HIGH-TECH INDUSTRIAL DEVELOPMENT ZONE POLICY AND FIRM INNOVATION ACTIVITIES: EVIDENCE FROM CHINA

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ABSTRACT

This thesis investigates whether high-tech industrial development zone policy affects firm innovation activities in China. We find the impact of the policy on firm patents is more significant in firms with fewer patents in the pretreatment period. We also find the policy has more effective impacts on firm patents in non-SOEs, small firms, and firms in developed regions. Besides, we provide two extensions. First, we show the policy has little effect on increasing the number of high-quality patents. Second, we show the policy has a significant positive influence on firm R&D expenditure, and the impact is more significant than on successful firm patent applications. The results indicate such a policy in China may have effective impacts on increasing innovation activities in certain firms, but the effects could be limited to meeting the requirements of the policy while having a relatively little influence on increasing firms' high-quality innovation outputs.

BIOGRAPHICAL SKETCH

Xueyun Luo is an MS student in the field of Applied Economics and Management within the Charles H. Dyson School of Applied Economics and Management at Cornell University. Before joining the MS program at Dyson, she received her Bachelor's degree in Sociology from Peking University in China. From 2019 to 2021, she continued her graduate study in the concentration of management at Dyson school. Her research interests are in the areas of economics of innovation and digitization. From August 2021, she will join the Ph.D. program housed within the Charles H. Dyson School of Applied Economics and Management at Cornell University to continue her graduate study.

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CHAPTER 1 INTRODUCTION

Innovation is a crucial contributor to a firm's competitive success and even a nation's sustainable development. Although it is widely discussed the influence of various determinants, such as tax incentives (Moretti and Wilson, 2014), science parks (Díez-Vial and Montoro-Sánchez, 2016), etc., on innovation activities in developed countries, little is known about whether those factors affect innovation activities in developing countries, especially the effectiveness of policies targeting innovation. The previous study in developed countries has produced mixed results of whether such an innovation policy could effectively stimulate R&D investments and increase innovation outputs (e.g., Busom, 2006; Hottenrott et al., 2017), and shown heterogeneity across various targets (Takalo et al., 2013). It is reasonable and necessary to ask whether such a policy could effectively improve firm innovation and what the heterogeneous effects are in the context of developing countries. First, policy incentives play a more important role in developing countries where market mechanisms are still not perfect, and firm performances rely more on institutional guidance[1]. Second, compared with the heterogeneous impacts in developed countries, the impacts in developing countries may have different sources of heterogeneity because of their different economic and social conditions. Third, patent quantity and R&D expenditure are widely used when looking into innovation activities, while little is known about patent quality in developing countries, although it has already brought increasing concerns to researchers and policymakers. Since patent quality matters more regarding fostering economic and social development, it is worth further exploring whether an innovation policy could effectively improve high-quality innovation outputs. In this thesis, we address the impact

[1] http://www.gov.cn/zhengce/2020-04/09/content_5500622.htm

of place-based policy on innovation activities in China. In specific, we ask whether high-tech industrial development zone policy affects firm patent quantity, patent quality, and R&D expenditure in China.

High-tech industrial development zone policy is a place-based policy aiming at improving firm innovation capacity, especially in high-tech sectors. The policy is involved in a broad range of aspects related to firm innovation, including financial supports, such as tax exemption, favorable loan conditions, and IPO, human capital, such as skilled employees and managers, and other institutional supports, such as priority of land use and simplified administrative procedures. Compared with previous research focusing on R&D subsidy programs (Guo et al., 2016), high-tech zone policy covers relatively comprehensive aspects to promote firm innovation capacity. On one hand, it provides full support for targeted firms to improve innovation, but it may lead to other heterogeneous effects across firms, such as geographical heterogeneity. On the other hand, with all those resources allocated, how effective is the policy? It is well documented that the Chinese government's intervention in business is inefficient (Brandt et al., 2013; Guo et al., 2014). Does it mitigate market failure on allocating innovation resources, or is it another government failure?

High-tech industrial development zones have gradually been established in different regions across China since China's reform and opening up in the late 1980s. We identify the geographical and temporal variations existing in the establishment of high-tech industrial development zones in China. Lu et al. (2019) point out that such a program is related to both existing firms and the entry of new ones, similar to the program's impact in India (Chaurey, 2017). We only investigate the impact on existing firms in the designated areas in the short run because it is hard to observe activities in new entrants before the establishment of high-tech industrial development zones. We consider firms whose location has been identified as a high-tech industrial development zone in the sample period as treated firms and apply the propensity score matching to construct our control firms from all other firms. We adopt a difference-in-difference approach that compares innovation activities in the treated firms before and after the establishment of high-tech industrial development zones to those in the control firms.

Li (2012) proposes that place-based policy is important for the growth of Chinese patenting at the provincial level, and Yang and Lee (2021) evaluates the degree of R&D misallocation across high-tech industrial development zones in China, while this thesis focuses on firm-level data allowing us to provide a more nuanced and mixed view on the efficacy of the policy that is only possible to be observed at the firm level. Following the establishment of high-tech industrial development zones in China, such a program could have a more significant positive impact on firms with fewer patents in the ex-ante treatment period because firms have incentives to increase their patent counts to gain a higher score so that they could be certified as high-tech enterprises and get benefit from the policy, and also because the distribution of firm patent counts has a long right tail. We consider using quantile regression to look into the impact on the number of firm patents in different percentiles. We find that treated firms increase their patent applications more than control groups in the lower percentile. In addition, we also find that the policy has more effective impacts on firm patents in small firms, non-SOEs, and firms in developed regions. We provide robustness checks to further examine our findings above.

We provide two extensions to our main findings, and we find that high-tech industrial development zone policy in China could lead to an increase in the number of firm patents and R&D expenditure. However, the results suggest that despite an increase in innovation inputs, there is not much of an increase in high-quality innovation outputs.

Specifically, beyond patent quantity, we first further explore whether the establishment of high-tech industrial development zones could positively affect firm patent quality. Patent quality is always a concern in both developing countries and developed countries (Thoma, 2013; Liu et al., 2014; Dang and Motohashi, 2015). Previous studies indicate that the explosive surge of Chinese patent applications filed is accompanied by a relatively low patent quality (Fisch et al., 2017). Therefore, it is reasonable and necessary to explore the influence on firm patent quality, and it has a great possibility that the establishment of high-tech industrial development zones may not effectively increase firm patent quality. When looking into firm patent quality instead of firm patent quantity, we find less evidence of an increase in high-quality patents though patent quantity has increased in China.

Second, we investigate the impact of the establishment of high-tech industrial development zones on firm R&D expenditure. To do this, we first analyze the impact using the total sample. Moreover, according to the requirements of high-tech industrial development policy, firms need to be certified as high-tech firms in order to enjoy the preferential policy. One of the conditions is that the ratio of total R&D expenditure to total sales should not be less than 5%. Hence, we then redo the analysis using subsamples split by the ratio below and above 5% before the treatment year. Our findings show that the establishment of high-tech industrial development zones has a significant positive influence on firm R&D expenditure, especially for firms whose ratio is below 5%, suggesting that firms below the threshold may have particular incentives to boost R&D expenditure to be above the threshold, and the impact is more significant than on the number of patent applications.

This thesis makes several contributions. First, at a broad level, this study contributes to the influence of a place-based policy as an incentive on firm innovation activities in the context of developing countries. Compared with related literature in developed countries and regions, the market imperfections in developing countries make government interventions, such as high-tech industrial development zone policy, still play an important role in leading and affecting firm performances. According to a China's government document in 2020[2], it points out that the technology and innovation market in China is still imperfect and needs to be improved. It listed several specific aspects. For instance, the allocation of innovation resources needs to be improved. The evaluation system of innovation achievements needs to be established and needs to be marketized and socialized. The technological elements and capital elements need to be integrated. One specific example is that it is still not common for China's commercial banks to provide loan services such as intellectual property pledges and expected income pledges. Also, labor mobility of knowledge workers is still limited by some non-market factors, such as residency (*hukou*) and evaluation system. Correspondingly, high-tech zone policy provides more resources for firms in the zones to improve their innovation and rewards innovation activities. It also provides favorable loan conditions for targeted firms, which could compensate for the imperfect capital market regarding loans for innovation. And the preferential policy for attracting knowledge workers also increases personnel mobility. With different economic and social conditions, our findings on the impacts of Chinese place-based policy on firm innovation activities may shed light on whether government intervention could mitigate market failure in China.

