefore, reasonable university R&D input can effectively enhance innovation output, and a moderate increase in university R&D input is beneficial for achieving the scale effect of innovation output[16-17]. From a macro perspective, there is still a significant gap between China and other developed countries in terms of R&D intensity and investment structure. China's R&D intensity is lower than the level of the United States fifteen years ago, and the proportion of R&D investment in colleges and universities is also notably low[18].

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At the governmental level, establishing an IP pilot city strengthens the government's strategic leadership role of in IP protection and R&D innovation. To align the construction process of an IP pilot city with the city's innovation system, the local government will optimize the environment for R&D inputs from universities. They will proactively increase support for innovation resources, prioritize scientific research funding for universities, and encourage enterprises and social capital to contribute to university R&D. By leveraging the institutional benefits of IP, urban R&D and innovation activities can be revitalized. At the enterprise level, the establishment of IP pilot cities will prompt local governments to increase funding for enterprises during the patent application and authorization process. This will effectively reduce the cost of patenting and R&D innovation, enabling enterprises to expand their R&D investment and further encourage them to invest more scientific and technological funds in universities as their main research base[19]. At the university level, the spolicy of IP pilot city improves the institutional environment, enabling the main body of innovation to benefit from the transformation of scientific and technological achievements. This, in turn, increases the willingness and motivation of the main body of innovation to invest more in innovation. Additionally, the policy of IP pilot city recognizes and respects innovative talents, attracting more high-end talents and creating a 'public pool' effect. This effect helps universities and colleges by allowing them to employ more high-quality scientific research talents to carry out research work more effectively [20]. Based on these observations, this paper proposes the following hypothesis:

H2: The pilot policy of IP city promotes university innovation by enhancing universities' R&D investment.

2.3. Innovation Cooperation Intensity and University Innovation

Innovation cooperation refers to the exchange, flow, and diffusion of various types of innovation resources to improve the efficiency of innovation by optimizing the allocation of innovation resources[21]. In cities, innovation cooperation mainly relies on enterprises, colleges and universities with talents and educational resources, and R&D institutions. Cooperation among the subjects in the innovation chain is crucial for innovation. Innovation cooperation between universities and enterprises has significant regional convenience and can achieve the significant effect of 1+1>2. Additionally, universities will have higher enthusiasm to cooperate and participate in innovation activities such as technology research and development, talent training, and resource sharing with enterprises if there are no IP problems [22]. To meet the major strategic needs of the country and solve technical difficulties, close cooperation between universities, research institutes, and enterprises is necessary. This cooperation should aim to deepen the integration of industry and education and form a mutually beneficial symbiotic innovation ecology.

IP pilot cities can benefit from more favorable innovation policies, which can stimulate cooperation among innovation subjects and promote innovative activities. Local governments can achieve this by formulating relevant policies, providing special funds, establishing cooperation platforms, and organizing joint research projects. These efforts aim to integrate industry, academia, and research into an innovation system. Additionally, it facilitates the efficient exchange of innovation factors and strengthens the connection between universities and localities, industries, and enterprises. This closer collaboration allows universities to bring their innovative technologies closer to the market[23]. To further enhance the development of IP pilot cities, local governments also play a crucial role in leading and guiding universities' IP work. They support the establishment of IP transformation centers, trading centers, and other market-oriented platforms to increase the market value of patents. Furthermore, universities are encouraged to establish technology transfer offices to improve their IP management capabilities[24], and promote cooperation with external partners. This collaboration enables universities to access advanced research equipment, technological platforms, and other resources, leading to resource sharing, complementary advantages, and the generation of more knowledge results. Based on these observations, this paper proposes the following hypothesis:

H3: The pilot policy of IP cities promotes university innovation by strengthening R&D cooperation.

3. Research Design

3.1. Multiple Time-Varing DID Model

This paper utilizes the double difference method to examine the influence of the establishment of IP pilot cities on university innovation. Out of the 234 cities sampled, a total of 64 cities were approved as IP pilot cities between 2007-2017, providing a suitable quasi-natural experiment. The experimental group consists of colleges and universities in the 64 selected IP pilot cities, while the control group comprises colleges and universities in non-selected cities. By comparing the experimental and control groups, the net effect of the national IP pilot city policy on university innovation is determined. Considering the variations in the timing of cities obtaining the national IP pilot city title, this study adopts the 'asymptotic double-difference method' as used in the studies of Beck et al. (2010) and Wang Kang et al. (2019) to test and identify the policy effect[25-26]., as shown in equation (1).

