Does the high-tech enterprise certification policy promote innovation in China?

Huiling Liu, Bo Li, Fei Xing and Kseniya Yakshtas

Abstract

This study investigates the impacts of the high-tech enterprise certification policy on enterprise innovation in China by analyzing the unique dataset of listed companies and their affiliates from 2006 to 2015. We exclude firms certified after year 2009 from the sample, because they may have engaged in R&D manipulation. The results show that the high-tech enterprise certification can promote enterprise innovation in China, especially the innovation captured by invention patents. The results of a rich set of robustness tests all support this conclusion. The study also concludes that the high-tech enterprise certification can influence enterprise innovation through "tangible" and "intangible" channels. Heterogeneity analysis shows that private enterprises, enterprises in industries with more competition, and equity-inspired enterprises benefit most from high-tech enterprise certification. This paper helps to comprehensively understand the validity of the innovation policy and the driving forces of enterprise innovation in China.

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Key words High-tech enterprise certification; innovation; R&D manipulation

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1. Introduction

Rapid growth and labor shortages have caused wages in China to rise substantially, far exceeding wages of other developing countries such as Bangladesh, India, and Vietnam. This has influenced China's competitive advantage in the international market and has contributed to a decreasing trade surplus. For China to step from a medium-income nation to a high-income nation successfully, the country's economic structure and growth model must be changed to emphasize innovation and productivity growth rather than cheap labor (Wei, 2018). Already the Chinese government has taken steps towards this goal. Nowadays growing prominence of innovation and patenting activities in China is increasingly gaining attention all over the world. The number of invention patent applications at China's State Intellectual Property Office (SIPO) increased from 14,409 in 1992 to 526,412 in 2011, overcoming the U.S.'s number of invention patent applications and making China the world's top patent filer (WIPO, 2012), a position China has since been able to hold. In 2015 the Chinese government also issued a strategic directive called "Made in China 2025", the priority of which is to promote and accelerate innovation.

As the main source of innovation in China, high-tech enterprises (HTEs) have been a focus of the Chinese government. Aimed at supporting HTEs' development, the Chinese Ministry of Science and Technology, the Chinese Ministry of Finance, and the Chinese National Tax Bureau jointly promulgated "National High-Tech Enterprise Certification Management Measures" (hereinafter referred to as "Certification Measures") and "High-Tech Enterprise Certification Management Working Guidelines" (hereinafter referred to as "Working Guidelines") on April 14, 2008, which was the first time for HTE certification to be fully carried out nationwide. On January 29, 2016, the "Certification Measures" were revised to enlarge the scope

of certification. Specifically, relevant standards were developed to encourage more innovation from small businesses (Yang et al., 2018).

The objective of this research is, accordingly, to identify the impact of the HTE certification policy on the technological innovation in China. Moreover, the study will provide evidence on how the government's "visible hand" can influence innovation as well as derive policy implications for Chinese policymakers and other countries' stakeholders who also have an interest in promoting innovations.

Existing theories have two opposite views on the relationship between the enterprise innovation and government support. One suggests that the innovation activities are highly risky, while government support can make up for market failures through pumping large amounts of resources into the companies, thereby stimulating corporate innovation behavior (Arrow 1972; Romer 1990; David 2000). Another theory argues that government cannot effectively allocate resources, and its direct intervention results in the distortion of competition and even the inhibition of corporate innovation (Michael and Pearce 2009; Yu et al. 2016). Most of the current literature focuses on a certain industrial policy or a single policy instrument (subsidy or tax preference) when exploring this subject. So far, very little analysis has been conducted on HTE certification, a recent and relatively comprehensive policy in China. Given this, this study will evaluate the impact of the "Certification Measures" on the patent applications by the companies and their affiliates in China, filling this gap in literature.

The contributions of our paper are as follows. First, there has been no consistency in arguments about the impact of government support on enterprise innovation, and the fact that Chinese government is deploying the HTE certification policy serves as an interesting case for reexamining this inconclusive issue. Second, the only few papers related to Chinese "Certification Measures" still have areas for improvement. They either concentrate on stock market reaction and earnings management (Xu and Zheng 2016; Yang et al. 2017) or have limited datasets and neglect the R&D manipulation problem (Xu 2017). Based on the previous research, this study focuses on "real" HTEs' innovation behavior after excluding companies engaged in R&D manipulation, and investigates more comprehensive samples to provide micro-level empirical evidence for the disputes over the influence of government support on corporate innovation. Third, according to Yu et al. (2016), companies may transfer the innovation activities to their affiliated companies. Therefore, it is not enough to consider only the number of patents filed by the listed companies when measuring innovation outputs. Thus, this study takes into account the subsidiaries, associates and joint ventures of the sample companies during the data collection. Fourth, in order to effectively address possible identification concerns, we use Heckman's two-step

method, Propensity Scoring Method, Difference-In-Difference method (PSM-DID), and other tests to ensure the robustness of the results. Finally, this study also analyzes the internal influence channels of HTE policy and some corporate heterogeneity effects, which improves the understanding of the transmission from macroeconomic policies to micro-market entities.

The remainder of this paper proceeds as follows. Section 2 presents the theoretical analysis and research hypotheses based on the policy background and relevant literature. Section 3 provides the information on sample selection, variable definitions, and summary statistics. Section 4 reports the main empirical results. Section 5 presents the conclusions and the policy recommendations.

2. Theoretical Analysis and Research Hypotheses

Innovation investment is a significant part of long-term strategy, directly affecting companies' future profitability and even the whole country's competitive advantages (Manso 2011). However, unlike ordinary investment, investment in R&D is characterized by positive externalities, high risks, high uncertainties, yield lags (Arrow 1972; Holmstrom 1989; Dosi et al. 2006), and high adjustment costs (Hall 2004), which leads to lack of innovation in firms. Under these scenarios, the government began to influence private enterprises' innovation activities by using financial measures as well as administrative control (Kang and Park 2012; Rao 2016). The HTE certification policy is an attempt of the Chinese government to address the challenge of boosting companies' technological innovation through the following channels.

2.1. "Tangible" Channel

At this stage, the market mechanism in China is not mature enough, and the government still controls the allocation of important resources required for enterprise survival and development. HTE certification can ensure that enterprises have enough "tangible" support, which smooths R&D expenditure path and decentralizes the risk of corporate innovation activities. Generally speaking, certified HTEs can obtain direct or indirect economic benefits on the following three levels.

The first level involves unified national polices. It is stated in the "Certification Measures" that in accordance with the "Enterprise Income Tax Law" and its "Implementation Regulations", the "Law of the People's Republic of China on the Administration of Tax Collection" and its "Implementation Regulations", enterprises that have obtained HTE certificates are entitled to such preferential taxation policies as 15% preferential income tax rates, R&D expenses deductions, and deductible taxes for using energy-saving and environmental-friendly equipment. The reduction of tax

burden cuts down enterprises' cash outflow to a certain extent, which improves their intrinsic capacity of financing innovation activities (Duchin et al. 2010).

The second level involves local policies. Certified HTEs can also enjoy various rewarding policies provided by the local governments, such as government subsidies, easier financing approval and land lease preferences. As a compensation for pioneer companies trying to innovate, government subsidies directly "transfer" some economic benefits to micro market players, which reduces corporate innovation costs and increases the funds available for research and development (Tether 2002; Chen et al. 2014).

