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Does Stronger Protection of Intellectual Property Improve Sustainable Development? Evidence from City Data in China

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Abstract: Achieving sustainable development goals is a challenge for countries. The core way is to enhance the green total factor productivity. While the literature has examined the various external institutional factors, there is a lack of research on the impact of intellectual property protection (IPP), which is an important external institution. This study adopts the differences-in-differences (DID) model and propensity scores matching (PSM) using the Chinese intellectual property model city policy (IPMP), as a quasi-natural experiment, and Chinese cities' panel data from 2005 to 2019 to investigate the effect of IPP on sustainable development. The findings demonstrate that: (1) The IPMP significantly increases urban GTFP. (2) Mediation mechanism analyses show that the IPMP can support urban GTFP by fostering technological advancement, boosting human capital, luring foreign direct investment, and modernizing industrial structure. (3) Heterogeneity analysis shows that the Chinese central region, the eastern region, and the region with more fiscal transparency are where the IPMP has the greatest promotion effect on GTFP. Lastly, this study provides several recommendations for the improvement of sustainability in China.

Keywords: intellectual property rights model city policy (IPMP); green total factor productivity (GTFP); PSM-DID

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1. Introduction

Currently, China is the world's largest carbon-emitting [1] and energy-consuming country [2], and there is an urgent need for China to change its crude development model. China's economy has grown by leaps and bounds since its reform and opening up. According to public information from the China Bureau of Statistics, China's GDP grew from RMB 0.46 trillion in 1980 to RMB 98.65 trillion in 2019, an increase of over 200 times, making it the world's second largest economy. However, what cannot be ignored is that China's quick economic development has cost the environment dearly. The long-standing crude development model of high input and high emission has led to serious environmental pollution. How to promote green total factor productivity (GTFP) to achieve the transformation of sustainable development by reducing energy consumption and pollution emission is a serious challenge in China [3].

With the worsening environmental pollution and climate problems, scholars have been prompted to focus on green economic development [3]. Early studies mainly used the TFP index to measure economic growth, ignoring non-desired outputs [4,5], but were unable to accurately assess changes in social welfare as well as economic performance [6]. Subsequently, GTFP was considered a better indicator to assess the harmonious and sustainable development of the economy and the environment, because it takes into account energy consumption and environmental pollution on the basis of TFP [7,8]. Recently, scholars have studied the impact of institutional factors on GTFP, mainly in terms of environmental regulation [9,10], industrial policy [11], tax policy [12], and foreign policy [13]. However,

the role of intellectual property protection (IPP) has been ignored. Specifically, IPP, as an important governmental institution, would protect knowledge creation [14,15], stimulate innovation [16–19], and promote TFP [20]. Therefore, it is likely that the IPP system will have an impact on GTFP. However, there is still a research gap here.

Only a few scholars have explored the environmental effects of IPP. Di Vita (2017) [21] found that enhancing the level of uniform minimum standards of IPP among World Trade Organization member countries may help reduce air pollution emissions. Hao et al. (2021) [22] included IPP, trade, foreign direct investment, and outward foreign direct investment in China in a unified analytical framework, using a dynamic threshold regression approach, and showed that trade technology spillovers can reduce carbon emissions only if the regional IPP level exceeds the threshold. On the other hand, Khurshid et al. (2022) [23] argued that technological innovation for carbon dioxide mitigation mainly focuses on the role of patents, ignoring trademarks. Yu (2022) [24] used hierarchical analysis to construct an index of green IPP systems, and their empirical study showed that green IPP has a non-linear impact on the ecological environment. Previous studies have focused on a single indicator of particular environmental pollution, ignoring the effect of IPP on GTFP.

China provides a good background for analyzing the impact of IPP on GTFP. As the second largest economy in the world, the high level of IP infringement in China has received widespread attention [13]. In 2012, the State Intellectual Property Office of China promulgated the Chinese intellectual property model city policy (IPMP). This policy is an important IPP institution in China that aims to strengthen the IPP in China. The main tasks are to formulate and implement urban IPP strategies, strengthen urban IPP management and service capacity building, improve urban IPP systems, increase the strength and depth of IPP policy implementation and coordination with related policies, enhance urban IPP creation capacity, enhance the economic efficiency of urban IPP application, enhance the effectiveness of urban IPP enforcement and protection, and enhance the development of IPP service industry. In this research, we used the IPMP as a quasi-natural experiment to examine the influence of IPP on GTFP and the mechanism of impact based on panel data of 256 Chinese cities from 2005 to 2019.