Second, this thesis complements existing studies on Chinese innovation policies by showing the heterogeneous effects of a comprehensive place-based policy across firms with different sizes, nature of ownership, and in different regions. On one hand, compared with papers

[2] http://www.gov.cn/zhengce/2020-04/09/content_5500622.htm

on Chinese place-based policy evaluations at a relatively macro-level focusing on FDI share, employment, wages, output, and productivity (Zheng et al., 2017; Lu et al., 2019), we study the outcomes of innovation at a firm level. Firms are the direct targets of this high-tech industrial development zone policy, and the improvement of firm innovation activities is the direct goal of this policy. Firms are also the main engine of innovation and the owner of Intellectual Property Rights (IPR). The innovation outcomes at a firm level are the direct responses to the policy, which could be more evident than the outcomes at a relatively macro-level in the short run. Those firm-level outcomes allow us to look at the heterogeneous treatment effects, providing a better sense of under what circumstances the policy works. On the other hand, compared with studies on policy incentives for firm innovation in China focusing on the average treatment effect of financial subsidy programs (e.g., Guo et al., 2016), this thesis looks into the heterogeneous effects of a more comprehensive place-based policy beyond financial incentives. The examples of market imperfection above indicate that other aspects need to be improved in addition to the financial aspect. Therefore, incentives for other aspects, such as attractiveness to knowledge workers, convenience for administrative issues, etc., could be important for increasing firm innovation activities. Unlike the average treatment effects of financial incentives, a more comprehensive place-based policy may benefit specific firms, and the efficacy of such a policy could be very heterogeneous across firms (Takalo et al., 2013). The heterogeneous effects across firms shown in this thesis may attract policymakers' attention to certain circumstances to implement such a comprehensive policy. To achieve the innovation goals, such as *Made in China 2025*, it would be helpful to understand the efficacy of such a policy on targeted firms to realize the catch-up achievements in the short run.

Third, in spite of the fact that patent quality is an essential dimension of innovation, few studies on Chinese patents have investigated this aspect (Liang, 2012; Dang and Motohashi, 2015; Yuan and Wen, 2018; Pang and Wang, 2020). High-quality patents are crucial elements of stimulating innovation and overall economic and social development (Hall et al., 2001). It is always a concern that patent quality may be stagnant despite an explosive surge of patent quantity, and it is necessary to explore whether high-tech industrial development zone policy affects high-quality innovation outputs. We use both invention patents and patent citations as two alternative measurements of patent quality to explore this question. The former is consistent with previous research in China (Yuan and Wen, 2018; Pang and Wang, 2020), and the latter is a widely used proxy variable (e.g., Hall et al., 2005; Qian, 2007; Moser and Nicholas, 2013). Our study helps to further the understanding of innovation activities based on various aspects.

The rest of the paper is structured as follows. Chapter 2 is a literature review on previous studies related to our research. Chapter 3 presents a brief institutional background for our research question. Chapter 4 shows a theoretical framework about the mechanisms and hypotheses on how the establishment of high-tech industrial development zones affects firm innovation activities in China. Chapter 5 describes the dataset, and Chapter 6 discusses the empirical approach and our analysis results. Chapter 7 is conclusion and discussion.

CHAPTER 2 LITERATURE REVIEW

Our study builds on and contributes to several streams of research. First, we add to a stream of research on Chinese patents. Second, our study is related to empirical work examining the impact of place-based policies in China. Finally, our study contributes to the literature associated with place-based policies evaluation in other countries and regions by providing evidence of whether such programs affect firm innovation in China.

2.1 Literature on Chinese patents

Innovation activities play an important role in economic development, and patenting is one of the primary outcomes of innovation (e.g., Hall et al., 2001). Researchers consider patents a better proxy of innovation than aggregate R&D expenditure data or self-reported innovation activities in survey data since patent data provide more detailed information (He et al., 2018a). R&D expenditure only measures the observable innovation inputs while ignoring the unobservable ones and the innovation outputs (He and Tian, 2013). In addition, when it comes to R&D expenditure, it is not compulsory for Chinese firms to disclose their R&D expenditure, leaving a great number of missing data. Moreover, since there is no standardized reporting requirement and regulation, R&D expenditure lacks comparability (Pang and Wang, 2020). In this thesis, we mainly use the number of firm patents as a proxy of firm innovation activities to investigate whether the establishment of high-tech industrial development zones affects innovation activities in China at the firm level. Besides, we also look into the effect on R&D expenditure.

In this subsection, we first provide a brief overview of studies related to Chinese patents, especially existing literature on the determinants of patents, and explain the challenges in the research on patents, both in general and specific to China. We first show the importance of extending research on patents to firm-level rather than at a relatively macro-level, like provincial or national level. We then further focus on Chinese patent quality, illustrating the general concerns shared on this issue in China and abroad and summarizing the alternative measurements of patent quality.

Due to the lack of firm identifiers in patent data, it is hard to match patents to other firm-level databases, leading to a huge challenge of understanding firm-level innovation. Although China is the top patent filers around the world and firms are the major component of patent filers, there is relatively little research on patents at the firm level in China (e.g., Pang and Wang, 2020; Zhuge et al., 2020). Instead, most previous studies on Chinese patents pay attention to a macro-level analysis, discussing an increase in national innovation capacity in China through advancement in technology, pro-patent legal change, and strategic alliances (e.g., Chen and Kenney, 2007; Hu and Mathews, 2008; Hu and Jefferson, 2009; Fang, 2011).

Li (2012) discusses various possible factors that may affect the increase in regional patent applications filed in China and proposes the provincial level policy initiatives as an alternative explanation to explain the explosive increase in patent applications filed. By focusing on patent subsidy programs launched by municipal governments of various provinces since 1999, Li (2012) uses province-level data to provide empirical evidence, arguing that patent subsidy programs implemented by the provincial government are an important incentive of the growth of provincial patenting in China. However, there is little research investigating how place-based policy affects firm innovation activities in China, and the heterogeneity among firms may lead to different impacts on different firms. The focus on firm-level data enables us to provide a more nuanced and mixed view on the efficacy of the policy that is only possible to be learned at the firm level. It is not only important for China itself to learn from its own history by exploring the incentives of firm innovation in China to find possible answers to the explosive surge of Chinese patent filing in the last two decades, but also a meaningful worldwide discussion since China accounts for 22% of the patent applications filed globally[3].

Firms are considered the main engines of innovation and technological advancement (Nelson and Winter, 1982; Porter, 1990). Firms are also the owner of these Intellectual Property Rights (IPR), and their decisions on patents are directly linked to other firm-level conditions (He et al., 2018a; 2018b). Hence, there exist increasing interests in conducting firm-level patent analysis in China by researchers, policymakers, and business managers. Following a number of great projects done in the last two decades for patent offices in developed economies, such as the United States Patent and Trademark Office (USPTO) (Hall et al., 2001) and European Patent Office (EPO), there are several databases trying to match patents data from China National Intellectual Property Administration (CNIPA)[4] to the firms that own them in China, such as China Stock Market & Accounting Research Database (CSMAR) and Chinese Patent Data Project (He et al., 2018a; 2018b), allowing analyses on firm innovation activities in China.

Although there is an increasing number of studies on the determinants of firm patents in China, existing literature mainly focuses on the impact of internal factors within firms on their innovation activities, including stock pledge (Pang and Wang, 2020), managerial experience abroad (Yuan and Wen, 2018), CEO's professional experience (He et al., 2019), directors' and officers' liability insurance (Hu et al., 2019), short selling (Li et al., 2019), motivations of M&As (Tong et al., 2020), mandatory internal control audits (Wang, 2020), non-executive employee

[3] https://www.cnbctv18.com/business/global-patent-filings-2019-china-tops-the-list-filings-by-huwaei-more-than-total-of-india-6719501.htm
[4] Used to be "State Intellectual Property Office (SIPO)"

equity incentive (Guo et al., 2019), collaboration culture (Pan et al., 2019), Confucian tradition (Xu and Li, 2019). Those findings on internal factors related to firm patents show that firm characteristics are associated with its innovation activities, which motivates the investigation on the heterogeneous effects of external policy on firm innovation activities across firms with different characteristics.