Finally, HTE certificates are jointly awarded by the three government departments, which makes it possible to prove enterprises' scientific and technological stance. So HTEs can use these authoritative "brands" to quickly enhance their reputation, which is conducive to accessing innovative resources from other sources and helps enhance innovative capacities.

H1: HTE certification can promote enterprise innovation through the "tangible" channel.

2.2. "Intangible" Channel

Enterprise innovation as an investment decision essentially depends on companies' power structure. In many cases, the failure of a corporate entity to innovate is not due to the absence of favorable conditions, but due to the lack of motivation (Frenkel 2000). For instance, the separation of listed companies' ownership and control power will lead to the "principal-agent problem". Corporate executives tend to concentrate on their own interests and prefer avoiding risks due to their individual wealth relying on a single company (Bertrand and Mullainathan 2003), which is inconsistent with corporate long-term development. HTE certification also provides "intangible" benefits, spurring enterprises to engage in more innovative activities.

First, the acceptance of innovation in corporate culture can greatly influence innovation behavior (Deshpande et al. 1993), and the stronger the emphasis on innovation, the more resources will be allocated for innovative activities (Hurley and Hult 1998). HTE certification policy helps corporate executives better understand the true value of innovation activities, thus reducing their short-sightedness and stimulating their innovation enthusiasm. Besides, the mandatory provisions under the "Certification Measures" also have a deterrent effect on HTEs, making the senior executives implement innovation projects for achieving policy goals.

Second, HTE certification requires enterprises to enhance disclosure of relevant information through jointly established information disclosure mechanisms in various

departments. It fosters creative behavior by making it easier for companies to attract the attention of angel investors, institutional investors as well as news media.

Finally, HTE certification improves corporate human capital. HTEs are generally more capable of retaining existing scientific research talents as well as attracting more management personnel with higher professional skills, who are more likely to support independent innovation activities (Holmstrom 1989).

H2: HTE certification can promote corporate innovation through the "intangible" channel.

2.3. The Impacts of Corporate Heterogeneity on the Effectiveness of HTE Certification

Any eligible enterprise in China can apply for the HTE certification according to the "Certification Measures". However, due to corporate heterogeneity, the effectiveness of HTE certification may exhibit discrepancy among different types of companies. We mainly discuss the moderating effect of ownership, corporate governance structure, and market competition.

First, we analyze firm ownership. Private enterprises face more resource constraints than state-owned enterprises. For example, state-owned commercial banks that monopolized credit market have a natural "financial discrimination" against private enterprises. Also, owing to the imperfection of some of the related systems in China, there is a more serious information asymmetry problem between private enterprises and external investors. These problems faced by private enterprises can be effectively mitigated with the help of HTE certificates, which will drive the development of private enterprises' innovation activities. By contrast, state-owned enterprises have more abundant original resources (Greve 2003), but due to the "resource curse"[1] their technological innovation can be insufficient. In addition, state-owned enterprises often have more social responsibilities, which distorts their business objectives. Hence, compared with state-owned enterprises that are not in urgent need to obtain resources and are less efficient in transforming resources into innovative results (Carman and Dominguez 2001), private enterprises can enjoy greater positive effects of HTE certification on their innovation performance.

Second, we study corporate governance structure. Compared with traditional

[1] The concept of "resource curse" was first mentioned in Auty's (1993) book "Rich Resources and Economic Growth". Its meaning suggests that resource-rich countries have grown slower than countries with relatively poor natural resources. Similarly, for enterprises, rich resources may lead to negative effects, such as exacerbation of their extensive development.

performance-based compensation incentive plans, the implementation of equity incentive plans can effectively align the interests of management with the interests of shareholders (Wu and Tu 2007), thus reducing the adverse effects of principal-agent problems, helping to prevent corporate managers from "enjoying a calm life" (Bertrand and Mullainathan 2003), and increasing corporate risk-taking level (John et al. 2008; Atanassov 2013). Therefore, as an innovation-oriented corporate governance structure (Jensen and Murphy 1990), the long-term incentives can provide management with opportunities to share corporate profits and motivate managers to focus on corporate technological innovation (Wu and Tu 2007; Armstrong et al. 2013).

Finally, we discuss market competition. Arrow (1972) believes that corporate innovation incentives under competitive conditions are significantly higher than those under monopolistic conditions. The "natural laws" of survival of the fittest in market competition will drive out inefficient companies. Therefore, if companies want to survive and maintain a large market share, they have to continuously carry out innovation activities and accelerate commercialization of innovation results. Some empirical studies have already proven that moderate market competition encourages enterprises to extensively upgrade products, services, and technologies (Jaffe 1988; Zucker and Darby 2007). We believe that enterprises in the environment with relatively high market competition have stronger innovation driving force, and for them HTE certification will have a better innovation promotion effect.

H3: Private enterprises, equity-inspired enterprises, and enterprises in industries with higher competition can enjoy greater positive effects of HTE certification on their innovation performance compared with state-owned enterprises, non-equity-inspired enterprises, and enterprises in industries with lower competition.

2.4 The Influence of R&D Manipulation on the Effectiveness of HTE Certification

It should not be overlooked that HTE certification is based on the ex-ante information delivered by enterprises, so there exists the same possibility of rent-seeking as for many other government-supported initiatives. That is, in order to meet the policy requirements, companies are prone to some "support-oriented" adverse selection behavior. For example, companies may engage in "pseudo" research and development to reach certification standards, or carry out "strategic" innovation[2] to gain relevant

[2] According to Li Wenjing and Zheng Manni (2016), if enterprises pursue "quantity" and "speed" to meet government requirements, they are carrying out "strategic" innovation for the sake of seeking interests. "High quality" innovation with the purpose of fostering technological advancement and gaining competitive advantages is called "substantial" innovation.

policy preferences (Li and Zheng 2016; Yang et al. 2017; Chen et al. 2018). If these "pseudo" HTEs can be effectively identified and excluded from our sample, the remaining "real" HTEs should have better innovation performance.

H4: After excluding the companies engaged in R&D manipulation, we can observe that HTE certification has a greater positive impact on corporate innovation.

3. Sample Selection, Variable Definition and Summary Statistics

3.1. Sample Selection

Data for this study is mainly drawn from CSMAR (China Stock Market & Accounting Research) database[3], WIND economic database, CNINFO[4] and the network of HTE certification management[5]. Some data on HTE certification and R&D is manually collected from the HTE certification announcements and listed companies' annual reports. Our sample includes all the listed companies traded on Shanghai and Shenzhen Stock Exchanges from 2006 to 2015. The sample period starts from 2006 is because China adopted a new accounting standard that year. Since then, R&D input data of Chinese listed companies has been disclosed more systematically. The sample period extends to 2016 when the "Certification Measures" was amended.

We treated the original data in the following ways. First, we excluded all financial companies and companies that have suffered losses for two or more consecutive fiscal years. Second, we excluded clearly unreasonable sample observations and made up for some missing data. Third, we performed 1% winsorize processing at the beginning and at the end of all continuous variables to eliminate the influence of extreme values. Eventually we obtained 15,825 sample observations for 2,409 companies. Among them, 1,188 companies issued the project information on HTE certification. They were defined as HTEs in this paper.