Compared with existing studies, this study may have the following contributions: First, there are few studies on the impact of IPP institutions on GTFP. Traditional TFP did not consider resource waste and environmental pollution. We use the super-SBM of non-expected output to measure GTFP, which can comprehensively measure the coordinated development of the regional economy and environment compared with single-factor indicators such as carbon emission reduction and air pollution. By examining the impact of the Chinese IPMP, as an exogenous shock, on urban GTFP, we provide new ideas to address the endogeneity problem in research. Our study extends the literature related to the influencing factors of GTFP. Second, the existing literature examined the effect of IPP on the environment and rarely involved the study of the influence mechanism. We propose that IPP can promote urban GTFP in four ways: by fostering technological advancement, boosting human capital, luring foreign direct investment, and modernizing industrial structure. Finally, existing studies have mainly been conducted at the national and provincial levels, ignoring the differences among cities within provinces. We conduct a more detailed analysis at the city level.

The paper is organized as follows: Section 2 presents the policy background and theoretical hypotheses, Section 3 presents the research design, Section 4 presents the empirical results and analysis, and Section 5 presents the study conclusions and recommendations.

2. Policy Background and Theoretical Hypotheses

2.1. Policy Background

China's IPP system started late. Initially, China promulgated the Provisional Regulations on the Protection of Invention Rights and Patent Rights, the Provisional Regulations on Trademark Registration, and began an initial exploration of the IPP system. Since its reform and opening up, China is in the process of switching from a planned economy to a market

economy. The construction of China's IPP system also developed rapidly. Subsequently, China became a manufacturing powerhouse amid the great wave of globalization. In 2012, the State Intellectual Property Office of China promulgated the IPMP and announced the first batch of 23 cities selected on 27 April 2012. Until 2020, six batches of pilot cities were identified, and a total of 64 cities were selected. The Chinese Intellectual Property Office will focus on providing support and increasing guidance to the pilot cities in the areas of IPP laws and regulations, IPP strategy formulation, responding to foreign-related IP disputes, patent information construction, and IPP financial support services.

The IPMP not only promotes the selected city's IPP efforts, but also enhances the innovation level and promotes economic growth. For example, according to the public data of the Changsha city Intellectual Property Office, Changsha city, which was selected as the IPMP city in 2012, has achieved remarkable results in comprehensively promoting IPP. First, Changsha city has made efforts to build a collaborative IPP mechanism by establishing an IP court and an IP crime investigation detachment. As of 2021, Changsha city handled more than 300 patent infringement cases, dealt with 600 cases of counterfeit patents, and recovered RMB 10 billion of economic losses for the city's enterprises. Secondly, the number of patent applications and patent licenses in Changsha increased 8 times and 3.5 times, respectively, and the investment in R&D increased from RMB 20 billion to more than RMB 100 billion. Finally, the number of high-tech enterprises in Changsha city grew from 922 to 5218, an increase of 4.7 times, and the added value of the high-tech industry grew by more than 10% annually.

2.2. Theoretical Framework

2.2.1. Basic Hypothesis

Based on the above background analysis, we argue that the emphasis of China's IPMP is to strengthen IPP, which will improve the development of the IPP system in the pilot cities as well as the intensity of IP judicial protection. Furthermore, the stronger IPP system of the pilot city will promote GTFP. First, the development model of the traditional economy, with high-speed economic growth as the main goal, relies heavily on the continuous input of energy, capital, and other factors, and has a sloppy development mode and serious environmental pollution. The improvement of the IPP system will enhance regional innovation and promote energy use efficiency [25]. Second, for developing countries, the capacity for knowledge creation is limited [26]. Foreign enterprises will not move their knowledge-intensive activities to regions with a weak IPP system to prevent technology leakage [27]. Therefore, the stronger IPP system of the pilot city would have a better chance of gaining the favor of foreign enterprises with advanced technologies, thus contributing to the enhancement of urban GTFP. Based on this, the following hypotheses are proposed.

H1. *The IPMP can enhance the urban GTFP.*

2.2.2. Hypothesis of Mechanism

Much literature has confirmed that technological innovation can promote GTFP [28,29]. We argue that the IPMP can enhance GTFP by promoting urban innovation. First, the construction of pilot cities can create a competitive market environment conducive to innovation and stimulate entrepreneurs' willingness to innovate by optimizing the IPP system and safeguarding innovation outcomes and innovation benefits. Second, innovation activities are characterized by long-term, high investment, and high risk [30], and enterprises' innovation activities are often inhibited by financing constraints [31]. The construction of the IPMP cities can broaden the financing channels of enterprises by establishing financial support measures, such as patent pledge financing and patent insurance, to alleviate the crowding-out effect of financing problems on innovation. Finally, the IPMP can reduce the risk of IP infringement on enterprises and enhance their confidence in disclosing information about R&D projects, thus reducing the information asymmetry between enterprises and investors and directly promoting their innovation behavior [32]. Based on this, we propose the following hypothesis.