There are several papers discussing how the external policy changes affect firm patents in China, especially concentrating on how tax policy contributes to firm innovation activities. Jiang et al. (2019) find that payroll tax avoidance is positively correlated with the number of firm patent applications. Liu and Zhao (2019) find that the value-added tax reform has a positive influence on firm patents by increasing the free cash flow after tax and decreasing the replacement cost of equipment used in innovation activities. However, Liu and Qiu (2016) utilize China's WTO accession in 2002 as a proxy of a drastic input tariff cut to show that input tariff cut leads to a decrease in patents filed by Chinese firms. Besides, Tang et al. (2020) point out that the development of digital finance has a positive impact on the increase of firm patents in China.

Despite the fact that there has been growing literature relating external policy changes to firm innovation activities, little is known about the effect of high-tech industrial development zone policy on firm patent applications in China. Understanding the role of high-tech industrial development zone policy in motivating firm innovation is important. It is a more comprehensive policy than tax incentives alone, which provides more and comprehensive support while also leading to government failure with more resource misallocation if it does not work effectively as expected. Evaluating the place-based policies targeting firm innovation in China could provide a potential practical reference for policymakers in other developing countries that share similar states of market development to design effective micro-level targeting policies so as to improve their own innovation activities, especially in the post-COVID world where the unexpected disruption is also a great opportunity for innovation.

2.2 Measurements of patent quality

Despite China surpassing the United States to be the top patent application filers in the world in 2019, the proportion of patent-intensive industries in GDP in China is still 4.5% behind developed countries in the European Union and the United States.[5,6] Researchers have also paid attention to patent quality in China, which is often assumed to be relatively low compared to the number of patent applications filed (e.g., Thoma, 2013; Liu et al., 2014; Dang and Motohashi, 2015). Fisch et al. (2017) use citation lag as a proxy of patent value since it is correlated with forward citations (Gay et al., 2005) while bypassing the truncation issue of most recent patents (Marco, 2007), and find a large citation lag in patents filed in China by Chinese applicants compared with other countries, showing that Chinese patents have a lower patent value, while they also find evidence of an increasing patent value in recent years. Ma et al. (2019) construct an integrated system to evaluate technological and model innovation competency, showing that although China's national innovation competency ranked among the top 20 since 2018 (Global Innovation Index, 2018; 2019), Chinese listed companies are still in their preliminary stage of innovation. Based on the concerns and discussions above, it is worthwhile to explore the influence on both patent quantity and patent quality.

[5] Patent-intensive industry refers to industries where the intensity and scale of invention patents meet the prescribed standards, rely on intellectual property rights to participate in market competition, and conform to the direction of innovation and development. According to China National Intellectual Property Administration and National Bureau of Statistics, patent-intensive industries include Information and Communication Technology manufacturing, Information and Communication Technology service, new equipment manufacturing, new material manufacturing, medical industry, environmental protection industry, R&D, design and technical service industry.
[6] http://www.xinhuanet.com/2020-04/24/c_1125898246.htm

To deal with the lack of citation information and well-documented patent claim information in China, Dang and Motohashi (2015) focus on the claim scope, proposing a novel method of using the number of nouns in claims as a proxy of patent quality, while previous studies on Chinese patents also focus on the originality of patents, using the number of invention patent applications that are eventually granted as an alternative measure of innovation quality because invention patents are the most original type compared with utility model patent and design patent (Yuan and Wen, 2018; Pang and Wang, 2020). In spite of the fact that the methods above partially reflect patent quality in China to some extent, using patent citations is still a more ideal and reasonable proxy variable to measure patent quality. As an Intellectual Property Right, patent quality is mainly associated with its social and economic significance. Patent citations reflect knowledge spillovers and can be used as indicators of the importance of individual patents (Hall et al., 2001). Therefore, patent citations are widely used as a measurement of patent quality (e.g., Hall et al., 2005; Qian, 2007; Moser and Nicholas, 2013). In our study, in addition to following the existing literature to use invention patents as an alternative measure of patent quality, we also collect data on Chinese patent citations from Google Patent. Following Trajtenberg (1990), we construct citation-weighted patents as a proxy variable of patent quality to further investigate whether the establishment of high-tech industrial development zones affects firm patent quality in China.

2.3 Impact of place-based policies in China

This subsection first briefly introduces high-tech industrial development zone policy and other place-based policies in China and possible mechanisms of how such programs could impact economic performances. We then review the findings of the influences of place-based policies in China on various outcomes, while little is known about the impacts on innovation activities. Finally, as an increasingly essential economic performance, how firms perform in innovation draws more attention in recent years. We summarize the previous studies on high-tech industrial development zones and innovation activities in China, although most of them are case studies and qualitative studies rather than quantitative analyses.

There exist long debates on the possible benefits and distortions related to the spatially targeted programs (Glaeser and Gottlieb, 2008; Glaeser et al., 2010; Greenstone and Looney, 2010; Moretti, 2013), such as productivity advancement (Greenstone et al., 2010; Kline and Moretti, 2011) as well as efficiency loss and resource misallocation (Busso et al., 2013). Although there have been increasingly comprehensive studies on place-based policies (e.g., Peters and Fisher, 2002; Busso et al., 2013), it is still a lack of empirical evidence to investigate the impact of such programs in developing countries.

In addition to related analyses in developed countries, evaluation for the place-based policies in developing countries is necessary for two reasons. On one hand, with different states of market development, place-based policies in developing countries could differ from those in developed countries. For example, placed-based policies in China contain preferential policies regarding administrative procedures, the priority of land use, etc., which are not usually included in policies in other developed countries. These aspects could also matter for firm innovation activities in China and may have different potential mechanisms. On the other hand, developing countries experience more uneven development when it comes to firms with different characteristics and in different regions (Bhalla, 1992). That is, for example, there could be larger gaps between small firms and large firms, State-Owned-Enterprises (SOEs) and non-State-Owned-Enterprises (non-SOEs), and firms in developed regions and less developed regions in developing countries than gaps in developed countries. These sources of heterogeneity could be different from those in developed countries and could show different heterogeneous impacts in developing countries. By exploring a more detailed understanding of the impact of such programs in developing countries, it might shed light on narrowing development gaps between firms and regions. Our study takes advantage of the gradual establishment of high-tech industrial development zones across Chinese municipalities since 1988 to fill this gap.

Similar to many place-based programs, high-tech industrial development zones are potentially associated with agglomeration economies (Combes et al., 2011). High-tech industrial development zones provide support of technologically advanced industrial facilities and infrastructures, close collaboration with universities and other research institutions, and other preferential policies, such as tax exemption and land priority, to attract and promote firms' innovation activities. On one hand, these supports attract new entries to the designated areas in the long run. However, because of the data limitation, we are not able to investigate the long-term effects in this thesis. On the other hand, these supports could also improve the innovation capacity in the existing firms in the designated areas in the short run. First, the establishment of high-tech industrial development zones enables firms to share facilities, infrastructures, research institutions, and other necessary conditions for conducting innovation activities (Ridley et al., 2006), which creates an innovative environment for the existing firms. Second, such agglomeration is associated with knowledge spillover, which could also benefit the existing firms by improving productivity and other aspects of the local economy (Rosenthal and Strange, 2003; 2004). As a result, in the short run, based on the agglomeration economies, high-tech industrial development zone policy may benefit firms in the regions where an innovative environment is better and that have well-developed conditions for such programs to be implemented. Since China has an uneven basis of innovation across regions, there may exist heterogeneous effects of such programs among regions.

Following existing literature on the impact of place-based policies in developed countries, researchers have also continuously explored the impacts of other place-based policies on China's economy, including the establishment of special economic zones and industrial parks. Most studies are relatively macro-level, investigating how special economic zones affect the local economy (Schminke and Van Biesebroeck, 2013; Alder et al., 2016). Wang (2013) finds that the establishment of special economic zones has a positive impact on foreign direct investment and wages for workers. Cheng (2015) shows that a special economic zone increased GDP by 1% to 2% per year across five years. Lu et al. (2019) also confirm this positive influence of special economic zones on capital investment and wages, and they find additional evidence supporting positive effects on employment, output, productivity, and the number of firms in the designated areas. Moreover, by studying 110 parks in eight major cities, Zheng et al. (2017) show an increasing effect on the overall human capital level, the FDI share, and local employment and wages. Existing literature also points out that the nonrandom siting of targeted zones could be challenge in identifying the effects. For example, if a place is chosen because of the high concentration of high productivity firms already there, these studies may be catching the cause rather than the effect. In general, to take into account the endogenous nature of place-based policies, they conduct the analyses conditional on baseline characteristics and test the pretreatment parallel trends.