3.2. Definition of Variables

Innovation level of enterprise (LnPat & LnInv). In contrast to R&D investment, innovation output can directly reflect a company's innovation ability (Aghion et al. 2005; Hagedoorn and Wang 2012). We use the number of total patent applications by

[3] Please access by: http://www.gtarsc.com/Home.

[4] Please access by: http://www.cninfo.com.cn/cninfo-new/index.

[5] Please access by: http://www.innocom.gov.cn/.

the sample companies and their affiliates as a measure of corporate innovation. According to the "Patent Law of the People's Republic of China", patents include inventions, utility models, and designs. Among them, inventions have the highest originality, thus they can better represent the level of enterprise innovation and are considered "substantial" corporate innovations (Tan et al. 2015). We use the number of corporate invention patent applications as an auxiliary measure of corporate innovation. We take the natural logarithm of (one plus) the raw patent data to construct the measure of the main innovation level.

HTE certification (Tec). HTE is defined in the "Certification Measure" as follows: "An enterprise implementing innovative activities in High-Tech Fields Supported by the State in order to form its core independent intellectual property rights and use the rights as a basis to carry out business activities. The enterprise should be a resident company registered in China (excluding Hong Kong, Macao and Taiwan) for more than one year." We here introduce a dummy variable of HTE, which, if a company obtains the certificate in a given year, has a value of 1, otherwise, is equal to 0.

Control variables. Referring to current empirical studies on enterprise innovation, such as He and Tian (2013), we introduce the following control variables. First, basic characteristics of enterprises, including *Firm Size (Size), Firm Age (Age), Ownership (State), Proportion of Independent Directors (IndRat), CEO Duality (Dual),* and *Institutional Investors Stake (Institution).* Second, corporate financial indicators, including *Product Market Competition (SaleRat), Return on Assets (ROA), Leverage (Leverage), Proportion of Fixed Assets (Fix), Liquidity (Liquidity), Operating Income Growth (Growth).* Third, external interference factors, including *Industry, Time,* and *Province Fixed Effect.*

The detailed definition of these key variables is shown in Table 1.

Table 1 Definition of Key Variables

Variable	Name	Definition
LnInv	Innovation level	Ln (number of total patent applications +1), number of total patent applications is a sum of the number of invention patent applications, utility model patent applications and design patent applications.
LnPat	Innovation level	Ln (number of invention patent applications+ 1)
Tec	HTE certification	Dummy variable, whether the enterprise obtained an HTE certificate (Yes=1, No=0)

Size	Firm size	Ln (total assets)
Age	Firm age	Natural logarithm of the establishing time, ln (current year – enterprise's establishment year +1)
SaleRat	Product market competition	Measured by the Sales expense rate, cost of sales / revenue
ROA	Return on assets	Net profits / total assets
Fix	Proportion of fixed assets	Net fixed assets / total assets
Leverage	Leverage	Total liabilities / total assets
Liquidity	Liquidity	(Current assets - current liabilities / total assets)
Growth	Growth rate of business income	(Operating income of this year - operating income of last year / operating income of last year)
State	Ownership	Dummy variable, whether the enterprise is a state-owned enterprise (Yes=1, No=0)
IndRat	Proportion of independent directors	Number of independent directors / total number of directors
Dual	CEO duality	Dummy variable, whether the chair and general manager is the same person (Yes=1, No=0)
Institution	Proportion of institutional investors	Number of shares held by institutional investors / total shares of the company, holding none has a value of 0

3.3. Summary Statistics

Table 2 shows the summary statistics for major variables. We report companies that have obtained and have not obtained HTE certificate respectively.

Table 2 Summary Statistics of Key Variables from 2006 to 2015

Variable	Sample with HTE certificates				Sample without HTE certificates			
	N	mean	sd	med	N	mean	sd	med

Patent	8326	51.7684	249.4553	14.0000	7499	43.2634	249.7268	4.0000
LnPat	8326	2.6368	1.4852	2.7081	7499	1.7742	1.7246	1.6094
Invention	8326	24.1458	181.0899	4.0000	7499	19.3036	135.3101	1.0000
LnInv	8326	1.7973	1.3601	1.6094	7499	1.1830	1.4498	0.6931
Size	8326	21.5607	1.0527	21.4141	7499	22.0626	1.5010	21.8937
Age	8326	2.6696	0.3204	2.7081	7496	2.7360	0.3492	2.7726
SaleRat	8326	0.0735	0.0814	0.0477	7486	0.0623	0.0788	0.0373
ROA	8326	0.0456	0.0779	0.0436	7499	0.1435	8.8771	0.0325
Fix	8326	0.2244	0.1375	0.2013	7499	0.2547	0.1847	0.2165
Leverage	8326	0.3937	0.2147	0.3821	7499	0.5870	2.1920	0.5022
Liquidity	8326	0.2748	0.2595	0.2589	7499	0.0661	1.7984	0.1211
Growth	7718	0.3020	5.0825	0.1344	7080	1.0096	26.8185	0.0968
State	8326	0.3331	0.4713	0.0000	7499	0.5471	0.4978	1.0000
IndRat	8274	0.3685	0.0524	0.3333	7441	0.3695	0.0564	0.3333
Dual	8211	0.2833	0.4506	0.0000	7313	0.1914	0.3935	0.0000
Institution	8326	0.0638	0.0910	0.0370	7499	0.0621	0.1023	0.0292

Note: this table reports the summary statistics for key variables from 2006 to 2015 and variables are defined in table 1.

As can be seen from the table, the mean of the number of total patent applications (invention patent applications) for sample companies is greater than its median, regardless of whether those companies are certified as HTEs. That is, the number of patent applications shows a clear right-aligned nature. The standard deviation is very large, which demonstrates that Chinese companies' innovative capabilities are uneven. On average, companies with HTE certificates in the sample are more innovation-intensive and have higher number of "substantive" innovations: certified companies applied for 51.77 patents per year, of which 24.15 were inventions, but non-certified companies applied for 43.26 patents each year, of which 19.30 were inventions. The characteristics of other control variables are similar to those of

previous studies and are not repeated here.

4. Empirical Results

4.1. Preliminary Analysis

Figure 1 shows the number of total patent applications[6] by the certified companies adjusted by industry and time before and after certification. We generated this figure by subtracting the average number of patent applications for all companies in a certain industry from the number of patent applications filed by the certified companies each year, and then averaging the differences. 0 point on the horizontal axis represents the year when a company obtained an HTE certificate for the first time, 1 (-1) point is the first year after (before) the certification year, other abscissas are analogous. Before the certification, the adjusted level of corporate patent applications was low and did not exhibit any obvious time trend. However, after HTE certification, the volume of companies' patent applications has maintained a significant upward trend at a relatively high level.