H2. *The IPMP can promote urban GTFP through technological innovation.*

The IPMP in China helps accelerate the accumulation of human capital, form a talent gathering effect, and promote urban GTFP. First, the IPMP will improve the business environment and the importance of innovative talents in the pilot cities, which will inevitably attract more high-tech enterprises and high-end talents to gather, forming a talent gathering effect and improving the human capital level of the pilot cities. Second, strengthening the development of IP talents is one of the main tasks in the construction of the IPMP pilot cities. Specific indicators include the development of education and training of IP talents, policies and measures for the introduction and cultivation of IP talents, the number of IP talents, and the annual financial investment in the work of IP talents, to enhance the human capital level of the governments of pilot cities. Further, human capital, especially highly skilled human capital, is the primary capital to promote TFP, and a high-quality talent pool is the core competitiveness of enterprises [33]. Moreover, the level of human capital in a region directly determines the region's ability to absorb innovative technologies [34]. Based on this, we propose the following hypothesis.

H3. *The IPMP can promote urban GTFP through boosting human capital.*

The IPMP attracts foreign direct investment and thus promotes GTFP. Under open conditions, if the host country establishes a complete IPP system, which can not only reduce the additional costs that multinational companies need to invest in the process of entry, investment, and operation due to information asymmetry [35], but also increase the imitation cost required for advanced technology to be imitated by host country enterprises, thus reducing the possibility of advanced technology being plagiarized the possibility of plagiarism of advanced technology is reduced [36], and the confidence of foreign direct investment is enhanced. In addition, strengthening IPP can also reduce the negative externalities of innovation results [37], increase the economic value of innovation results, enhance the profitability of foreign direct investment, and thus encourage foreign investment. Based on this, we propose the following hypothesis.

H4. *The IPMP can promote urban GTFP through luring foreign direct investment.*

The IPMP promotes GTFP through industrial structure upgrading. Implementing reforms to strengthen IPP in developing countries can cause a reallocation of resources, attract advanced industries, and cause industrial transfer [38]. On the one hand, strengthening the IPP system can effectively accelerate the flow of innovation resources among industries within a region [39], enhance the efficiency of resource allocation among industries, and upgrade the industrial structure; on the other hand, strengthening IPP can attract various factors to flow into the region [40], alleviate the pressure of insufficient resources, and promote industrial structure upgrading. Further, industrial upgrading can not only boost the transition of specified resources to the tertiary and clean industries and reduce environmental pollution [41], but also facilitate the formation of upstream and downstream industries matching with industry and improve regional production efficiency [42], which is conducive to enhancing urban GTFP.

H5. *The IPMP can Promote Urban GTFP through modernizing industrial structure.*

Based on the previous analysis, we plotted the impact mechanism of China's IPMP on GTFP, as shown in Figure 1.

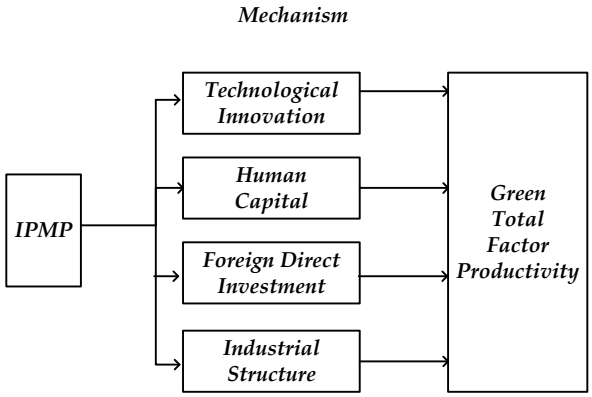

Figure 1. Effect mechanism of the IPMP on GTFP.

3. Study Design

3.1. Model Construction

Considering that the traditional DID method does not apply to quasi-natural experiments with multiple time points, this study uses the multi-period DID method to assess the impact of the *IPMP* on *GTFP*. Since the probability that unobserved factors and policy shocks can have the same distribution in different years is smaller, the multi-period DID approach is less susceptible to confounding factors, and its assessment results are more accurate. We first constructed the following multi-period DID model:

$$GTFP_{i,t} = \alpha_0 + \alpha_1 IPMP_{i,t} + \sum control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (1)$$

where $GTFP_{i,t}$ indicates *GTFP* in city i in year t; $IPMP_{i,t}$ is a dummy variable, and the value is 1 if city i is selected as a pilot city in year t, otherwise it is 0; $control_{i,t}$ indicates a series of control variables; μ_i indicates city fixed effects; σ_t indicates year fixed effect; $\varepsilon_{i,t}$ indicates random error term.