$$Univpat_{i,s,t} = \alpha_0 + \alpha_1 Treat_i * Time_{i,s,t} + \alpha_2 Ctrl_{i,s,t} + \beta_i + \gamma_s + \delta_t + \varepsilon_{i,s,t} \quad (1)$$

In this model, i denotes city, s denotes university, and t denotes time. $Univpat$ denotes university innovation level. The explanatory variable $Treat * Time$ is the double difference estimator. $Ctrl$ denotes the control variable. β_i is the city fixed effect. γ_s is the university fixed effect. δ_t is the time fixed effect. ε denotes the random disturbance term. The coefficient α_1 indicates the policy implementation effect of the national IP pilot city on the impact of innovation in colleges and universities. If α_1 is greater than 0, it means that the IP pilot city policy can promote innovation in colleges and universities.

3.2. Variable Selection

Explained variables. The explanatory variable in this paper is university innovation, which is measured using the number of patents granted by colleges and universities in the current year (GTtgrapat) [27-28]. This measurement is based on the mainstream practice of existing domestic and international studies. Additionally, the robustness test includes the total number of patent applications by universities in the current year (GTtapppat) to ensure the reliability of the regression results from the benchmark analysis.

Explanatory variables. Thee core explanatory variable of this paper is the IP model city ($Treat * Time$). Following Yuan Hang et al. (2018), it is represented as a dummy variable for IP model cities[29]. The variable $Time$ is used to measure the impact of policies related to IP pilot cities on the pilot cities. If city i is recognized as a national IP pilot city in year t, the variable $Treat$ is assigned a value of 1, and the $Time$ variable in the subsequent years is also assigned a value of 1. Conversely, if $Treat$ is assigned a value of 0, the $Time$ variable in the previous years is also assigned a value of 0. The estimation of the cross-multiplier term $Treat * Time$ coefficient represents the innovation effect of universities in the construction of IP model cities.

Control variables. Based on previous research, this paper selects control variables focusing on the university and city levels. At the university level, variables such as the number of appraised achievements of universities (Numir), the amount of scientific and technological funds allocated for the year (Amtastf), the actual income of technology transfer of universities for the year (Rittc), the total number of scientific and technological projects (Tnumsttp), and the number of scientists and engineers (Setrp) were considered. At the city level, variables such as the level of financial development (Finadevelop), the level of economic development (PcptlGRP), industrial structure level (Industrlevel), and science and technology expenditure (STspend) were taken into account. Please refer to Table 1 for detailed definitions of these variables.

Table 1. Key variables and definitions.

Variable category	Variable name	Variable symbol	Variable definitions

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Explained variables	Number of patents granted by university	GTtgrapat	The logarithm of the sum of the number of patents granted for inventions, utility models, and design patents + 1
Explanatory variable	IP Pilot City Policy	Treat*Time	Grouping dummy variables multiplied by policy implementation dummy variables
Control variable	Number of results identified by universities	Numir	The logarithm of the number of results validated by university in the year + 1
	Actual income from university technology transfer for the year	Rittc	The logarithm of the actual income from technology transfer of universities for the year + 1
	Amount of university S&T funding allocated for the year	Amtastf	The logarithm of the sum of government transfers, enterprise transfers, and other sources of funding + 1
	Total number of university S&T projects	Tnumsttp	The logarithm of the total number of S&T projects of universities in the current year + 1
	Number of university scientists and engineers	Setrp	The logarithm of the sum of the number of scientists and engineers in the teaching and research staff, and the research and development staff
	Level of city financial development	Finadevelop	The ratio of the balance of loans from financial institutions to regional GDP at the end of the year
	Level of city economic development	PcptlGRP	Regional GDP per capita
	Level of city industrial structure	Industrlevel	The share of secondary sector in GDP
	Expenditure on city science and technology	STspend	The logarithm of the the amount of science and technology expenditures in cities

3.3. Data Description

This study focuses on the data regarding science and technology (S&T) activities of Chinese universities and the economic data at the corresponding city level of these universities from 2007 to 2017. The S&T and patent data at the university level were primarily obtained from the China Research Data Service Platform (CNRDS) database. The city-level data were sourced from the China Urban Statistical Yearbook of previous years, while the data on IP model cities were collected from the official website of the State IP Office (SIPO). The selection of this data is based on the principles of data representativeness and accessibility. In order to obtain empirical data that meets the requirements of the empirical research in this paper, the raw data obtained through the aforementioned methods was processed as follows: Firstly, city samples that underwent administrative division adjustments during the period of 2007-2017 and had significant missing data on key variables (such as Hami City, Danzhou City, Linzhi City, Nagchu City, Shannan City, etc.). Secondly, specialized colleges and universities were excluded from the sample of colleges and universities, and the remaining samples of undergraduate colleges and universities with significant missing data on key variables (such as Kashgar University, Changsha Medical College, Haikou