Although there exists increasing literature related to the impact of place-based policies on the local economy at the regional level in China, few studies have discussed how such policies affect firm performance at a relatively micro-level. It is necessary to investigate the outcomes of such programs at the firm level since most of those place-based programs are targeted at enterprises, and the primary purpose of these programs is to promote the transformation and upgrading of firms in the real economy. Chen et al. (2019) use the mass closure of development zones to show that loss of development zone policies results in a significant reduction of firms' total factor productivity (TFP). In contrast to Chen et al. (2019), our study concentrates on the impact of high-tech industrial development zones, a specifically targeted subset of the general development zones in China, on firm innovation activities, which is directly associated with the establishment of high-tech industrial development zones and the primary goal of such high-tech industrial development zone policies. Innovation is an important driving force of economic development, and firms are the main engine to conduct innovation activities and to realize innovative ideas into industrial advancement. Therefore, it has meaningful implications for both academic researchers and policymakers to understand how such a spatially targeted program affects firm innovation activities in the designated areas. Moreover, there are differences in terms of the effect of entry to a place-based policy and exit from a place-based policy.

Besides the outcomes that place-based policies in China could affect, as an increasingly essential economic performance, firms' performance in innovation attracts more attention in recent years. There are several previous papers exploring the association between high-tech industrial development zone policy and innovation activities. Lai and Shyu (2005) compare the Zhangjiang high-tech industrial development zone in Shanghai and the Hsinchu science-based industrial park in Taiwan to show the heterogeneity in determinants of innovation capacity between the two parks above, including the basic research infrastructure, sophisticated and demanding local customer base, and the presence of clusters instead of isolated industries. Tan (2006) and Motohashi (2013) study firms in the Zhongguancun science park, where Tan (2006) emphasizes the importance of clustering in firm innovation in the designated area, while Motohashi (2013) notices the role that informal connections with faculties and students in the universities play. Xie et al. (2018) use Wuhan Donghu high-tech industrial development zone as their sample to show an incubation effect on science and technology enterprises in this region. Both of the two studies above are case studies and theoretical analyses. Little is known about how generally effective high-tech industrial development zone policy work nationwide in China, and there is still a lack of empirical research to quantitatively investigate how the general establishment of high-tech industrial development zones affect firm innovation activities. Our study takes advantage of the geographical and temporal variation of the establishment of high-tech industrial development zones in China and provides evidence of whether such high-tech industrial development zone policies affect firm innovation activities.

2.4 Place-based policy evaluation in developed countries and regions

In general, place-based policies refer to government interventions aiming to improve the economic performance within a designated area (Neumark and Simpson, 2015). This subsection reviews previous literature related to place-based policy evaluation in developed countries and regions, trying to provide existing findings to build on and potential directions that this thesis could proceed.

Most existing research on the impacts of place-based policies in the United States and European countries also focuses on traditional outcomes, such as employment and wages (Kline and Moretti, 2014a), although the findings of whether and how such programs work vary differently. On one hand, some studies find evidence to support a positive impact of place-based policies on economic performances, at least in the short term. For example, several studies conclude that place-based policies have positive employment effects (e.g., Wilder and Rubin, 1996; O'Keefe, 2004; Ham et al., 2011). Freedman (2013) and Busso et al. (2013) also find a significant positive effect on employment growth and job growth. Besides, Freedman (2013) shows an increase in median home value, while a significant negative effect on the vacancy rate. Busso et al. (2013) and Reynolds and Rohlin (2014) show an increase in wages. Moreover, Givord et al. (2013) and Mayer et al. (2017) provide evidence of positive effects on business creation in and relocation into a zone. On the other hand, some researchers doubt the significant effects of such programs (Glaeser and Gottlieb, 2008; Glaeser et al., 2010). Rossi-Hansberg et al.(2010), Neumark and Kolko (2010), and Kline and Morett (2014b) generally conclude that place-based policies do not cause net growth in the designated areas.

It is widely discussed whether and how place-based policies affect economic growth in terms of employment, wages, and other traditional outcomes, but little is known about the impacts of such programs on firm performances, such as innovation. Among few such related studies, Huang et al. (2012) investigate firm innovation in policy-driven parks using data of manufacturing firms in the information and communication technology (ICT) sector in Taiwan. Huang et al. (2012) find that firms in the policy-driven parks gain more innovation benefits and the heterogeneous effects indicate that small firms benefit more than large firms regarding innovation performance.

Existing literature in developed countries and regions has indicated that place-based policies are associated with economic performances, although there are still debates on whether such programs have a significant effect on economic outcomes. Previous discussions are mainly around traditional performances, such as employment, wages, poverty, etc., but relatively few studies pay attention to the impact on firm innovation, which has become increasingly important in economic growth and the critical determinants of sustainable development. Although few studies have looked into this direction in developed countries and regions, it is still worth proceeding further to explore whether place-based policies affect firm innovation in developing countries and who benefits more from such programs than others in the context of innovation.

It is important to investigate those questions above in developing countries for several reasons. First, compared to place-based policies focusing on financial incentives, such as Enterprise zone and Community development and locally led initiatives in developed countries (Neumark and Simpson, 2015), place-based policies in China go beyond financial incentives, covering more dimensions such as land support, IPO priority, and other administrative and institutional supports. On one hand, it indicates more comprehensive incentives and supports. On the other hand, it could also lead to government failure with more resource misallocation if such programs are inefficient. Therefore, it asks for understanding whether such programs could work effectively. Second, considering the fact that there exists much more uneven development among firms with different characteristics and in different regions in developing countries, the incentives from such programs may have heterogeneous effects on the outcomes, since they have different development bases and the preferential policies that such programs provide may be fundamentally helpful for some firms while not necessary for others. By further evaluating the heterogeneous effects of the establishment of high-tech industrial development zones on firm innovation activities between small firms and large firms, non-SOEs and SOEs, developed regions and less developed regions in China, this study attempts to understand whether the preferential policies of such a program could provide more effective impacts for certain firms compared to others, and to shed light on policymakers' awareness of whether such programs are effective regarding the overall outcomes and the heterogeneous outcomes among different targets.

Our study contributes to the stream of literature on whether spatially technological targeted programs affect firm innovation activities by enriching the empirical evidence in China. By quantitatively investigating the impact of the establishment of high-tech industrial development zones on firm innovation activities in China regarding both patent quantity and patent quality as well as R&D expenditure, our study also contributes to related literature on the determinants of the explosive surge of Chinese patent applications and the influence of place-based policies in China.

CHAPTER 3 INSTITUTIONAL BACKGROUND

3.1 Status of Chinese patents

Referring to the relevant patent laws in Europe and Japan, China enacted the first patent law in 1985 and has been amended three times in 1992, 2000, and 2008, respectively. This progress enables the Chinese patent system to be aligned with international norms (Park, 2008). The China National Intellectual Property Administration (CNIPA)[7] grants three types of patents: invention patents, utility model patents (similar to the German Gebrauchsmuster), and design patents. According to the *Patent Law* in China, invention patent refers to new technical solutions proposed for products, methods, or their improvements, utility model patent refers to a new technical solution that replaces the practicality of the shape, structure, or combination of the product, and design patent refers to a new design that is aesthetically pleasing to the product's shape, pattern, or color.

According to the statistics from CNIPA (2019), in 2019, China has 1.4 million invention patent applications, 2.268 million utility model patent applications, and 0.712 million design patent applications. World Intellectual Property Organization (WIPO) shows that China has exceeded the U.S. for the first time regarding patent applications, ranking the first in the world and accounting for nearly half of the total patent filers all over the world. China overtook the U.S. to become the world's top invention patent filer in 2011 and has maintained this position since then (WIPO, 2012). National Bureau of Statistics in China released the added value of patent-intensive industries for the first time in *Statistical Classification of Intellectual Property (Patent) Intensive Industries (2019)*, showing that the added value of China's patent-intensive

[7] CNIPA used to be State Intellectual Property Office of China (SIPO).

industries reached 10.7 trillion RMB (around 1.5 trillion dollars), accounting for 11.6% of GDP, and contributing 15.7% to GDP growth in 2018. Patent-intensive industries have become essential support for high-quality economic development in China.