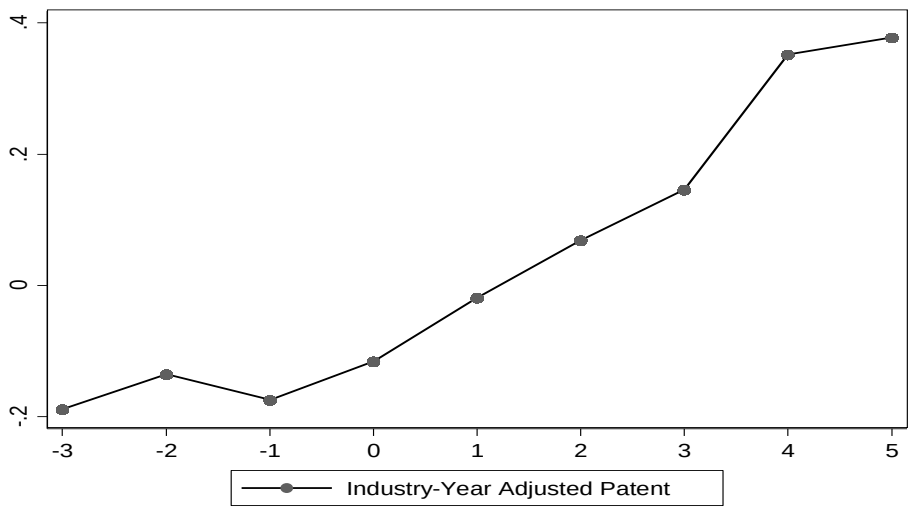


Figure 1. Patent applications adjusted by industry and time before and after certification

Simple graphic analysis cannot fully portray the relationship between HTE certification and corporate innovation, so in order to study it, we established a benchmark model.

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta Tec_i + \beta' X_{it} + \sum Year + \sum Ind + \sum Prov + \epsilon_{it} \quad (1)$$

[6] The figure of inventions is similar, which is shown in the appendix.

The explained variable $LnPat_{it}(LnInv_{it})$ is a natural logarithm of one plus the number of total patent applications (invention patent applications) for enterprise i in year t, reflecting the level of innovation. The main explanatory variable is Tec_i. If enterprise i has obtained an HTE certificate, Tec_i equals 1, otherwise it is 0. X_{it} is a vector of control variables. We also control for year fixed effects $\sum Year$, industry fixed effects $\sum Ind$ and province fixed effects $\sum Prov$, ϵ_{it} is the residual error. Since the number of patents cannot be negative, we adopted Tobit estimation method[7] in the study.

To test Hypothesis 4, we first obtained a sub-sample by excluding companies certified as HTEs after 2009. Then we successively regressed the full sample and the sub-sample. Results are shown in Table 3.

Table 3 **Preliminary analysis: Tobit regression**

	Full sample		Sample excluding companies certified after 2009	
	(1)	(2)	(3)	(4)
	LnPat	*LnInv*	*LnPat*	*LnInv*
Tec	**0.6589*** **	**0.5717*** **	**0.8172*** **	**0.7644*** **
	(21.78)	(18.59)	(22.50)	(20.98)
Size	0.7309***	0.7221***	0.7226***	0.7146***
	(54.85)	(51.33)	(47.17)	(45.10)
Age	-0.1005**	-0.1073**	-0.2208***	-0.2337***
	(-2.04)	(-2.13)	(-3.56)	(-3.72)
SaleRat	2.1311***	1.7458***	2.3827***	2.1245***
	(9.85)	(8.65)	(8.72)	(8.55)
ROA	0.0092	0.0117	0.0057	0.0078
	(0.49)	(0.70)	(0.31)	(0.48)

[7] Unless specified otherwise, simple regressions using the patent data as an explained variable all adopted Tobit estimation method in this paper.

Fix	-0.2902*	-0.2821	-0.3774*	-0.3375
	(-1.68)	(-1.50)	(-1.96)	(-1.61)
Leverage	0.2499**	0.2584**	0.2299**	0.2438*
	(2.39)	(2.20)	(1.99)	(1.83)
Liquidity	0.3404*	0.3760*	0.3074	0.3502
	(1.83)	(1.77)	(1.52)	(1.47)
Growth	-0.0016**	-0.0010***	-0.0015**	-0.0010**
	(-2.27)	(-2.71)	(-2.17)	(-2.46)
State	-0.0167	0.0921***	-0.0468	0.0562
	(-0.52)	(2.82)	(-1.24)	(1.50)
IndRat	0.4681*	0.2966	0.6195**	0.5165*
	(1.91)	(1.21)	(2.02)	(1.74)
Dual	0.1157***	0.1165***	0.0967**	0.0932**
	(3.81)	(3.68)	(2.43)	(2.27)
Institution	0.6574***	0.6317***	0.7336***	0.5894***
	(4.93)	(4.79)	(5.11)	(4.21)
Year FEs	Yes	Yes	Yes	Yes
Ind FEs	Yes	Yes	Yes	Yes
Prov FEs	Yes	Yes	Yes	Yes
Constant	-16.0758***	-16.5212***	-15.5890***	-16.1470***
	(-40.97)	(-38.56)	(-34.77)	(-33.48)
Observations	14428	14428	10701	10701
Pesudo R^2	0.1657	0.1628	0.1792	0.1874

Notes: The first and second columns provide results for the full sample. The third and fourth

columns provide results for the sub-sample which has excluded HTEs certified after 2009. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

As can be seen from Table 3, first, the coefficients of Tec are all significant and positive, so we can initially assume that HTE certification has improved the average level of corporate innovation. Second, the values of the coefficients in the sub-sample are greater than those of the full sample, which can be explained as follows. According to Yang (2017), companies under tax incentives may manipulate R&D investment to reach the requirements of HTE certification, and companies involved in R&D manipulation usually have poor innovative performance since they are just seeking policy benefits. We noticed a series of quantitative conditions for HTE certification that were aimed at the overall performance of enterprises in the past three fiscal years. Therefore, there are reasons to believe that for companies with R&D manipulation it was impossible to be certified before 2009[8]. When we used the full sample, the existence of these profit-driven companies hindered the appearance of the positive effects of the HTE certification policy. In the above subsample we excluded companies certified after 2009, therefore excluding companies possibly involved in R&D manipulation. The *Tec* coefficients are now larger, and Hypothesis 4 is verified. In order to ensure the validity of the subsequent analyses, they will be based on the subsample.

The coefficients of control variables indicate that companies with larger size, younger age, stronger product market competition, higher leverage ratios, higher institutional investors' shareholding ratios and lower operating income growth rates will have more patent applications. In addition, the corporate structure with integration of chair and general manager positions is also conducive to corporate innovation.

4.2. Robustness Test

4.2.1. Analysis Based on Heckman Two-step Method

Considering the possible sample selection bias, we used Heckman two-step method to do further research. The specific process can be divided into two stages. The first stage was constructing a selection model. We used Probit model to estimate the probability of a company obtaining an HTE certificate and then constructed the

[8] According to Yang Guochao et al. (2017), it is not difficult to track down the traces of companies' R&D manipulation. For instance, Nanling Civil Explosion company announced that it obtained the HTE certificate on May 26, 2011. Then it was found that in 2009, 2010, and 2011, the company's R&D investment accounted for 3% of the sales revenue for the year, which is exactly the regulatory threshold specified in "Certification Measures".