College of Economics, Yunnan Police College, Southwest University of Political Science and Law, and other colleges and universities) were also excluded. Thirdly, for the samples of cities and colleges and universities that had partially missing indexes, the missing data were supplemented by referring to the annual reports of statistics and using linear interpolation. Fourthly, to mitigate the impact of outliers, all continuous variables were logarithmically transformed and winsorized at the upper and lower 1% levels. Finally, a total of 6668 observations were obtained, including 50 cities in the experimental group, 184 cities in the control group, and 942 general colleges and universities. Table 2 presents the descriptive statistics of the main variables.

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. dev.	Min	Max
lnGTtgrapat	6668	1.132842	2.129193	0	12.54
lnNumir	5771	1.534961	1.458188	0	4.727388
lnAmtastf	6668	10.32499	2.163569	0	14.45748
lnRittc	6668	3.284496	3.715637	0	10.76266
lnTnumsttp	6668	5.528675	1.555761	0	8.495766
lnSetrp	6668	6.799968	1.114953	3.367296	9.422706
Finadevelop	5771	1.311684	.6597962	.3620147	3.288189
PcptlGRP	5771	5.994771	3.207033	1.2032	15.0853
Industrlevel	6636	4.442355	1.046416	1.9265	6.8975
InSTspend	6668	11.51324	1.582075	8.409608	15.04431

4. Empirical Results and Analyses

4.1. Benchmark Analysis

Table 3 presents the results of the baseline model estimates, examining the impact of the IP pilot city policy on innovation in universities. Models (1), (2), and (3) all include city fixed effects and time fixed effects. Model (2) additionally incorporates university -level control variables, while model (3) includes both university-level and city-level control variables. The estimated coefficients for the policy variable 'IP pilot city' remain positive across all models, regardless of the inclusion of control variables. Moreover, all coefficients pass the significance test at the 1% level, indicating that the IP pilot city policy effectively facilitates innovation in colleges and universities within the pilot region. The estimated coefficients for the policy variable decrease as control variables are added at the university and city levels, suggesting the presence of other factors influencing university innovation at these levels. This highlights the importance of considering these factors to obtain a more accurate estimation of the net effect of the policy. Model (3) demonstrates that after accounting for potential interfering factors, the implementation of the IP pilot city policy significantly promotes university innovation, leading to a approximately 55% increase in the number of patents granted by universities in the pilot region. Consequently, Hypothesis 1 is confirmed.

Table 3. Benchmark regression estimates.

Variables	(1)	(2)	(3)
Treat*Time	0.699***	0.648***	0.551***
	(11.04)	(10.28)	(8.687)
lnNumir		0.0476**	0.0519**
		(2.058)	(2.243)
lnAmtastf		0.00860	0.00670
		(1.176)	(0.921)

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lnRittc		-0.265***	-0.254***
		(-7.081)	(-6.815)
lnTnumsttp		0.0228	0.0151
		(0.423)	(0.280)
lnSetrp		-0.0348	-0.0760
		(-0.290)	(-0.631)
Finadevelop			-0.0618
			(-0.946)
PcptlGRP			0.0891***
			(5.066)
Industrlevel			-0.243***
			(-5.542)
InSTspend			0.135**
			(2.264)
Observations	6582	5,654	5,646
R-squared	0.7836	0.789	0.792
Year FE	NO	YES	YES
City FE	NO	YES	YES

Notes：Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.2. Robustness Test

(1) Parallel Trend Test

The unbiased estimation results of the multi-period double-difference method depend on the benchmark regression model meeting the parallel trend assumption. This assumption requires that colleges and universities in IP pilot cities and non-IP pilot cities have similar trends of change before policy implementation. Failure to meet this assumption can lead to overestimation or underestimation of the policy's effect. To test the parallel trend, this paper adopts the processing method used by Beck et al. (2010) and presents the test results in Table 4. The base period for the policy is set as the year before its implementation, with the current period being 2012. The parallel trend test covers data from 5 years before the policy's occurrence to 5 years after its implementation. The coefficients of each policy point are considered significant at a 90% level. Table 4 shown that the impact of the IP model city policy on colleges and universities in the host city did not pass the significance level test before recognition. This indicates that there was no significant difference in the innovation level of colleges and universities between the model city and the non-model city prior to the assessment, confirming the assumption of the parallel trend. After being assessed as an IP model city, the innovation level of colleges and universities in the model city exhibited an upward trend without any time lag effect. This suggests that the promotion effect of the national IP model city policy is gradually increasing.