There is no doubt that China has been experiencing substantial growth in patent applications, but this explosive surge also leads to concerns about patent quality. National Natural Science Foundation of China points out that the extreme-growing number of patent applications is far from the reality of innovation capacity in China[8]. Patent citations are often used as a proxy of patent quality or patent value, reflecting the economic significance of a patent (e.g., Harhoff et al., 2003; Li, 2012). Patent citations serve as informative links between patenting innovation activities. As pointed out in Hall et al. (2001), patent citations indicate not only knowledge flowing from one patent to other citing patents but also the importance of the cited patent.

As an Intellectual Property right, patent citations are required by the law. According to the *Patent Law* in China, Article 17 stipulates that "the specification shall include the following content... (2) Background technology: specify the background technology needed for understanding, searching, and examining the invention or utility model. If possible, cite the documents that reflect these background technology." The *Patent Examination Guideline* further specifies the clause above. "The background technology part of the instruction of an invention or utility model patent shall... and as far as possible cite documents reflecting these background technologies. In particular, the citations shall include the independent rights in the claims of the invention or utility model patent. The citations shall include the prior documents closest to the

[8] http://www.nsfc.gov.cn/csc/20340/20289/20805/index.html#

invention or utility model patent application. The documents cited in the specification can be patent documents or non-patent documents."

Based on the different purposes of citation, there exist two types of citations in patents. One is inventor citations. It refers to the citations made and recorded in the patent instruction by the patent inventors in the process of completing the invention and creation described in this patent application. The other is examiner citation. It refers to the citations made by patent examiners when examining patent applications.

Although China has experienced explosive growth in domestic patents application during the past two decades, it is still in the effort of improving patent quality. Developed countries, such as Japan, the United States, South Korea, and Germany, account for a large proportion of patent citations of Chinese patent applications. From 2008 to 2013, 42% of patent citations are from other foreign countries, and foreign patents are cited even more than Chinese patents in the fields of chemical medicine, electronic information, engines, vehicles, and printing (CNIPA, 2014).

CNIPA (2014) also shows that enterprises account for 48% of the domestic invention patents that are highly cited, while the other 52% are universities (30%), research institutions (8%), and individual (14%), indicating that enterprises still play a dominant role in technological innovation in China. There are a great number of national and local incentive policies to be implemented to increase the number of patent applications filed by enterprises, such as the *Outline of National Intellectual Property Strategy* and high-tech industrial development zone policy.

3.2 High-tech industrial development zone policy

High-tech industrial development zone is an administrative area established by governments at the national or provincial level. It is a specific area set up for the purpose of developing high and new technologies after China's reform and opening up in the late 1980s. In August 1988, China's national high-tech industrialization development plan (The Torch Plan) began to be implemented. The establishment of high-tech industrial development zones is the core content of the Torch Plan. The first high-tech industrial development zone is the Beijing Experimental Zone for New Technology and Industrial Development, the predecessor of the *Zhongguancun* Science Park, approved by the State Council in 1988. Since then, a number of high-tech industrial development zones have been approved in different cities around China in the following years.

The government gives this area preferential taxation and loan policies as well as other various reform measures to encourage the technology development in the areas of information technology, biotechnology, and new materials technology, including eleven specific technologies, including new energy and efficient energy-saving technology, new environmental protection technology, electronics and information technology, bioengineering and new medical technology, new materials and application technology, advanced manufacturing technology, aerospace technology, marine engineering technology, nuclear application technology, modern agricultural technology, and other new processes and technologies applied in the transformation of traditional industries[9].

Only firms in high-tech industrial development zones that are considered as high-tech enterprises can enjoy the preferential policy. There are certain criteria that firms are required to

[9]https://baike.baidu.com/item/%E9%AB%98%E6%96%B0%E6%8A%80%E6%9C%AF%E4%BA%A7%E4%B8%9A%E5%BC%80%E5%8F%91%E5%8C%BA/7559109?fromtitle=%E9%AB%98%E6%96%B0%E6%8A%80%E6%9C%AF%E5%BC%80%E5%8F%91%E5%8C%BA&fromid=2555632

meet to be regarded as high-tech enterprises, such as (1) the enterprise needs to obtain the ownership of the Intellectual Property Rights of its main products (services) that play a core technical support, and the number of patents is one of the score measurements, (2) scientific and technical personnel with college degree or above account for more than 30% of the total number of employees of the enterprise, and scientific and technical personnel engaged in R&D of high-tech products should account for more than 10% of the total number of enterprise employee, (3) the company's annual expenditure on high-tech and product R&D should account for more than 5% of the company's total sales for the year, and sum of the technical income of high-tech enterprises, the sales income of high-tech products should account for more than 60% of the total income of the enterprise for the year, and the investment of new enterprises in the high-tech field accounts for more than 60% of the total investment, (4) the main person in charge of an enterprise should be a full-time person familiar with the company's product research, development, production and operation, and attaching importance to technological innovation[10]. Firms need to fulfill all these criteria to get benefit from the policy.

In return, the preferential policy also encourages R&D, including incentives on tax reduction, high-tech labor force subsidies, land priority, IPO condition, etc.[11] In specific, the core preferential policy is about tax, including (1) A preferential income tax rate of 15%, which is equivalent to a 40% reduction from the original 25%. (2) In accordance with the relevant regulations on processing with imported materials, the customs shall exempt import duties, import product taxes and value-added tax based on the actual export quantity processed. (3) Export products produced by high-tech enterprises are exempt from export duties except for products restricted by the state or otherwise stipulated by the state. Other benefits contained in

[10] http://www.gov.cn/gongbao/content/2001/content_60688.htm
[11] http://www.people.cn/zixun/flfgk/item/dwjjf/falv/2/2-1-43.html

this high-tech industrial development zone policy include (1) The raw materials and parts imported by high-tech enterprises established in high-tech industrial development zones for the production of export products are exempt from import licenses, and the customs inspects and releases them on the basis of the export contracts and the approval documents of high-tech industrial development zones. (2) Banks can arrange the issuance of a certain amount of long-term bonds to high-tech industrial development zones to raise funds from the society to support the development of high-tech industries. (3) Relevant departments may establish venture capital funds in high-tech industrial development zones for the development of riskier high-tech products. For high-tech industrial development zones with more mature conditions, venture capital companies can be established. (4) The production and operating capital construction projects of high-tech enterprises shall be constructed in accordance with the unified planning and be included in the local fixed asset investment scale first. (5) With the approval of the local people's government, high-tech enterprises can be exempted from purchasing national key construction bonds. (6) Instruments and equipment used by high-tech enterprises for high-tech development and production of high-tech products can be rapidly depreciated. (7) Settlement incentive subsidies for the high-tech skill labor force. These specific benefits beyond tax could be slightly different across regions based on specific situations.

In Newmark and Simpson’s (2014) review of place-based policy, they point out that place-based policies target both underperforming areas and areas that are already doing well in economic performances. For high-tech industrial development zones in China, the sites are first located either in the largest cities or in business cities to shape a favorable environment (Yang and Lee, 2021), and have expanded to other regions around China, including less developed regions. Table 1 shows the geographical distribution of national high-tech industrial development zones across provinces, and the average size and total size of the zones in each provinces. The distribution and size reveal a heterogeneous pattern across provinces. Table 2 is a quantitative overview of high-tech industrial development zones in China, indicating that high-tech industrial development zones play an increasingly critical role in China's economy (Yang and Lee, 2021).