A prerequisite for ensuring unbiasedness when testing the average treatment effect of the impact of the *IPMP* on *GTFP* using Model (1) is that before policy implementation, the experimental and control groups need to satisfy the parallel trend hypothesis, i.e., the same trend in the outcome variable exists for the sample before it becomes a pilot city, and if the trends are inconsistent, the DID identification is biased of the sample. In this study, we use event analysis to test whether the sample meets the parallel trend and whether there is a dynamic effect. The model is set as follows:

$$GTFP_{i,t} = \alpha_0 + \sum_{k=-7}^{7} \alpha_k IPMP_{i,t} + \sum control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (2)$$

where the first *IPMP* pilot city is in 2012, and the latest is 2019, so the value of k ranges from -7 to 7. In the specific regression analysis, this position takes $k = -7$, i.e., the 7th year before the pilot policy, as the base period, by comparing the coefficients in Model (2) α_k to assess the dynamic impact on *GTFP* before and after the *IPMP* pilot city.

3.2. Definitions of Variable and Data Sources

3.2.1. Green Total Factor Productivity (GTFP)

Distinct from the traditional TFP calculation, *GTFP* contains two important connotations: improving productivity and protecting the environment [43]. In selecting input indicators, both productive factor inputs, such as human and capital inputs, and resource consumption, such as water supply and electricity supply, are selected and included as input variables. In the selection of output indicators, the maximization of desired outputs, such as economic development and green ecological benefits, are considered, as well as the constraints on economic development from three types of non-desired environmental pollution outputs, such as sewage, sulfur dioxide, and solid waste. Table 1 shows the

selected input/output indicators. In terms of the choice of method, this paper adopts a non-radial, non-angle super-SBM model to calculate *GTFP*.

Table 1. Definition of input and output metrics for *GTFP* calculations.

First-Level Indicators	Second-Level Indicators	Definition
Inputs	Workforce	The total amount of employment in urban units at year-end
	Capital Stock	Estimated by the perpetual inventory method
	Water Supply	Annual water supply
	Electricity Supply	Annual power generation
Desirable outputs	GDP	Real gross domestic product measured in 2000 as the base period
	Green Coverage	The percentage of built-up area that is covered by forest
Undesirable outputs	Industrial Waste	The quantity of industrial wastewater dumped
	Sulfur Dioxide Emissions	The quantity of industrial sulfur dioxide emitted
	Soot Emission	The quantity of industrial soot (dust) emitted

3.2.2. Intellectual Property Rights Model City Policy (IPMP)

The *IPMP* pilot cities selected in this study include 64 cities. If city *i* is approved as a pilot city in year *t*, the dummy variable *IPMP* takes the value of 1 in year *t*, i.e., thereafter, otherwise, *IPMP* takes the value of 0. The estimated coefficient α_1 of *IPMP*, i.e., the green economy effect of *IPMP*, indicates the average change of the green economy of *IPMP* relative to that of non-pilot cities.

3.2.3. Controlled Variables

Following the literature on green productivity [44,45], the control variables selected in this paper are: the level of urban economic development (*PGDP*), expressed as the logarithm of urban GDP per capita; population density (*POP*), using the number of 10,000 people per square kilometer; financial development (*FIN*), using total loans from financial institutions as a share of GDP; fiscal self-sufficiency (*FGOV*), using fiscal expenditure as a share of GDP. The descriptive statistics of the main variables in this paper are shown in Table 2.

Table 2. Descriptive statistics.

Variables	Obs.	Mean	Std. Dev.	Min	Max
GTFP	3840	0.816	0.087	0.632	1.058
IPMP	3840	0.086	0.281	0.000	1.000
PGDP	3840	1.428	0.562	0.000	3.867
POP	3840	0.043	0.033	0.000	0.266
FIN	3840	1.324	1.184	0.075	24.800
FGOV	3840	0.104	0.127	0.019	2.564
INNOV	3840	3.410	1.957	0.000	10.182
HUMAN	3840	12.591	25.112	0.000	193.498
FDI	3840	0.131	0.412	0.000	10.428
IS	3840	0.383	0.104	0.000	0.853

3.3. Data Sources and Statistical Characteristics

We examine the impact of the IPMP on GTFP using a sample of city-level data. As of 2020, the Chinese Intellectual Property Office has published a list of five national IPMP pilot cities. Considering the availability of city data, this study selects a sample of 256 cities from 2005 to 2019 as the study population, of which 64 cities were selected as national IPMP pilot cities during the sample period, and the data are obtained from the Chinese Intellectual Property Office by manually collecting and organizing the relevant documents from the State Intellectual Property Office. The city panel data are obtained from the China City Statistical Yearbook, the China City Construction Statistical Yearbook, the Wind database, and the CSMAR database.

4. Empirical Results

4.1. Baseline Regression

The empirical results are presented in Table 3, where Column (1) is regressed using only the core explanatory variable *IPMP*, and the coefficient of *IPMP* is significantly positive (0.1274, significant at the 1% level). Column (2) adds control variables, and Column (3) further adds time and city fixed effects, and the coefficient of *IPMP* is still significantly positive at the 1% level. This indicates that *IPMP* prompts local governments to strengthen IPP, leading to an increase in *GTFP* in cities, and Hypothesis 1 is confirmed.