Table 4. Parallel trend test.

Policy Year	Policy Test	Policy Year	Policy Test
pre5	-0.264	post1	0.364***
	(-1.161)		(3.781)
pre4	0.299	post2	0.537***
	(1.475)		(5.397)
pre3	-0.231	post3	0.689***
	(-1.182)		(6.319)
pre2	-0.159	post4	0.800***
	(-1.618)		(6.724)
current	0.182*	post5	1.060***
	(1.924)		(7.016)
Observations	6,582	Observations	6,582
R-squared	0.786	R-squared	0.786

Notes：Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

(2) Placebo Test

The placebo test is a valid method to ensure that the baseline regression results are not influenced by random chance events. In this study, the policy placebo test was conducted by randomly selecting the experimental group and estimating the model 500 times through a random simulation process, as illustrated in Figure 1. The horizontal axis represents the estimated coefficient of the policy effect, while the vertical axis represents the kernel density value and the p-value of the estimated coefficient. Fig. 1 demonstrates that the mean value of the estimated coefficients for the policy effect is 0, with most of the p-values above 0.1. Moreover, the actual estimated coefficients for the policy effect of the IP pilot city fall within the range of low probability events in the placebo test plot. Therefore, the impact of the IP pilot city policy on university innovation is not a result of random chance, and the findings of this study are robust and reliable.

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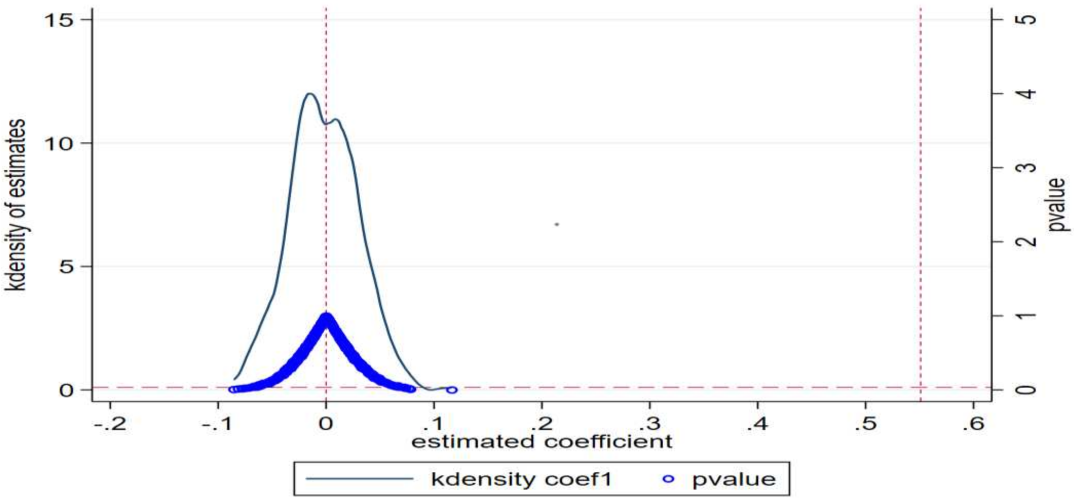

Figure 1. Placebo test.

(3) Propensity Score Matching-Double Difference Method (PSM-DID)

As an exogenous policy shock, the IP pilot cities have effectively addressed the endogeneity problem. However, it is important to note that the selection of pilot city areas may not have been random, and there may be variations between different cities and universities, which could introduce some 'noise' to the policy evaluation results in this study. To overcome this, we employ propensity score matching to identify a comparable control group for each experimental group. We then use the matched samples to estimate the logit model. To ensure the reliability of the matching results, we employ a year-by-year matching method to screen the control group colleges. Table 5 presents the model regression estimation results using the PSM-DID method, which includes three matching methods: k-nearest neighbors, nuclear matching, and radius matching. The results in Table 5 indicate that the coefficient value of the policy effect is significantly positive at the 1% level for all three approaches. This means that after accounting for differences in university and city characteristics, the IP pilot city policy plays a significant role in promoting innovation in universities. Therefore, the estimation results of PSM-DID further support the robustness of the findings of this paper.