Table 1 Geographical Distribution of National High-tech Zones in China, 2018

Province	Total Number of NHIZs	Region	Average Area	Total Area
Beijing	1	East Coast	232.5	232.5
Tianjin	1	East Coast	98.0	98.0
Hebei	5	East Coast	110.1	550.3
Shanxi	2	Center	7.8	15.5
Neimenggu	3	North	86.0	258.0
Liaoning	8	East Coast	67.5	472.5
Jilin	5	North	26.1	130.3
Heilongjiang	3	North	78.6	235.8
Shanghai	2	East Coast	44.5	88.9
Jiangsu	17	East Coast	86.4	1468.8
Zhejiang	8	East Coast	79.5	635.6
Anhui	5	Center	42.7	213.5
Fujian	7	East Coast	102.1	714.8
Jiangxi	7	Center	129.9	909.2
Shangdong	13	East Coast	221.6	2880.8
Henan	7	Center	50.7	355.1
Hubei	12	Center	90.0	1080.0
Hunan	8	Center	116.1	928.9
Guangdong	12	East Coast	37.9	455.3
Guangxi	4	West	71.7	286.9
Hainan	1	East Coast	76.0	76.0
Chongqing	2	West	76.5	153.0
Sichuan	8	West	131.6	1052.8
Guizhou	2	West	12.1	24.2
Yunnan	2	West	50.0	100.0
Shaanxi	7	Center	92.8	649.8
Gansu	2	West	95.4	190.8
Ningxia	2	West	153.8	307.5
Qinghai	1	West	300.0	300.0
Xinjiang	3	West	152.8	458.4

Notes: NHIZs refer to National High-tech Industrial Development Zones.
Areas are scaled by km^2.
Source: Wikipedia, Baidu

Table 2 Basic Statistics of High-tech Industrial Development Zones in China

Year	Output (RMB Billion)	Export (US$ Billion)	R&D (RMB Billion)	Output/ GDP	Export/ Total Exports	R&D/ Business R&D
1997	310.92	6.48	NA	3.9	4.08	NA
1998	433.36	8.53	NA	5.09	5.22	NA
1999	594.4	11.9	NA	6.56	6.81	NA
2000	794.2	18.58	15.54	7.92	8.31	26.3
2001	1,011.68	22.66	22.18	9.13	9.45	35.22
2002	1,293.71	32.92	31.45	10.63	11.08	39.91
2003	1,725.74	51.02	41.95	12.56	12.65	43.67
2004	2,263.89	82.38	61.38	13.99	14.9	47.53
2005	2,895.76	111.65	80.62	15.46	15.66	49.08
2006	3,589.90	136.1	106.42	16.36	14.86	51.32
2007	4,437.69	172.81	134.88	16.42	14.95	51.66
2008	5,268.47	201.52	166.82	16.49	14.9	50.38
2009	6,115.14	200.72	134.27	17.52	17.63	32.26
2010	8,431.82	264.8	181.25	20.41	23.14	35.8
2011	10,567.96	318.06	226.9	21.6	16.8	35.34
2012	12,860.39	376.04	274.91	23.8	18.4	36.05
2013	15,136.76	413.33	348.88	25.43	18.7	39.48
2014	16,993.69	435.14	399.57	26.39	18.5	40.7
2015	18,601.83	473.27	452.16	27.14	20.82	42.7

Notes: Data source is Yang and Lee (2021).
NA denotes data being unavailable.
Ratio is presented as %.

CHAPTER 4 THEORETICAL FRAMEWORK

High-tech industrial development zone policy in China directly targets firm technology innovation capacity, which provides various specific incentives from financial aspects to institutional aspects in order to increase firm innovation activities and ultimately promote the transforming and upgrading of China's economy. On one hand, this policy could have influences on firms that have already existed in those areas, especially in the short run. The related policies of the establishment of high-tech industrial development zones provide additional incentives and a better innovative environment for existing firms to conduct more innovation activities. On the other hand, this policy could also attract new firms to locate in the designated areas. Place-based policies are always associated with agglomeration economies (Combes et al., 2011), increasing new entries and shaping clustering effects. However, due to the fact that the agglomeration needs long-term to be reflected and we do not have information on either address changes or enough long post-treatment period, the impact of high-tech industrial development zone policy on new firm entries is beyond our scope. This thesis focuses on the effect on the existing firms in those designated areas.

The establishment of high-tech industrial development zones could improve firm innovation activities by increasing both R&D expenditures and patents. This policy could directly increase firms' R&D expenditure and the number of patent applications by providing financial support and setting up requirements on R&D expenditure that firms need to meet to enjoy the preferential policies and the number of patents as a score measurement. Furthermore, as high-tech firms, this policy could also increase their patent applications to protect their Intellectual Property Rights (IPR), since filing patent applications could both benefit their future innovation because of the patent thicket and could be regarded as a market signal showing their strong technical foundations.

Specifically, high-tech industrial development zone policy includes high-skilled employees and managers, loan support, tax exemption, etc., trying to stimulate firm patent applications through several mechanisms. First, high-tech industrial development zone policy could increase firm patent applications by relaxing financial constraints. Innovation activities are generally considered as an investment that is high-risk and costly and requires a long period to get payback (Kleis et al., 2012). Therefore, firms' innovation investment is faced with a bunch of limitations and challenges. The preferential financial policies for firms in high-tech industrial development zones include tax exemption, supports from bank loans and IPO in the stock market, and a preferential depreciation rate of fixed assets. Compared with developed countries, these financial support policies could be even more helpful in developing countries where financial markets have not been well developed (Galbis, 1977). By decreasing the expenditure and increasing the loan channels and loan capacities, firms are able to relax their financial constraints and may have more budget for expenditures on R&D, law issues, hiring high-skilled workers, etc. (Li, 2011). As one of the key inputs of innovation, such incremental R&D expenditures could enable firms to conduct more innovation activities and spend more resources on protecting their Intellectual Property Rights (IPR) (Hall et al., 2010).

Second, high-tech industrial development zone policy could positively affect firm innovation activities because the policy could form the clustering of knowledge workers and research institutions. Knowledge workers are the core element of innovation activities (Davenport et al., 2002), providing both technical knowledge and legal knowledge. High-tech industrial development zone policy attracts knowledge workers by providing both economic compensations and registered residency (*Hukou*). These additional institutional policies provide a great competitive ability for high-tech firms to recruit high-skilled workers (Zhang et al., 2020). Otherwise, they may lack advantages compared with other government agencies. In addition to the attraction of knowledge workers, the establishment of high-tech industrial development zones is always accompanied by the clustering of research institutions, universities, advanced facilities, and necessary infrastructure (Fukugawa, 2006), which may cause a closer and more effective collaboration to increase the innovation activities in the firms located in these designated areas in the long run, though we may not be able to show this in the existing firms in the short run.

Finally, high-tech industrial development zone policy could have a positive impact on firm innovation activities through other institutional supports. As a nation where government intervention plays a relatively important role in firm decision makings and marketing performance (Chen et al., 2011), institutional supports are not only a symbol of the national development direction but also provides actual convenience regarding administrative issues in China (Liu et al., 2011). On one hand, institutional supports could provide a creative environment along with other necessary facilities for innovation and make innovation an increasingly popular trend. On the other hand, by providing actual convenience on administrative issues, such as simplifying administrative approval procedure, institutional supports could save firms' resources on unnecessary aspects and spend more on R&D. Given the findings in the existing literature that institutional and political supports are positively correlated with firm innovation activities (Michailova et al., 2013; Schøtt and Jensen, 2016), it is reasonable to expect that such institutional and political supports in high-tech industrial development zones could also bring an increase in the innovation activities in the targeted firms.

Hypothesis 1: The establishment of high-tech industrial development zones has a positive impact on firm patents.

Given the relatively uneven development of firms with different characteristics and in different regions in China (Fan, 1997; Wang, 1999), heterogeneous effects may exist regarding whether and how the establishment of high-tech industrial development zones on patents among firms and regions. We consider the heterogeneous effects based on the following three aspects, among non-SOEs and SOEs, among small firms and large firms, and among developed regions and less developed regions.