Inverse Mills Ratio Parameter *Lambda*. In the second stage, the *Lambda* parameter was added as an additional explanatory variable to our previous benchmark influence model. For effective identification, Heckman two-stage model requires the selection model containing at least one exclusive variable, so we need to find a variable that will determine whether a company obtains an HTE certificate but will not directly affect company's innovation level. The findings of Guo et al. (2016) suggest that the total number of firms in high-tech zones of the cities where HTEs are located in each given year can be used as an instrument variable to identify the probability of an enterprise acquiring government R&D subsidies. Similarly, for our model, we selected the total number of companies that have obtained HTE certificates in the given company's home province to be used in the selection model. This variable choice is mainly based on our understanding of the "Certification Measures". Accordingly, the science and administrative departments of provinces, autonomous regions, directly administered municipalities, and municipalities with independent planning status together with the financial and taxation departments at the same level constitute the administrative organs that carry out the certification work within their administrative areas. Therefore, the more companies are certified as HTEs in a certain province, the better the certification work in the region is carried out. Due to path dependence, there can be a certain basis for local enterprises' applications for HTE certificates, which can influence whether companies in the area can be certified. However, the number of companies that have been certified in a province is a macro-variable compared with enterprises' own attributes, and it is not an important factor affecting a company's innovation activities. Table 4 reports the results of this method's second step.

Table 4 Robustness test: Heckman two-step method

	(1)	(2)
	LnPat	*LnInv*
Tec	**0.8017*** **	**0.7600*** **
	(22.26)	(20.93)
lambda	**0.9602*** **	**0.6997** **
	(3.49)	(2.29)
Control	Yes	Yes
Year	Yes	Yes

Ind	Yes	Yes
Prov	Yes	Yes
Constant	-17.7446***	-17.6754***
	(-25.23)	(-23.93)
Observations	9823	9823
Pesudo R^2	0.1760	0.1802

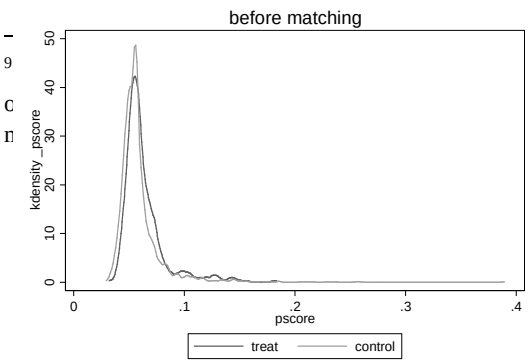
Notes: Control are all the control variables, for simplicity, we will not report their estimation results anymore. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

From the table, we can see that coefficients of *Lambda* and *Tec* are both significant and positive. It proves that there exists an issue of sample selection. In addition, after mitigating this bias, we find that obtaining HTE certificates still significantly increases companies' number of patent applications.

4.2.2. Analysis Based on PSM-DID Method

In addition to the selection bias, there may also be endogenous problems caused by the mixed bias and reverse causality. We subsequently used PSM-DID method to better control these issues. The basic idea is that if a company which will obtain an HTE certificate before its certification is completely similar to a counterpart that will not be certified, then, the only factor leading to their difference in innovation level is whether the company is certified as an HTE.

The first step is Propensity Score Matching (PSM), which provides a feasible strategy for match by turning high-dimensional corporate characteristics into propensity scores. We matched the sample treatment group and control group in the same year and in the same industry according to important corporate characteristic variables, including the number of accumulated patent applications (LnPats) and the growth rate of the total patent applications (PatGrowth[9]). Figure 2 shows the comparison of score density before and after matching. Overall, our matching quality is satisfying, as the distributions of score density in the two groups are very close after matching.



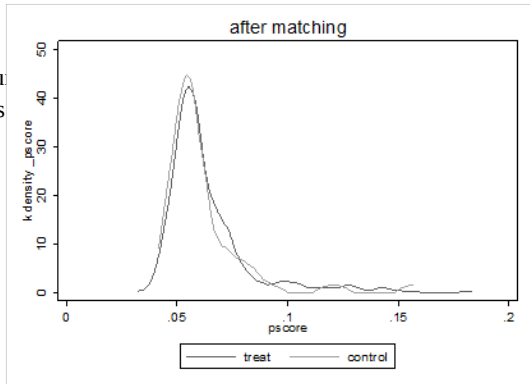


Figure 2. Propensity Score Matching Effect

The second step is Difference-In-Difference (DID). We used the matched sample[10] to examine the causal relationship between HTE certification and enterprise innovation, and a general DID model is as follows.

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta Tec_i \times After_{it} + \beta' X_{it} + \sum Year + \sum Firm + \epsilon_{it} \quad (2)$$

Where $Tec_i \times After_{it}$ is a dummy variable that captures the policy-time effect. A value of 1 represents the enterprise-year observations in the treatment group after certification, while a value of 0 indicates the enterprise-year observations in the control group or in the treatment group before certification. $\sum Firm$ represents the control variable for enterprise individual effects. The definition of other variables is the same as above. Table 5 reports the regression results. Regardless of whether the explained variable is the number of total patent applications or the number of invention patent applications, the coefficients of $Tec_i \times After_{it}$ are significant and positive, which proves that even after controlling for related endogenous problems, the corporate innovation promotion effect of HTE certification remains evident.

Table 5 Robustness test: Analysis based on PSM-DID method

	(1)	(2)
	LnPat	*LnInv*
Tec*After	**0.2171****	**0.2590*****
	(2.31)	(2.75)
Control	Yes	Yes
Year	Yes	Yes
Firm	Yes	Yes
Constant	-10.1191***	-11.0837***
	(-6.61)	(-7.36)

[10] The matched sample satisfies the common trend condition, which is shown in the Appendix.

Observations	3409	3409
Pesudo R^2	0.3787	0.3723

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

4.2.3. Certification Instances and Corporate Innovation

We also used the amount of times a company is certified (which we further refer to as certification instances) across the sample period to measure HTE certification policy implementation intensity (the more certification instances, the deeper the company is affected by the certification policy) and examined its impact on corporate innovation. Based on the aforementioned theoretical analyses and empirical conclusions, it can be inferred that the impact of innovation will be more obvious with the certification instances increasing. The specific estimation model is as follows:

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta Ins_{i,t-1} + \beta' X_{it} + \sum Year + \sum Ind + \epsilon_{it} \quad (3)$$

$Ins_{i,t-1}$is the number of accumulated instances of company *i* and its subsidiaries, associates, and joint ventures obtaining HTE certificates in year *t-1*. HTE certificates are valid for three years. After the expiration, the HTE certificates can be renewed multiple times. The definition of other variables is consistent with the previous text. We lagged Num for a period to reduce the possibility of reverse causality between certification instances and corporate innovation. Even if a business with stronger innovation ability may be able to obtain HTE certificates many times later, its current innovation level cannot affect its certification times in the previous period. It can be seen from Table 6 that the coefficients of $Ins_{i,t-1}$ are significant and positive, which once again confirms that HTE certification can promote enterprise innovation. Moreover, with an increase in the number of instances of enterprise certification, that positive correlation also increased.