Table 5. PSM-DID test.

Variables	K-nearest neighbour matching	Nuclear matching	Radius matching
Treat*Time	0.4588***	0.5728***	0.5783***
	(4.7681)	(9.0112)	(8.9561)
Observations	5,091	6,075	5,825
R-squared	0.7808	0.7723	0.7735
Year FE	YES	YES	YES
City FE	YES	YES	YES

Notes：Robust t-statistics in parentheses,*** p<0.01, ** p<0.05, * p<0.1.

(4) Lagged Period and Replacement of Explanatory Variables

To account for the potential time lag in innovation activities and address the issue of endogeneity between variables and the IP pilot city policy, we estimate the model with explanatory variables lagged by one and two periods, as shown in columns (1) and (2) of Table 6. The regression results indicate that the coefficients on the policy effects are significantly positive, confirming the robustness of our baseline model estimates. Additionally, to ensure that differences in the measurement of explanatory variables do not affect the model estimation results, we replaced the number of patents granted with the number of patent applications filed by universities in the current year. The model

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estimation results, presented in column (3) of Table 6, demonstrate that the significance and direction of the estimated coefficients remain unchanged, further supporting the robust impact of the national IP pilot city policy on the promotion of innovation in universities.

Table 6. Lagged period and replacement of explanatory variables test.

Variables	(1)	(2)	(3)
Treat*Time	0.0826***	0.0956***	1.242***
	(3.150)	(3.477)	(12.28)
Observations	4,637	3,987	6,582
R-squared	0.819	0.845	0.800
Year FE	YES	YES	YES
City FE	YES	YES	YES

Notes：Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.3. Heterogeneity Analysis

4.3.1. City Hierarchical Heterogeneity

Chinese cities are categorized into different political levels, which leads to varying allocation of resources such as funds, infrastructure, and preferential policies. This can result in different roles for IP model cities. To address this, the cities belonging to the sample universities are divided into key city groups and general city groups. Key city groups consist of provincial capital cities, while general city groups include ordinary prefecture-level cities. The regression results in Table 7, columns I and II, report the impact of the IP pilot city policy on the innovation level of universities in cities at different levels. The results indicate that the estimated coefficients of the double difference terms are significantly positive for both groups of colleges and universities. Moreover, and the estimated coefficients of the double difference terms for colleges and universities in the key city group are larger than those in the general city group. This suggests that the IP pilot city policy has a significant effect on the innovation level of universities in cities at different levels, with a more pronounced effect on universities in the key city group. This could be attributed to the comparative advantages enjoyed by key cities in terms of innovation resources, institutional environment, innovation atmosphere, and economic development level. Consequently, colleges and universities in key cities are more likely to attract innovation resources and stimulate innovation motivation, in key cities IP policy.

Table 7. Heterogeneity analysis in different cities.

Variables	General cities	Key cities	Eastern cities	Central cities	Western cities
Treat*Time	0.517***	0.779***	0.422***	0.556***	0.801***
	(4.687)	(7.989)	(4.114)	(6.313)	(5.355)
Observations	3,498	2,148	2,638	1,747	1,261
R-squared	0.775	0.807	0.820	0.724	0.746
Year FE	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES

Notes：Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.3.2. City Regional Heterogeneity

As the frontier of reform and opening up, the eastern region has a head start in terms of economic development, a well-established factor market, and better conditions for innovation and development compared to the central and western regions. Therefore, the establishment of IP model cities may have varying effects in the east, central, and western regions due to their locational differences. To

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investigate this, this paper conducts regression analyses on sample cities in each region to examine the heterogeneity in the innovation effect of universities based on their location. The regression results of the IP pilot city policy on the innovation level of universities in different location cities are presented in columns III, IV and V of Table 7. The results indicate that the estimated coefficients of the double difference terms are significantly positive for all three groups of universities in different locations. Moreover, the estimated coefficients of the double difference terms are the largest for urban universities in the western region and the smallest in the eastern region. This suggests that the IP pilot city policy has a significant effect on the innovation level of universities in different locations, with a more pronounced effect observed in the western city group. This may be attributed to the fact that, compared to eastern cities, western cities are generally more economically underdeveloped, resulting in weaker IP awareness and lower IP protection capabilities. Consequently, universities in the western cities are more strongly motivated by IP policies and have greater potential for improvement.