The first heterogeneity regarding the impact of the establishment of high-tech industrial development zones on firm patent applications may exist between non-SOEs and SOEs. As an official government intervention, high-tech industrial development zone policy provides political support for firms in the designated areas by both providing actual convenience in related administrative issues and showing a signal of national development direction to the market. There are several major differences between non-SOEs and SOEs that could lead to the heterogeneous effects of the innovation outcomes of this policy. The most important one is the advantages of political connections that SOEs have over non-SOEs (Liu et al., 2013). Owned by the state, SOEs are closely connected with the government and have enjoyed a great number of political supports even without other policies like high-tech industrial development zone policy to be implemented (Liu et al., 2019). As a result, the additional political supports of high-tech industrial development zone policy may be a repeat of the resources that SOEs have already had and lead to relatively few marginal effects on them. Additionally, SOEs' may not have the same incentives to maximize profits due to what is known as soft budget constraints[12]. On the

[12] Soft budget constraints: When an economic organization encounters financial difficulties, it can continue to survive such an economic phenomenon with the help of external organizations. Its basic characteristics are: the

contrary, non-SOEs are in a disadvantaged position in terms of political connections in general. These political supports could make up for the gaps because of ownership property between non-SOEs and SOEs, which may have a more significant impact on non-SOEs that may lack political connections otherwise. The political supports of high-tech industrial development zone policy could provide convenience for administrative issues (Cingano and Pinotti, 2013) and allocate more resources to R&D (Wang et al., 2018; Tsai et al., 2018), which could increase firm innovation activities in non-SOEs. Moreover, another difference between non-SOEs and SOEs is that SOEs have a national endorsement for their asset, while non-SOEs face more limitations and restrictions when it comes to financial decisions (Yusuf et al., 2005). As a high-risk and costly activity that requires a long period to get payback (Kleis et al., 2012), non-SOEs may have more concerns when making decisions on innovation investment. Therefore, the extra financial supports from high-tech industrial development zone policy could ease their worries to some extent and spend more on innovation investment, increasing their patent applications.

Hypothesis 2: The establishment of high-tech industrial development zones has a more significant positive impact on firm patent applications in non-SOEs.

The second heterogeneous effects of the establishment of high-tech industrial development zones on firm patent applications are between small firms and large firms. The preferential financial policies offered in high-tech industrial development zones could relax those financial constraints, increasing innovation investments. Compared with large firms, small firms are faced with more financial constraints and more concerns when making decisions on

survival of an enterprise does not only depend on its input cost and sales profit; the technological progress and development of an enterprise does not only depend on the accumulation of internal funds; the enterprise does not need to adapt to the price under any circumstances, and the response to the price is extremely weak; companies do not take risks themselves, and can pass on the adverse consequences of the external environment and their actions to buyers and the country; companies' demand for inputs is almost insatiable.

innovation investments (Scellato, 2007). Hence, the extra financial supports may have more marginal effects on easing financial concerns and increasing innovation activities for small firms than for large firms. Another potential reason for a more significant impact on small firms draws upon the human capital of knowledge workers. In general, large firms are more attractive in recruitment (Horwitz et al., 2003) due to stability, brand effects, registered residency (*Hukou*), and other welfare. The policies in high-tech industrial development zones targeting knowledge workers include both economic incentives and institutional supports, which could compensate small firms and make them have comparable abilities to compete with large firms regarding the recruitment of high-skilled workers. Additionally, firms need to reach a certain threshold of R&D expenditure to be certified as high-tech enterprises, and the number of patent applications is also one of the score measurements so that they could get benefits of the policy. In this case, small firms may need to invest more in R&D and increase the number of patents to enjoy the policy, while large firms may not need to do anything since they may already meet the criteria.

Hypothesis 3: The establishment of high-tech industrial development zones has a more significant positive impact on firm patent applications in small firms.

The last heterogeneity of the innovation outcomes of the establishment of high-tech industrial development zones is among regions. On one hand, knowledge spillover effects have been widely discussed in agglomeration economies (e.g., Rosenthal and Strange, 2003; 2004). The clustering of firms with more technological innovation could create potential knowledge spillover effects, increase local productivity, benefit firms in the same areas, and increase innovation activities and patent applications within the regions. On the other hand, the clustering of firms with technological innovation enables firms to share facilities, infrastructures, research institutions, and other necessary conditions for conducting innovation activities (Ridley et al., 2006). Therefore, the establishment of high-tech industrial development zones may have a more significant positive influence on patent applications for firms located in the regions where innovation has already been well developed. As a result, the establishment of high-tech industrial development zones could have a more effective impact on increasing firm innovation activities in the regions with more innovation activities before in the short run.

Hypothesis 4: The establishment of high-tech industrial development zones has a more significant positive impact on firm patent applications in developed regions.

CHAPTER 5 DATA

5.1 Data and Sample

Firm-level analyses in China mainly use either A-share listed firms or industrial firms. However, the patent data for industrial firms is only available before 2010. Therefore, to measure how the establishment of high-tech industrial development zones influenced firms patenting in China, we use A-share listed firms, including firms on the mainboard, SME board, and Growth Enterprise Market, as our samples. We combine data sources about firms and regions to construct panel data. Our firm-level data come from China Stock Market & Accounting Research Database (CSMAR) and RESSET Database. Both databases are comprehensive and research-oriented, focusing on listed firms in China and widely used in academic research (e.g., Han et al., 2015; Ma and Khanna, 2016). We obtain firm-level data, including patents, financial situations, employees, board and manager, and salaries, from CSMAR, while nature of ownership from RESSET. The raw data contains 3,579 firms in total.

We obtain our core dependent variable, the number of patents, from CSMAR (e.g., Pang and Wang, 2020; Zhuge et al., 2020). Consistent with prior studies (Gans et al., 2008; Jia et al., 2019), we regard the year of application as the time when a patent was produced. There are three types of patents, including invention patent, utility model patent, and design patent. According to the *Patent Law* in China[13], invention patent refers to new technical solutions proposed for products, methods or their improvements, utility model patent refers to a new technical solution that replaces the practicality of the shape, structure or combination of the product, and design patent refers to a new design that is aesthetically pleasing to the product's shape, pattern, or

[13] https://www.wipo.int/edocs/lexdocs/laws/zh/cn/cn028zh.pdf

color. Since design patent is less involved with substantial innovation activities, we also use patents except design patents as an alternative dependent variable (Tan et al., 2020; Liu and Zhao, 2019). We further analyze the effect on invention patents separately as an alternative measurement of patent quality since invention patents focus more on originality (Yuan and Wen, 2018; Pang and Wang, 2020).

To obtain location-level measures of the establishment of high-tech industrial development zones, we use the keywords in the detailed location information of a specific firm. Consistent with prior research (e.g., Lu et al., 2019), if the detailed address contains a group of words including high-tech (*gaoxin*), science park (*kejiyuan*), pioneer park (*chuangyeyuan*), investment zone (*touziqu*), torch park (*huojuyuan*), and torch zone (*huojuqu*), which are often used to describe zones where high/new-technology are supposed to locate, the firm can be identified as located in a high-tech industrial development zone. Firm address information is also from CSMAR, including both registration address and patenting address. Other regional-level variables, including GDP, population, and patent, come from the National Bureau of Statistics.

Considering high-tech industrial development zone policy and the purpose of our study, we limit our sample as follows. First, high-tech industrial development zone policy requires both the registration address and the patenting address in a high-tech industrial development zone to enjoy the preferential policy. Therefore, we drop firms with different registration address and patenting addresses.

Second, since we would like to investigate how the establishment of high-tech industrial development zones affects firm patenting, we need firm information in both the pre- and post-period of the establishment of high-tech industrial development zones to compare. We obtain the timing of the establishment of high-tech industrial development zones from the official websites of each high-tech industrial development zone. Since some high-tech industrial development zones have been expanded over time, we consider the timing of the establishment of a high-tech development zone for each firm based on the year when the firm's location was included in high-tech industrial development zone. For example, although Zhongguancun Science Park was first established in 1988, it expanded its original area by including Tsinghua Science Park in 2001, Zhongguancun Science Park-Daxing Biomedical Base in 2006, etc. It is hard to calculate the timing distribution for all high-tech industrial development zones in China. We present the number of the establishment of high-tech development zones that contain A-share listed firms and the number of firms treated each year in Table 3.

Table 3 Number of High-tech Industrial Development Zones Established Each Year

year	# of high-tech development zones			treated firms
	total	national	provincial	
1991	21	21	0	174
1992	26	25	1	90
1993	3	2	1	9
1994	3	2	1	20
1995	2	1	1	1
1996	1	1	0	34
1997	0	0	0	0
1998	1	0	1	1
1999	1	1	0	1
2000	3	1	2	3
2001	5	2	3	3
2002	3	2	1	5
2003	6	1	5	5
2004	1	0	1	1
2005	2	1	1	1
2006	5	3	2	6
2007	1	1	0	5
2008	2	2	0	4
2009	4	3	1	7
2010	10	9	1	9

2011	4	4	0	17
2012	10	10	0	13
2013	2	1	1	2
2014	3	1	2	3
2015	6	6	0	6

Considering the earliest available information on all the data we need, our sample period starts in 1999. Table 3 shows that there are many high-tech industrial development zones established in or before 1999, which means treated firms only contain information in the post-period of the establishment. Additionally, since our data is an unbalanced panel data, there may exist treated firms in a high-tech industrial development zone established after 1999, but still without pre-period of the establishment. We exclude all the firms that do not contain information in the pre-period of the establishment.