Table 6 Robustness test: Certification instances and corporate innovation

	(1)	(2)
	LnPat	*LnInv*
Ins	**0.2717*** **	**0.2616*** **
	(21.15)	(20.38)

Control	Yes	Yes
Year	Yes	Yes
Ind	Yes	Yes
Prov	Yes	Yes
Constant	-14.7152***	-15.1217***
	(-30.78)	(-29.30)
Observations	9171	9171
Pesudo R^2	0.1779	0.1851

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

4.2.4. Other Robustness tests

Alternative Measure of Innovation

Research based on U.S. data often measures the quality of corporate innovation through patent citations. However, China has not completely disclosed the information on corporate patent citations yet. Referring to the study of Tan et al. (2015), we used the number of granted corporate patents as a measure of patent quality. To be specific, we constructed the variable *LnGra* (natural logarithm of one plus the number of granted patents in a given year) based on the number of enterprise's patents authorized by the end of 2017, the data update time. In addition, we also used the proportion of invention patent applications (*InvRat*, invention patent applications/the number of total patent applications) to measure corporate innovation efficiency.

Table 7 **Other robustness tests**

	(1)	(2)	(3)	(4)
	LnGra	*InvRat*	*LnPat*	*LnInv*
Tec	**0.7692*** **	**0.0340*** **	**0.8108*** **	**0.7561*** **
	(20.86)	(3.91)	(22.13)	(20.56)

Control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
Prov	Yes	Yes	Yes	Yes
Constant	-15.4458***	0.1626	-15.6206***	-16.1821***
	(-33.98)	(1.38)	(-34.79)	(-33.53)
Observations	10701	8099	10629	10629
Pesudo R^2	0.1755	0.2363	0.1789	0.1869

Notes: Column 1 and 2 use the sample with alternative measure of innovation. Column 3 and 4 use the sample excluding companies involved in other projects. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

From Table 7, we can find that coefficients of *Tec* are all significant and positive, indicating that HTE certification also enhances the quality and efficiency of corporate innovation. According to the "Working Guidelines", the HTE evaluation system adopts a scoring system in which the core independent intellectual property rights are the primary target. If a company owns one patent for invention or six intellectual property rights, it can gain the "A" file (24 to 30 points). That is, HTE certification may make enterprises more inclined to high-level innovations. Our results show that the proportion of invention patents has increased. Again, HTE certification has promoted corporate innovation, especially the innovation of inventions.

Excluding Companies Involved in Other Projects

In addition to HTE certificates, enterprises may also get other types of qualification certificates, such as Technologically Advanced Service Company, Key Enterprises within National Planning and Layout, Enterprise Technology Centers, Innovative Enterprises, the Torch Program, the 863 Program, Comprehensive Utilization of Resources, Technology Business Incubator, Integrated Circuit Design Company, Leading Enterprise, and Emerging Industry Strategic Backbone Enterprise. In order to eliminate this interference, we excluded from the sample all the companies that have other certificates except HTE certificates. Results of the reexamination are also shown in Table 7. The policy effect is still significant and positive and the coefficient sizes are still very close to our previous results, indicating that the main conclusions are not affected.

4.3. Mechanism Test and Heterogeneity Analysis

According to our previous theoretical analysis, we believe that HTE certification can influence companies' innovation activities through "tangible" and "intangible" channels. We tested them in turn here.

4.3.1. "Tangible" Channel

The "tangible" mechanism mainly works through tax preferences, R&D subsidies and bank credits the businesses can obtain. Referring to Li Weian et al. (2016), we used indicator $TaxYh = Tax \times (\frac{25\%}{r} - 1)/TP$ to measure the income tax concessions of certified enterprises, where r is the current income tax rate of a certified enterprise and 25% is the uniform corporate income tax rate in China. The deduction of 1 from the ratio of the two is the proportion of preferential tax rate this enterprise has obtained, which is then multiplied by its current income tax expenses to get the specific amount of tax benefits, and finally adjusted by its EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization). R&D subsidies (*Sub*) are obtained by taking the natural logarithm of total R&D subsidies a company received plus one. Bank credits (*Ldebt*) is the natural logarithm of a company's long-term borrowings plus one. Specifically, based on benchmark model (1), we established the following mediation model to test Hypothesis 1:

$$Tangible_{it} = \alpha + \beta Tec_{it} + \beta' X_{it} + \sum + \epsilon_{it} \tag{4}$$

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta_1 Tangible_{it} + \beta Tec_{it} + \beta' X_{it} + \sum + \epsilon_{it} \tag{5}$$

$Tangible_{it}$ captures the "tangible" channel, including tax preferences, R&D subsidies, and bank credits company i obtained in year t. Other variables' definitions are consistent with the previous text. Given the results of the benchmark model, if β coefficient in equation (4) and β_1 coefficient in equation (5) are significant and positive, and the value or significance of β coefficient in equation (5) is lower than that in equation (1), then there exists an intermediary effect. Table 8 reports the test results. We found that HTE certification has significantly improved corporate tax preferences and R&D subsidies but has not influenced bank credits[11]. As for tax preferences and R&D subsidies, β_1 coefficients in equation (5) are significant and positive, and the value of β coefficient in equation (5) is lower than that in equation (1). This indicates that the "tangible" channel does exist, and it mainly works through tax preferences and R&D subsidies. The insignificance of bank credits reflects the fact

[11] Results of the regression on bank credits are shown in the Appendix.

that China's financial market has not yet been able to serve HTEs in a satisfactory manner.

Table 8 **Mechanism test: "Tangible" channel**

	Tax preferences			R&D subsidies		
	(1)	(2)	(3)	(4)	(5)	(6)
	TaxYh	*LnPat*	*LnInv*	*Sub*	*LnPat*	*LnInv*
Tec	**0.1114*** **	**0.7758*** **	**0.7293*** **	**0.8718*** **	**0.7856*** **	**0.7287*** **
	(5.43)	(21.43)	(19.97)	(10.14)	(21.81)	(20.17)
Tangible		**0.0407** **	**0.0422** **		**0.0599*** **	**0.0563*** **
		(2.03)	(2.09)		(10.53)	(9.19)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes	Yes	Yes
Prov	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.5331***	-15.6344***	-16.6447***	-33.5454***	-14.2371***	-14.9251***
	(5.19)	(-35.15)	(-36.31)	(-25.75)	(-30.29)	(-29.22)
Observations	10492	10492	10492	10700	10700	10700
Pesudo R^2	0.5181	0.1785	0.1870	0.1636	0.1832	0.1910

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

4.3.2. "Intangible" Channel

In order to study whether HTE certification can influence corporate innovation through the abovementioned "intangible" channel, we selected important innovative elements, the percentage of R&D expenditure and R&D staff, as the proxy variables to test Hypothesis 2. Similarly, we established the following mediation test model.

$$Intangible_{it} = \alpha + \beta Tec_{it} + \beta' X_{it} + \sum + \epsilon_{it} \quad (6)$$

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta_1 Intangible_{it} + \beta Tec_{it} + \beta' X_{it} + \sum + \epsilon_{it} \quad (7)$$

where $Intangible_{it}$ captures the "intangible" channel, expressed in terms of R&D expenditure intensity (*RDE*, R&D capital/operating income) and R&D staff proportion (*RDS*, number of R&D technicians/number of total employees). Other variables' definition is consistent with the previous text. According to Table 9, HTE certification has significantly improved R&D expenditure intensity and the proportion of R&D staff. β_1 coefficient in equation (7) is significant and positive and the value of β coefficient in equation (7) is lower than that in equation (1), which indicates that HTE certification can increase patent applications by increasing the input of corporate innovation factors. That is, HTE certification improve companies' motivation to engage in more technological innovation activities, which proves that the "intangible" channel exists.