4.3.3. University Grades Heterogeneity

Chinese universities are categorized into different administrative levels, resulting in varying distribution of financial resources, human resources, and research platforms. This differentiation may lead to the establishment of IP model cities with varying effects. To address this, the sample colleges and universities in this study are divided into two groups: key colleges and universities and general colleges and universities. The key colleges and universities include those classified as '211' and provincial-ministry co-built colleges and universities, while the general colleges and universities comprise the remaining ordinary institutions. The regression results of the IP pilot city policy on the innovation level of these different groups of universities are presented in columns I and II of Table 8. The results demonstrate that the estimated coefficients of the double difference terms are significantly positive for both groups of universities, with a larger effect observed for the key universities group. This indicates that the IP pilot city policy has a significant impact on the innovation level of universities at different levels, with a more pronounced effect on key universities. This could be attributed to the comparative advantages of key universities in terms of research conditions, human resources, institutional environment, innovation atmosphere, and brand effect. These advantages make it easier for them to optimize the allocation of innovation resources, thereby stimulating more positive outcomes in response to the IP policy incentives.

Table 8. Heterogeneity analysis in different university.

Variables	Key university	General university	Invention Patent	Utility Model Patent	Design Patent
Treat*Time	0.727***	0.436***	0.253***	0.275***	0.0290**
	(4.021)	(7.347)	(8.147)	(8.216)	(2.567)
Observations	1,009	4,636	5,646	5,646	5,646
R-squared	0.848	0.679	0.841	0.673	0.553
Year FE	YES	YES	YES	YES	YES
City FE	YES	YES	YES	YES	YES

Notes：Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

4.3.4. Patent Type Heterogeneity

The State IP Office (SIPO) classifies patents into three types: invention patents, utility model patents, and design patents. The examination difficulty of these patents decreases in the mentioned order. Invention patents are considered to reflect upstream patents in the chain of innovation activities, focusing more on technological research, development and process innovation. On the other hand, utility model patents and design patents are seen as downstream patents in the chain of innovation activities, with a greater emphasis on product research, development and product

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innovation. The value of different types of patents in universities varies, which can lead to different roles in the establishment of IP model cities. To explore this, this paper conducts regression analyses on invention patents, utility model patents and design patents of universities to examine the heterogeneity of innovation effects based on patent type. The regression results of the IP pilot city policy on the innovation level of different types of patents in universities are reported in columns III, IV and V of Table 8. The results indicate that the estimated coefficients of the double-difference terms are significantly positive for all three types of university patents. Furthermore, the estimated coefficients of the double-difference terms are higher for invention patents and utility model patents compared to design patents. This suggests that the IP pilot city policy has a noteworthy impact on the innovation level of different types of patents in universities. It can simultaneously promote process innovation and product innovation in universities, with a stronger effect on the promotion of high-tech value patents.

4.4. Mechanism Analysis

Based on the theoretical analysis discussed in the previous section, the IP pilot city policy primarily fosters innovation in universities by focusing on two action pathways: increasing R&D investment and promoting innovation cooperation. In line with this, our paper incorporates the findings of Beck et al. (2010) and expands on model (1) by introducing the variables of R&D investment mechanism and innovation cooperation mechanism. This leads to the construction of a triple difference method model, represented by equation (2):

$$UnivPat_{i,s,t} = \alpha_0 + \alpha_1 Treat_i * Time_{i,s,t} \times M + \alpha_2 Treat_i * Time_{i,s,t} + \alpha_3 Ctrl_{i,s,t} + \beta_i + \gamma_s + \delta_t + \varepsilon_{i,s,t} \quad (2)$$

In this study, we use two variables to characterize the mechanism of R&D investment and innovation cooperation. The first variable is the full-time equivalent research and development personnel (Fterdp) and the amount of internal expenditure on science and technology in the current year (Amtiexpstf) of universities. The second variable is the number of patents jointly granted in the current year (Utgrapat) of universities. The results of the mechanism tests are presented in Table 9. Models (1) and (2) of Table 9 show the estimation results of the R&D investment promotion perspective. The coefficients of the triple difference terms Treat*Time*Fterdp and Treat*Time*Amtiexpstf are both significantly positive at the 1% level. This suggests that the establishment of an IP pilot city promotes R&D investment by enhancing innovation in universities. Model (3) of Table 9 presents the estimation results of the innovation cooperation promotion perspective. The coefficient of the triple difference term Treat*Time*Utgrapat is also significantly positive at the 1% level. This indicates that the establishment of an IP model city can enhance university innovation by promoting R&D cooperation. Therefore, Hypotheses 2 and 3 are supported.

Table 9. Mechanism analysis.