Table 3. Baseline regression results.

	(1)	(2)	(3)
	GTFP	**GTFP**	**GTFP**
IPMP	0.1274 ***	0.0445 ***	0.0209 ***
	(0.0043)	(0.0032)	(0.0035)
PGDP		0.0519 ***	0.0059 ***
		(0.0012)	(0.0023)
POP		0.3245 ***	0.2813 **
		(0.0248)	(0.1393)
FIN		0.0271 ***	0.0154 ***
		(0.0013)	(0.0038)
FGOV		0.2525 ***	0.0567 ***
		(0.0083)	(0.0129)
Cons	0.8157 ***	0.7046 ***	0.7200 ***
	(0.0011)	(0.0029)	(0.0093)
N	3840	3840	3840
Year FE	No	No	Yes
City FE	No	No	Yes
Adj. R^2	0.1763	0.5793	0.7088

Note: Robustness standard errors are in parentheses, ***, **, * denote passing the test at 1%, 5%, and 10% significance levels, respectively.

In terms of control variables, *PGDP* and *POP* have a positive effect on *GTFP*, indicating that the higher the level of economic development and the higher the population density, the higher the level of urban *GTFP*. The effect of *FIN* on *GTFP* is positive, indicating that the level of financial development is related to *GTFP*, and regions with a higher level of financial development also have higher *GTFP*. *FGOV* has a positive effect on *GTFP*, i.e., regions with high financial self-sufficiency have a significant positive effect on *GTFP* as local governments can develop a green economy.

4.2. Parallel Trend tests and Dynamic Effects

The parallel trend assumption must be satisfied by the empirical study using the DID method, i.e., the trend of the experimental group is consistent with the control group before becoming a pilot city. If there are systematic differences before becoming a pilot city, it will have an impact on the empirical findings. Parallel trend tests and dynamic effects are shown in Figure 2.

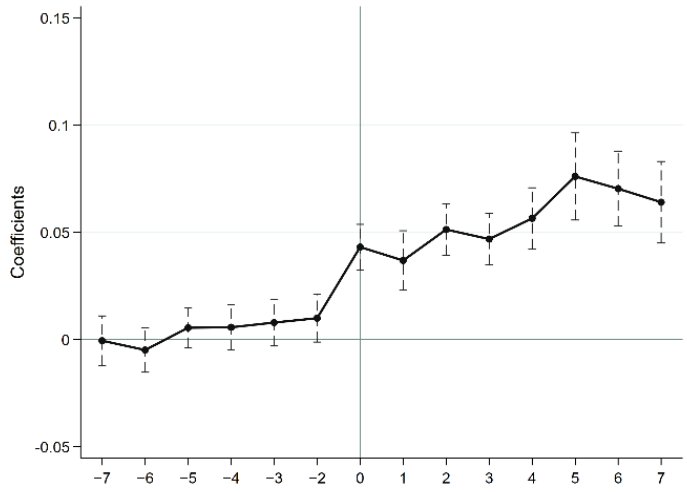

Figure 2. Test for parallel trends.

From Figure 2, the coefficients of the core explanatory variables before the implementation of *IPMP* are all insignificant, i.e., the experimental group and the control group do not differ significantly from one another before being approved as an IPMP pilot city. The coefficients of the core explanatory variables become significantly positive after becoming an IP model pilot city, which indicates that there is no significant difference between the *GTFP* of the experimental group and the control group before becoming an IPMP pilot city; after becoming a pilot city, the *GTFP* of the pilot city increases significantly. This shows the parallel trend hypothesis is satisfied. Overall, the promotion effect of *IPMP* on *GTFP* exists in the long term with a significant dynamic effect.

4.3. Robustness Tests

4.3.1. PSM-DID

Since differences in city characteristics may lead to the problem of individual heterogeneity between the experimental and control groups in the DID model, which reduces the robustness of the estimation results of the DID model. Therefore, this paper uses the propensity score matching method (PSM) to match the 64 experimental cities with the most similar city characteristics to the control group, so that there is no significant difference between the experimental and control group cities as much as possible before the construction of the model cities, and then uses the DID method to test the policy effects of the establishment of the IPMP cities. Specifically, in this paper, the nearest neighbor matching (1:1) propensity score matching method is used to screen out the control group samples matched with the experimental group, establish a logit model of whether the cities are the IPMP pilot cities, and select city-level control variables as the matching covariates. The results of the DID estimation using the matched samples are shown in Column (1) of Table 4. The PSM-DID estimation results show that the sign, estimated coefficient magnitude, and significance of the core explanatory variable IPMP are consistent with the baseline results. After considering the possible sample selection bias, the conclusions of this paper are not substantially changed, and the IPMP does promote GTFP improvement.