Table 9 Mechanism test: "Intangible" Channel

	R&D expenditure intensity（%）			R&D staff proportion（%）		
	(1)	(2)	(3)	(4)	(5)	(6)
	RDE	*LnPat*	*LnInv*	*RDS*	*LnPat*	*LnInv*
Tec	**1.2008*** **	**0.8094*** **	**0.7543*** **	**2.0888*** **	**0.8139*** **	**0.7590*** **
	(8.06)	(22.27)	(20.75)	(20.07)	(22.47)	(20.98)
Intangible		**0.0232*** **	**0.0323*** **		**0.0065*** **	**0.0110*** **
		(3.30)	(3.78)		(4.60)	(7.66)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes	Yes	Yes
Prov	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-4.7333**	-15.7457***	-16.3723***	-100.7850***	-15.6820***	-16.2971***
	(-2.08)	(-34.99)	(-33.89)	(-25.75)	(-35.20)	(-34.43)
Observations	10701	10701	10701	10701	10701	10701

Pesudo R^2	0.1096	0.1801	0.1895	0.1901	0.1797	0.1891

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

4.3.3. Further Analysis

As for the "tangible" channel, relatively standard tax preferences and R&D subsidies give companies a stable expectation of funds, which may also increase companies' tendency to overinvest in projects with high returns and short-term cycles, distracting enterprises from technological innovation (Boeing 2016). It is worth mentioning that the effect of taxation and subsidy policy tools under HTE certification in our study is a net effect. The positive effect dominates, which implicates that serious innovative resource constraints still exist in current Chinese context and the promotion effect can be exerted.

It may be easier to obtain HTE certificates for enterprises located in high-tech development zones or in more economically, financially, and legally developed regions. Therefore, the number of patents enterprises applied for in these areas would have been higher regardless of HTE certification. There is the possibility that it is not HTE certification that leads to a higher level of technological innovation. Nevertheless, based on the following three points, we can exclude the interference of this possibility in our main results. First, we have already controlled for provincial fixed effects. Second, not all companies in these areas have been certified as HTEs, which means that even though the sample includes enterprises in these areas, within these areas we can still control for the effect of HTE certification. Our regression results let us conclude that the promotion of enterprise innovation exists. Finally, we collected the data on the index of market intermediary organizations and environmental legal system development in various provinces across the country, and then put the index into our model as a control variable (Wang et al 2017). A further test found that even if the regional environment scores were controlled for, HTE certification still significantly promoted corporate innovation.

In this paper, two main underlying channels are proposed and tested. Empirically, our results show that even after controlling for the two channels, HTE certification still significantly promotes corporate innovation[12]. As a result, we assume that HTE certification may have a direct promotion effect on enterprise patent applications, or there may exist other undiscovered channels, which requires further study.

[12] After combining (5) and (7), that is, the simultaneous control of tangible and intangible channels, we found that the coefficient of HTE certification is still significant, this part is shown in the appendix.

4.3.4. Corporate Heterogeneity's Impact on the Effectiveness of HTE Certification

In order to further examine the influence of firms' heterogeneity, the following empirical analysis was conducted. First, we ran a test for the interaction of a dummy of firm's ownership and a dummy of HTE certification. Second, we ran a test for the interaction of a dummy of equity incentive (*EI;* when there is equity incentive, the value is 1, otherwise it is 0) and a dummy of HTE certification. Third, we calculated the Herfindahl index (*HHI*) based on company's operating income (The larger the index, the greater the degree of industry concentration and the lower the level of market competition). Also, we ran a test for the interaction of *HHI* and a dummy of HTE certification. Table 10 presents all the results.

Table 10 **Heterogeneity analysis**

	Ownership		Equity incentive		Market competition	
	(1)	(2)	(3)	(4)	(5)	(6)
	LnPat	*LnInv*	*LnPat*	*LnInv*	*LnPat*	*LnInv*
Tec	0.8698***	0.7688***	0.7498***	0.6917***	1.5512***	1.5512***
	(20.36)	(17.79)	(17.49)	(16.24)	(35.14)	(35.14)
State*Tec	**-0.1064****	**-0.0052****				
	(-2.23)	(-2.11)				
EI*Tec			**0.1431*****	**0.1532*****		
			(3.19)	(3.37)		
HHI*Tec					**-5.3494*****	**-6.8571*****
					(-4.97)	(-5.21)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes	Yes	Yes
Prov	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-15.5740***	-16.2027***	-15.5739***	-16.1297***	-10.4881***	-11.2678***

	(-34.73)	(-33.63)	(-34.76)	(-33.48)	(-22.58)	(-24.14)
Observations	10701	10701	10701	10701	10701	10701
Pesudo R^2	0.1792	0.1873	0.1794	0.1876	0.0919	0.1014

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

We can see that, first, for each group, HTE certification is significantly and positively associated with corporate innovation. Second, as our theoretical part predicts, the coefficients of interaction terms for ownership are significant and negative. In other words, compared with state-owned enterprises, private enterprises are more sensitive to the innovation incentive effect of HTE certification. The coefficients of interaction terms for corporate governance are significant and positive. That is, equity-incentive enterprises enjoy a greater positive adjustment effect of HTE certification on their innovation ability compared with non-equity-incentive companies. The coefficients of interaction terms for market competition are significant and negative, which means that the higher the degree of competition of the industry where the company belongs, the greater the promotion effect of HTE certification. In summary, Hypothesis 3 holds.

5. Conclusion

Innovation has always been among the priorities of government policy and academic research. Taking China's "National HTE Certification Administrative Measures" as background, we study Chinese enterprises' patenting activities after excluding enterprises involved in R&D manipulation from the sample. We find that HTE certification policy has significantly promoted Chinese enterprises' innovation activities, especially boosting their patented inventions. This conclusion remains sound after addressing a series of identification issues. Moreover, the more certification instances an enterprise has, the stronger the innovative promotion effect it can achieve. Further, we analyze underlying mechanisms and find that there exist "tangible" and "intangible" channels of the policy's innovation promotion effect. Also, corporate heterogeneity factors such as ownership, equity incentives, and industry competition level can influence the effectiveness of HTE certification.