Variables	(1)	(2)	(3)
Treat*Time * Fterdp	0.551***		
	(8.699)		
Treat*Time * Amtiexpstf		0.540***	
		(8.240)	
Treat*Time * Utgrapat			0.388***
			(7.183)
Observations	5,646	5,367	5,646
R-squared	0.792	0.797	0.854
Year FE	YES	YES	YES
City FE	YES	YES	YES

Notes：Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

5. Conclusions and Policy Implications

This paper conducts a theoretical analysis on the effect of the construction of IP model cities on the innovation level of colleges and universities in China. The study focuses on 942 undergraduate colleges and universities in 234 prefecture-level cities from 2007 to 2017. Using a multi-temporal double difference model, the empirical analysis reveals that the establishment of IP pilot cities has a positive impact on the innovation level of colleges and universities. This effect varies across cities and colleges, with high-administrative-grade cities experiencing a stronger enhancement effect compared to ordinary prefectures. Moreover, colleges and universities in the western region show a stronger enhancement effect than those in the central and eastern regions. Additionally, the enhancement effect on innovation is stronger for high-administrative-grade colleges and universities compared to other general undergraduate colleges. Furthermore, the study finds that the role of innovation enhancement is greater for invention and utility model patents than for design patents in colleges and universities. Mechanism tests demonstrate that increased R&D investment and enhanced of innovation cooperation are effective mechanisms for the IP model city to enhance the innovation level in colleges and universities. These conclusions are robust even after conducting various tests, such as the parallel trend test, placebo test, propensity score matching-double difference method test, lagged period model test, and replacement of explanatory variables.

The findings of this study provide valuable insights for the national IP pilot city policy and contribute to the ongoing debate on the impact of IP in protecting innovation. Firstly, it is essential to have a strong belief in the national IP pilot city policy and expand its implementation to include more cities, especially in the western region. The establishment of IP pilot cities has already achieved significant success, and it is crucial to allocate resources strategically to further promote the policy. Additionally, it is important to explore the broader implications of the IP system and integrate IP strategy into the city's economic and social development, thereby enhancing the strategic position of IP. Secondly, it is important to summarize the laws and experiences in establishing IP model cities and develop more instructive and targeted policy guidelines. The impact of IP pilot city policies varies among different cities, districts, universities, and patents, highlighting the need to consolidate common experience, refine policies, focus on key areas, strengthen policy implementation, and enhance the incentive effect. Thirdly, attention should be given to the synergistic effect of other policies in driving innovation at universities. While the IP pilot city policy has clearly promoted innovation in universities, it indicates that other effective policies to foster innovation in universities are insufficient. Studies have demonstrated that policies such as financial assistance and industry-university-research cooperation can also facilitate innovation. Therefore, combining financial assistance for R&D investments, strengthening innovation cooperation through industry-university-research policies, and integrating these efforts with IP policies can generate a synergistic effect and promote innovation in universities more effectively and efficiently.

This paper examines the impact of IP pilot city policies on universities, contributing to the evaluation of such policies and providing empirical evidence of the innovation effect of IP in universities. Future research can expand on the study in the following ways: Firstly, by expanding the indicators used to measure innovation in universities, focusing not only on quantity but also on quality to obtain more accurate results. Secondly, by extending the sample scope to include urban policy practices in other developing and developed countries, as the applicability of the conclusions to these regions is yet to be verified. Thirdly, by refining the categorization of universities, and conducting policy research on universities with different orientations such as teaching-orientation and research-orientation to obtain more specific research findings.

References

1. Etzkowitz H, Leydesdorff L. The Endless Transition: A “Triple Helix” of University-Industry-Government Relations[J]. Minerva, 1998, 36(3): 203-208.
2. Etzkowitz H, Leydesdorff L. The dynamics of innovation: from National Systems and “Mode 2” to a Triple Helix of university–industry–government relations[J]. Research Policy, 2000, 29(2):109-123.
3. Lemley M A, Shapiro C. Probabilistic Patents[J]. The journal of economic perspectives, 2005, 19(2):75-98.