Table 4. Robustness test.

	(1)	(2)	(3)	(4)
	GTFP	**Alternative GTFP**	**GTFP**	**GTFP**
IPMP	0.0090 *** (0.0031)	0.0097 *** (0.0019)	0.0215 *** (0.0038)	0.0177 *** (0.0047)
INNOVPolicy			0.0038 (0.0039)	
SMARTPolicy			−0.0064 ** (0.0029)	
Cons	1.0096 *** (0.0062)	0.5195 *** (0.0036)	0.6795 *** (0.0066)	0.6747 *** (0.0080)
N	1920	3840	3840	3300
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Adj. R^2	0.2473	0.7999	0.8018	0.7995

Note: Robustness standard errors are in parentheses, ***, **, * denote passing the test at 1%, 5%, and 10% significance levels, respectively.

4.3.2. Replacing the Dependent Variable

This paper adopts the methodology of Shi and Li (2019) [46] and replaces the original non-desired output indicator with CO2 emissions to re-measure GTFP. As can be seen from Column (2) of Table 4, the regression results of replacing GTFP are still significantly positive at the 1% level. It indicates that after replacing the dependent variable, the pilot cities of the IPMP still significantly stimulate the improvement of GTFP, which strengthens the robustness and credibility of the basic conclusion.

4.3.3. Excluding Other Policy Interference

The improvement of urban GTFP is not only influenced by the IPMP, but also by other related policies. We add the DID term of national innovation city pilot policy (*INNOVPolicy*) to the baseline model, and similarly, we also construct the DID term of national smart city pilot policy (*SMARTPolicy*). It can be seen from Column (3) of Table 4, after controlling for other policy disturbances, the IPMP still has a significant contribution to urban GTFP, which indicates that the results of this paper are still robust.

4.3.4. Excluding Provincial Capitals and Sub-Provincial Cities

Compared with other cities, provincial capitals and sub-provincial cities have more advantages in terms of political and economic resources, which may affect the study findings. For this reason, provincial capitals and sub-provincial cities are excluded from the robustness test in this paper. From Column (4) of Table 4, the regression results do not change substantially, and IPMP still has a significant positive effect on GTFP, which also indicates that the conclusions are robust.

4.4. Placebo Test

To verify that the promotion effect of IPMP on GTFP was not caused by other random factors, a placebo test was conducted by re-randomizing the treatment and control groups with reference to the study of Cai et al. (2016) [47]. First, 64 cities were randomly selected separately as the new experimental group and the remaining cities as the control group to construct the spurious pilot policy DID term $IPMP_{i,t}\_False$. Second, based on the spurious pilot policy DID term $IPMP_{i,t}\_False$, regression estimation was performed according to Model (1), and the above process was repeated 1000 times to simulate obtaining 1000 estimated coefficients.

Figure 3 reports the kernel density distribution of the 1000 estimated coefficients of the DID term of the spurious pilot policy $IPMP_{i,t}\_False$. The distribution of the estimated coefficients of the placebo test is mostly concentrated around the zero point and basically obeys the normal distribution, and the *p*-value of most of the estimated coefficients is greater than 0.1, indicating that most of the estimated coefficients are close to 0 and insignificant. This indicates that the promotion effect of *IPMP* on *GTFP* passes the placebo test, which verifies the robustness of the previous empirical results.

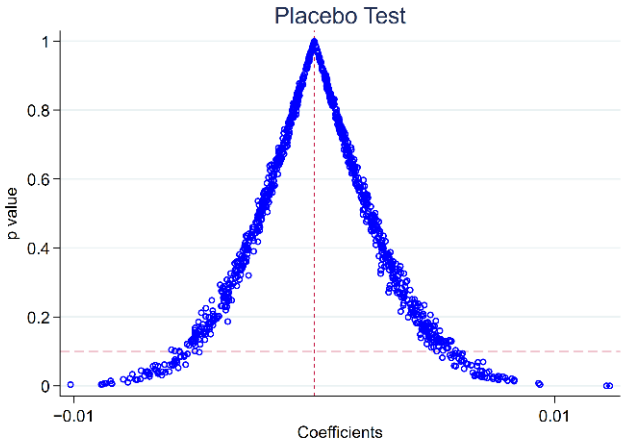

Figure 3. Placebo test.