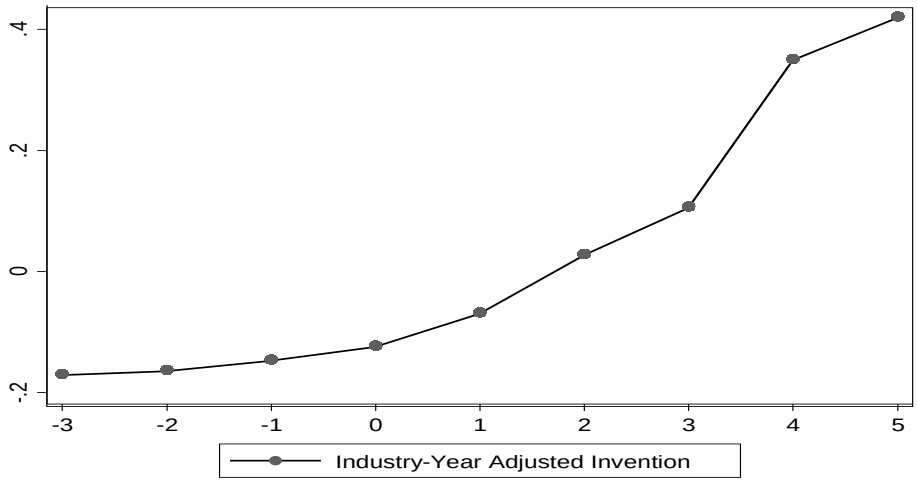
This study reveals the role of the Chinese government's "visible hand" in enterprise innovation and has important policy implications. First, the HTE certification policy indeed promotes innovation in "real" HTEs, but there also exist noises from "pseudo" HTEs. Hence, the certification criteria and audit procedures should comprehensively evaluate companies' innovation capabilities to leave less

space for R&D manipulation. In addition, the follow-up tracking and supervising governance need to be strengthened, thus identifying "pseudo" HTEs as early as possible to avoid the misallocation of market resources. Second, it is necessary to prudently employ policy instruments such as tax preferences and R&D subsidies, which aims at cultivating the philosophy of indigenous innovation among enterprises. Third, we believe that only policies based on corporate characteristics can be effective. Therefore, firm heterogeneity should be considered and appropriate dynamic adjustments should be made in the process of policy implementation. Fourth, the system of Chinese financial market should keep being improved, guiding investors to correctly understand and support corporate innovation, thus creating a good "mass innovation" atmosphere.

This paper also leaves some areas for further research. First, patent data cannot fully reflect enterprise innovation level, therefore a better measure for enterprise innovation remains to be adopted. Second, the influence of macroeconomics on micro-subjects is complex. Although we attempt to reveal the underlying mechanism, a better quantification of "tangible" and "intangible" channels still needs to be developed. Third, while excluding the companies certified after 2009, we may have also accidentally excluded some innovative ones. Therefore, identifying enterprises with R&D manipulation using more accurate methods is also among the further research goals.

Appendix

Appendix A: Preliminary Analysis



Appendix Figure 1. Invention patent applications adjusted by industry and time before and after certification

Appendix B: Robustness Analysis

We set up the following models to test the common trend condition:

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta Tec_i \times After_{2006} + \beta_1 Tec_i + \beta_2 After_{2006} + \beta' X_{it} + \sum + \epsilon_{it} \quad (8)$$

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta Tec_i \times After_{2007} + \beta_1 Tec_i + \beta_2 After_{2007} + \beta' X_{it} + \sum + \epsilon_{it} \quad (9)$$

Since the "Certification Measures" was promulgated in 2008, we tested the common trend condition by replacing the dummy of certification time ($After_{it}$) with $After_{2006}$ (take 0 before 2006 and 1 after 2006) and $After_{2007}$ (0 before 2007 and 1 after 2007).The coefficients of the interaction items reflect the difference between the treatment group and the control group in a certain year before implementation of the policy. As can be seen from Appendix table 2, the coefficients are not significant, so common trend condition is satisfied.

Appendix Table 1 **Common trend**

	2006		2007	
Variable	(1)	(2)	(3)	(4)
	LnPat	*LnInv*	*LnPat*	*LnInv*
Tec* After2006	**-0.4048**	**-0.3368**		
	(-1.58)	**(-1.33)**		
Tec* After2007			**-0.1500**	**-0.3386**
			(-0.67)	**(-1.53)**
Tec	0.7645***	0.6697***	0.7558***	0.6843***
	(8.72)	(7.77)	(8.52)	(7.85)
After2006	-0.0113	-0.1275		
	(-0.05)	(-0.55)		
After2007			-0.0247	0.0325
			(-0.12)	(0.16)
Control	Yes	Yes	Yes	Yes

Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
Prov	Yes	Yes	Yes	Yes
Constant	-16.3309***	-17.8156***	-16.6077***	-18.0450***
	(-26.42)	(-26.74)	(-26.51)	(-27.38)
Observations	3409	3409	3409	3409
Pesudo R^2	0.2070	0.1833	0.2056	0.1823

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

Appendix C: Mechanism test

Appendix Table 2 **Mechanism test: Bank credit**

	(1)	(2)	(3)
	Ldebt	*LnPat*	*LnInv*
Tec	0.4833	0.8189***	0.7659***
	(1.57)	(22.48)	(20.97)
Ldebt		-0.0018	0.0015
		(-0.91)	(0.75)
Control	Yes	Yes	Yes
Year	Yes	Yes	Yes
Ind	Yes	Yes	Yes
Prov	Yes	Yes	Yes
Constant	-116.5556***	-15.7195***	-16.0488***
	(-37.92)	(-33.41)	(-32.03)
Observations	10674	10674	10674
Pesudo R^2	0.0730	0.1792	0.1873

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

Appendix D: Further analysis

Appendix Table 3 Economic, financial and legal institutional environment

	(1)	(2)	(3)	(4)
	LnPat	*LnInv*	*LnGra*	*InvRat*
Tec	**0.8155*****	**0.7630*****	**0.7666*****	**0.0342*****
	(22.43)	(20.93)	(20.77)	(3.93)
System	-0.0202*	-0.0152	-0.0301**	0.0020
	(-1.66)	(-1.24)	(-2.42)	(0.64)
Control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
Prov	Yes	Yes	Yes	Yes
Constant	-15.3932***	-16.0018***	-15.1534***	0.1435
	(-33.23)	(-32.32)	(-32.26)	(1.18)
Observations	10701	10701	10701	8099
Pesudo R^2	0.1793	0.1874	0.1757	0.2364

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

Equation (5) and equation (7) were merged to obtain the following equation (10), and the regression was performed. Results are shown in Appendix Table 5.

$$LnPat_{it}(LnInv_{it}) = \alpha + \beta_1 Ability_{it} + \beta_2 Motivation_{it} + \beta Tec_{it} + \beta' X_{it} + \sum + \epsilon_{it} \quad (10)$$

Appendix Table 4 Direct effects or other underlying mechanisms

		(1)	(2)
		LnPat	*LnInv*
	Tec	**0.7395*** **	**0.6865*** **
		(20.60)	(19.05)
	TaxYh	0.0126	0.0258
		(0.60)	(1.32)
Tangible	*Sub*	0.0596***	0.0554***
		(10.37)	(9.00)
	RDC	0.0269***	0.0359***
		(4.07)	(4.99)
Intangible	*RDP*	0.0036**	0.0075***
		(2.48)	(5.08)
	Control	Yes	Yes
	Year	Yes	Yes
	Ind	Yes	Yes
	Prov	Yes	Yes
	Constant	-14.5690***	-15.7772***
		(-31.50)	(-32.80)
	Observations	10491	10491
	Pesudo R^2	0.1839	0.1940

Notes: ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. T statistics are in brackets.

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