4. Wu Chaopeng, Tang Di. Intellectual Property Rights Enforcement，Corporate Innovation and Operating Performance: Evidence from China's Listed Companies[J]. Economic Research Journal, 2016(11):125-139. (in Chinese)
5. Ji Xiangyu, Gu Naihua. Does the Establishment of Intellectual Property Model Cities Affect Innovation Quality? [J]. Journal of Finance and Economics, 2021(5):49-63. (in Chinese)
6. Qin Bo, Gao Angang. The impact of intellectual property city pilots on industrial structure upgrading: empirical evidence based on DID[J]. Industrial Economics Research, 2020(5):45-57. (in Chinese)
7. Xu Yang，Wei Dongming. Urban intellectual property strategy and enterprise innovation: a quasi-natural experiment from national intellectual property model city[J]. Industrial Economics Research, 2021（4）：99-114. (in Chinese)
8. Mowery D C, Nelson R R, Sampat B N, et al. The Growth of Patenting and Licensing by U.S. Universities: An Assessment of the Effects of the Bayh-Dole Act of 1980[J].Research Policy, 2001, 30(1):99-119.
9. Nelson R R . Observations on the Post-Bayh-Dole Rise of Patenting at American Universities[J]. Journal of Technology Transfer, 2001, 26(1-2):13-19.
10. Nelson R R. The Simple Economics of Basic Scientific Research[J]. Journal of Political Economy, 1959, 67(3):297-306.
11. Romer P M. Increasing Returns and Long-Run Growth[J]. Journal of Political Economy, 1986, 94(5):1002-1037.
12. Coase R H. The problem of social cost[J]. Journal of Law and Economics, 1960, 3(1): 1-44.
13. Demsetz H. Toward a Theory of Property Rights[J]. The American Economic Review, 1967, 57(2):347-359.
14. Solow R M. Technical Change And The Aggregate Production Function[J]. Review of Economics and Statistics, 1957, 39(3)：312-320.
15. Lichtenberg F R. The Private R and D Investment Response to Federal Design and Technical Competitions[J]. American Economic Review，1988，78(3):550－559.
16. Coupé T. Science Is Golden: Academic R&D and University Patents[J].Journal of Technology Transfer, 2003, 28(1):31-46.
17. Li Boxi, Cui Xin, Zhu Chengliang. Nonlinear spillover effect of university R&D expenditure on R&D quality under the regulation of government funding[J]. Journal of Macro-quality Research, 2023,11(01):113-128. (in Chinese)
18. Hu Jianyong, Xu Jiqin, Yang Shaohua. Analysis on the contribution of colleges and universities to the increase of R&D personnel and expenditure in China[J]. R&D Management, 2009,21(04):97-100. (in Chinese)
19. Hall B H, Harhoff D. Recent Research on the Economics of Patents[J].Annual Review of Economics, 2012, 4(1):541-565.
20. Cao Longsheng，Zhao Jingfeng. The Empirical Research about the Influence of Patent System on Regional Technology Innovation Performance——Based on Patent Protection[J]. China Soft Science, 2019(5):97-103. (in Chinese)
21. Qin Liuting, Zeng Gang. Impact of innovation cooperation of different spatial scales on urban innovation performance in the Yangtze River Delta region. Scientia Geographica Sinica, 2022,42(10):1747-1756. (in Chinese)
22. Bronwyn H. Hall, Albert N. Link and John T. Scott. Barriers Inhibiting Industry from Partnering with Universities: Evidence from the Advanced Technology Program[J]. The Journal of Technology Transfer, 2001, 26(1-2):87-98.
23. Lu Xianxiang. On Property Right Systems，Factor Market and High－Quality Development[J]. Economic Review Journal，2020(1):65-73+2. (in Chinese)
24. Debackere K , Veugelers R .The role of academic technology transfer organizations in improving industry science links[J].Research Policy, 2005, 34(3):321-342.
25. Beck T, Levine R, Levkov A . Big Bad Banks? The Winners and Losers from Bank Deregulation in the United States[J].The Journal of Finance, 2010, 65(5):1637-1667.
26. Wang Kang, Li Yifei, Li Jing, et al. What makes an incubator promote business innovation? --- Micro-evidence from Haidian Science and Technology Park in Zhongguancun［J］. Journal of Management World，2019(11):102-118. (in Chinese)
27. He Z L，Tong T W，Zhang Y，et al. Constructing a Chinese patent database of listed firms in China: descriptions，lessons，and insights［J］. Journal of Economics＆Management Strategy，2018，27(3):579-606.
28. Bai Junhong，Liu Yi. Does Market Integration Promote Spatial Convergence of Regional Innovation?［J］. Finance＆Trade Economics，2020，41（1）：96−109. (in Chinese)
29. Yuan Hang, Zhu Chengliang. Do National High-Tech Zones Promote the Transformation and Upgrading of China's Industrial Structure［J］. China Industrial Economics，2018(8):60-77. (in Chinese)