4.5. Mechanisms Analysis

In the theoretical analysis, the IPMP will lead to the improvement of GTFP through four mechanisms: industrial upgrading effect, technological innovation effect, talent clustering effect, and foreign investment effect. Based on the results of the benchmark regression, this section will test the above intermediary effects based on the aforementioned theoretical mechanisms, to clarify the formation path of the green economy effect of IPMP. Combined with Model (1), we adopt the mediating effect model to test the above paths, and the specific settings are as follows:

$$M_{i,t} = \beta_0 + \beta_1 IPMP_{i,t} + \sum control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (3)$$

$$GTFP_{i,t} = \gamma_0 + \gamma_1 IPMP_{i,t} + \gamma_2 M_{i,t} + \sum control_{i,t} + \mu_i + \sigma_t + \varepsilon_{i,t} \quad (4)$$

where *M* is a mediating variable representing industrial structure (*IS*), technological innovation (*INNOV*), human capital (*HUMAN*), and foreign investment (*FDI*), as mentioned above. First, we use the natural logarithm of the number of green patent applications in the city plus one to represent the level of technological innovation in the city (*INNOV*) [43]. Second, we use the total number of university students in school to represent the city's human capital (*HUMAN*) [44]. Third, we used the amount of real foreign direct investment as a share of GDP to denote foreign direct investment (*FDI*) [45]. Finally, we use the share of the tertiary sector in GDP to indicate the change in industrial structure (*IS*) [46]. The specific regression results are shown in Tables 5 and 6.

Table 5. Mechanism test: technological innovation effect and talent clustering effect.

	(1)	(2)	(3)	(4)
	INNOV	**GTFP**	**HUMAN**	**GTFP**
IPMP	0.3216 ***	0.0151 ***	2.0830 ***	0.0186 ***
	(0.0888)	(0.0042)	(0.4634)	(0.0049)
INNOV		0.0180 ***		
		(0.0024)		
HUMAN				0.0011 ***
				(0.0003)
Cons	0.6317 **	0.6011 ***	5.5010 ***	0.5661 ***
	(0.3009)	(0.0117)	(0.6505)	(0.0139)
N	3840	3840	3840	3840
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Adj. R^2	0.6131	0.7390	0.1958	0.7826

Note: Robustness standard errors are in parentheses, ***, **, * denote passing the test at 1%, 5%, and 10% significance levels, respectively.

Table 6. Mechanism test: foreign investment effect and industrial upgrading effect.

	(1)	(2)	(3)	(4)
	FDI	**GTFP**	**IS**	**GTFP**
IPMP	0.0679 ***	0.0207 ***	0.0343 ***	0.0201 ***
	(0.0251)	(0.0043)	(0.0056)	(0.0033)
FDI		0.0033 ***		
		(0.0010)		
IS				0.0219 *
				(0.0126)
Cons	0.3073 ***	0.5821 ***	0.2511 ***	0.7112 ***
	(0.0502)	(0.0132)	(0.0225)	(0.0090)
N	2710	2710	3840	3840
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Adj. R^2	0.2099	0.7825	0.2379	0.7758

Note: Robustness standard errors are in parentheses, ***, **, * denote passing the test at 1%, 5%, and 10% significance levels, respectively.

4.5.1. Technological Innovation Effect

Columns (1) and (2) in Table 5 show the results of the regression with *INNOV* as the mediating variable. As shown, *IPMP* significantly stimulates the level of technological innovation. At the same time, both technological innovation and *IPMP* have a significant positive effect on *GTFP*, which indicates a significant mediating effect of technological innovation. In other words, *IPMP* is beneficial for cities to enhance the level of technological innovation and promote *GTFP*, which confirms Hypothesis 2.

4.5.2. Talent Clustering Effect

The IPMP strengthens regional IPP, which will not only prompt the city to pay attention to talent cultivation, but also attract talent mobility and improve the city's human capital level. Columns (3) and (4) in Table 5 are with *HUMAN* as the mediating variable. The regression results show that the national IP demonstration city policy has a significant positive effect on *HUMAN*. Meanwhile, both *IPMP* and *HUMAN* significantly promote

GTFP, which also shows the significant mediating influence of *HUMAN*. Obviously, Hypothesis 3 is confirmed.

4.5.3. Foreign Investment Effect

The IPMP enhances IPP and is conducive to attracting foreign investment. Columns (1) and (2) in Table 6 report the regression results using *FDI* as the mediating variable, which indicates that IPMP significantly increases FDI. At the same time, both *IPMP* and *FDI* have a significant positive effect on GTFP, which confirms the mediating effect of FDI. IPMP increased the regional IPP, which stimulated the willingness of foreign investment, and then increased GTFP. Thus, Hypothesis 4 is verified.

4.5.4. Industrial Upgrading Effect

First, we use *IS* as the explanatory variable in Model (3), and the results are shown in Column (3) of Table 6, where the estimated coefficient of *IPMP* on *IS* is significantly positive at the 1% level again. We further test the mediating variable by substituting it into Model (4), and Column (4) shows that the coefficient of IS is still significantly positive at the 10% level, while the estimated coefficient of *IPMP* decreases compared with the baseline regression results in Table 3, further verifying that industrial structure upgrading is a mediating factor of the IPMP affecting GTFP. Therefore, Hypothesis 5 is also confirmed.

4.6. Heterogeneity Analysis

4.6.1. Location Heterogeneity

China can be divided into the eastern region, central region, and western region by geographical location. Therefore, we divide 256 cities to further test the locational heterogeneity of the pilot effect of China's IPMP. Columns (1)–(3) of Table 7 show that China's *IPMP* significantly increases the *GTFP* of pilot cities in the eastern and central regions. The coefficient of IPMP in the western region is not significant, indicating that the *IPMP* in the western region cannot significantly increase the urban *GTFP*.

Table 7. Heterogeneity analysis.

	(1)	(2)	(3)	(4)	(5)
	East	**Central**	**Western**	**High**	**Low**
IPMP	0.0123 **	0.0159 ***	0.0192	0.0171 ***	0.0071
	(0.0048)	(0.0058)	(0.0142)	(0.0041)	(0.0060)
Cons	0.7442 ***	0.6769 ***	0.6942 ***	0.7151 ***	0.7244 ***
	(0.0201)	(0.0177)	(0.0284)	(0.0120)	(0.0101)
N	990	970	750	1640	1070
Controls	Yes	Yes	Yes	Controls	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.7126	0.7252	0.6980	0.7229	0.7004

Note: Robustness standard errors are in parentheses, ***, **, * denote passing the test at 1%, 5%, and 10% significance levels, respectively.

This may be because, relatively speaking, the eastern region is already in the middle or mature stage of economic development and IPP by its location, and has developed obvious advantages in green economic development, which may diminish the marginal effect of China's IPMP; on the contrary, the central region is in the primary development stage of economic development and IPP, and China's IPMP can give greater impetus to the construction of the local IPP system, which in turn has a significant effect on the GTFP.

4.6.2. Fiscal Transparency Heterogeneity

The effectiveness of implementing government policies will depend on the government's governing ability, and city fiscal transparency can well reflect the governing ability of local governments [48]. In this paper, we classify the government fiscal transparency of cities according to the 2019 China Municipal Government Fiscal Transparency Research Report published by Tsinghua University, China, and set the cities ranked in the top 50% of fiscal transparency as the higher fiscal transparency group and the cities ranked in the bottom 50% as the lower fiscal transparency group. Columns (4) and (5) of Table 7 show that China's IPMP has a significant positive effect only in the higher fiscal transparency cities; the regression coefficients in the lower fiscal transparency cities are not significant, although they are positive. This may be because the effect of China's IPMP is weakened when local governments are less capable of governing.

5. Conclusions and Policy Implications

What is the impact of enhanced IPP on urban GTFP? The answer has important implications for China, which is working towards a green development transition, and for other developing countries where IPP is weak. Based on the panel data of 256 cities in China from 2005 to 2019, this study considers the IPMP as a quasi-natural experiment and examines the effect and mechanism of the IPMP on the GTFP of the pilot cities using a multi-period DID method. The main findings are as follows: First, the IPMP in China has a significant promotion effect on GTFP. The GTFP significantly increases after the selection of China's IPMP pilot cities, and this finding passes the parallel trend test and still holds in the robustness tests of replacing the explanatory variables, excluding other related policy interference, excluding provincial capitals and sub-provincial cities, and changing to the PSM-DID method to correct for sample bias with the placebo test. Second, the influence mechanism of IPMP on GTFP mainly includes the industrial upgrading effect, the technological innovation effect, the talent clustering effect, and the foreign investment effect. Third, the heterogeneity analysis shows that compared with non-pilot cities, the pilot cities significantly increase the GTFP in the eastern and central regions; however, the promotion effect on pilot cities in the western region is not obvious. In addition, the IPMP has a significant positive impact only in cities with higher fiscal transparency, and the promotion effect on cities with lower fiscal transparency is not significant.

IPMP is an important part of realizing the construction of a strong IPP country in China, and IPP is an important external institutional guarantee for creating a good market environment, innovation environment, and stimulating green economic development. Examining whether the construction of IPR model cities can promote the development of urban GTFP is of great practical significance for strengthening IPR protection and achieving high-quality development. China's IPMP is an important current IPR protection policy in China, and it is particularly important to scientifically evaluate the effect of this pilot policy on GTFP.

Therefore, this paper puts forward the following policy recommendations. First, the Chinese government should continue to strengthen IPP policies and expand the scope of the IPMP pilot city. This will not only protect the interests of innovators, but also help promote sustainable development. Second, China's IPMP has less impact on GTFP in western cities and cities with less financial transparency. Therefore, in the specific IPP program, the Chinese government should consider the condition constraints of western cities and cities with lower financial transparency, and increase support and supervision accordingly to promote the coordinated development of IPP, environment, and economy. Finally, the Chinese government should further strengthen the IPP strengthening strategy to promote industrial structure upgrading, enhance technological innovation, attract talent concentration and foreign investment, and ultimately promote the development of a green economy.

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