Next, considering information needed in the pre-treatment period for comparison with that in the post-treatment period, we identify a set of treated firms that have information in at least three years before the establishment of a high-tech industrial development zone, which leaves us with 44 treated firms (456 observations) in total. The whole sample selection process is shown in Table 4.

Table 4 Sample Selection Process

	Deleted	Remained		
		Total	Treated	Control
Total		3,579	513	3,066
drop firms with different address	350	3,229	420	2,809
drop treated firms entering after the establishment of zones	329	2,900	91	2,809
drop treated firms without information in pre-treatment years	16	2,884	75	2,809
keep treated firms with information in at least 3 pre-treatment years	31	2,853	44	2,809

Although limitation is made in the sample selection process above, a common problem to be addressed is selection bias. The establishment of high-tech industrial development zones can be affected by other observable and unobservable variables at both the firm level and region level, such as firm asset, loan, employee, salary, regional GDP, population, and patent. To address the selection problem, we undertake the approach of propensity score matching (Leuven and Sianesi, 2003). Since high-tech industrial development zone policy is an industrial policy, we only use GDP in the second sector. The second sector is an economic sector describing the role of manufacturing. It encompasses the industries which produce a finished, usable product or are involved in construction. We use the Probit model to do the propensity score matching, and the result is shown in Table 5.

Table 5 Propensity Score Matching

	coefficient	std. err.	z	p-value
current asset	0.1130	0.0132	8.58	0.000
non-current asset	-0.1094	0.0114	-9.61	0.000
loan	-0.0243	0.0118	-2.05	0.040
net profit	0.0000	0.0000	-0.81	0.419
age	-0.1099	0.0264	-4.16	0.000
employee	-0.0628	0.0198	-3.18	0.001
salary	-0.0157	0.0098	-1.60	0.109
Whether firm has patent	0.2622	0.0232	11.30	0.000
average regional GDP growth rate in the 2nd sector in past 5 years	0.3708	0.0805	4.61	0.000
lagged regional GDP in the 2nd sector	0.0618	0.0173	3.58	0.000
lagged regional population growth rate	0.0355	0.0019	18.36	0.000
average regional stock invention patent in the past 5 years	0.0484	0.0095	5.12	0.000
Year FE		Y		
Industry FE		Y		
N		29,897		

Notes: current asset, non-current asset, loan, age, employee, salary, lagged GDP in the 2nd sector, average stock invention patent in the past 5 years are logged values.

For each treated firm, we match the five most similar control firms based on the probabilities to be in a high-tech industrial development zone from the results in the model above in the three pre-treatment years. Control firms can be matched repeatedly to different treated firms. There are 199 control firms (2,036 observations) matched to the treated firms in total. We also exclude firms in the agriculture and entertainment industries because there are relatively few patents or R&D investments in these industries. Considering the time lags in patent applications and the impact of policy on firm patents, we limit our sample period to 1999-2016.

5.2 Summary Statistics

Previous research on patents has been aware of the special features of patent data. For example, the number of patents has a distribution of a great proportion of zero patents and a long right tail (e.g., Gurmu and Pérez-Sebastián, 2008), which exists in our patent data as well. Figure 1 shows the distribution of the number of patents per year, which directly reveals the difference between the treated group and the control group regarding the number of zero patents. The detailed summary statistics of the dependent variables in Table 6 provide a specific distribution of the data.

Given the special features of patent data discussed above, we assume that heterogeneous effects may exist among different distributions of patents. After applying a linear regression model first, we conduct a quantile regression. We consider the following three aspects, including small firms and large firms, state-owned enterprises (SOEs) and non-SOEs, firms in developed regions and less developed regions, to analyze the heterogeneous effects. One major concern about the linear models is that the distribution of the error terms of the logged patents may not be normal. Then we consider count data models that are more suitable for patent data. Two classic count data models are the Poisson model and the negative binomial model. In the Poisson model, the dependent variable should follow a Poisson distribution, which means the variance is supposed to be equal to the mean. This variance restriction is likely to be violated in our study. In the negative binomial model, heterogeneity in the mean is allowed, and thus the variance restriction is relaxed. Therefore, we only use the negative binomial model as a robustness check. Besides, we do parallel trend tests for the assumptions of using the difference-in-difference method that the treated and control groups have similar trends in the pre-treatment periods. As further extensions, we explore the effects on firm patent quality and R&D expenditure. We also apply a linear probability model for all the linear regressions mentioned above to analyze the extensive margin. The results are quite similar to those in the linear regression models. The tables for extensive margin are shown in the appendix.

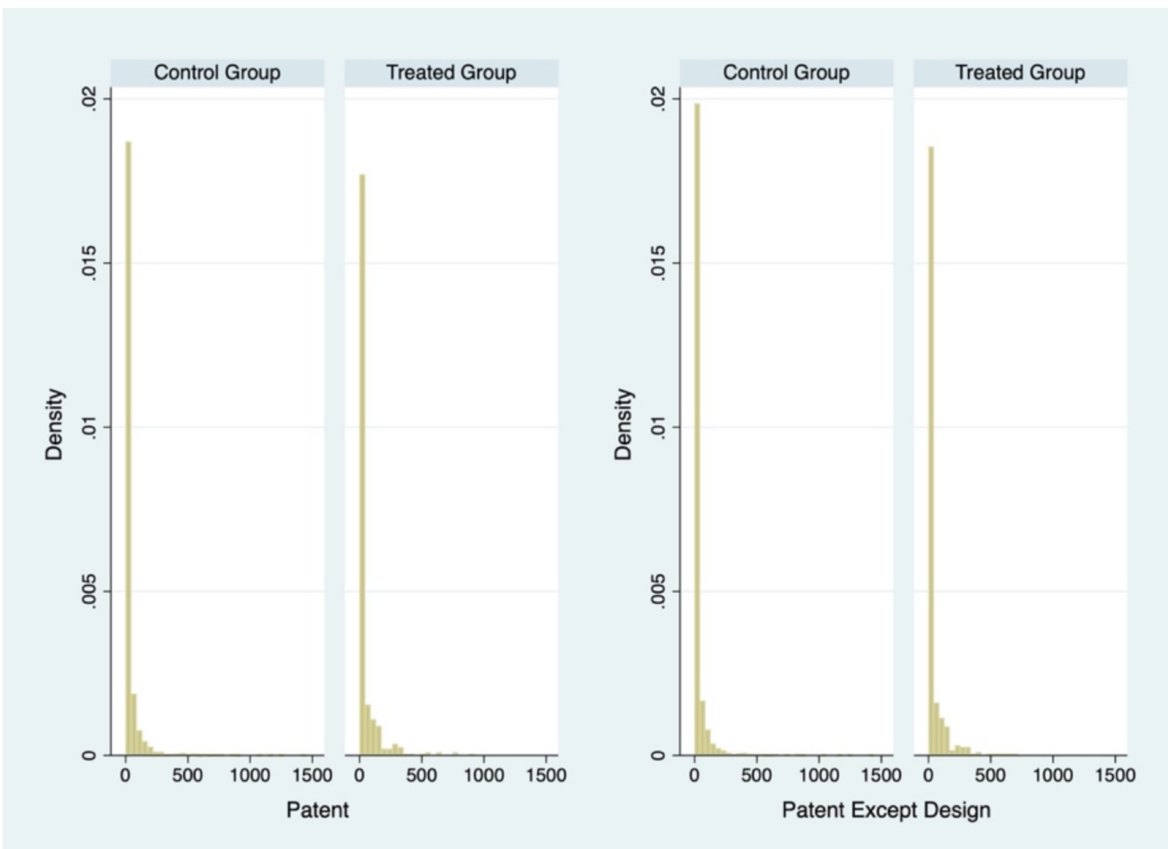

Figure 1 Distribution of the Dependent Variables

Table 6 Detailed Summary Statistics of the Dependent Variables

Panel A: Number of Patents				
	treated		control	
	Percentiles	Smallest	Percentiles	Smallest
1%	0	0	0	0
5%	0	0	0	0
10%	0	0	0	0
25%	0	0	0	0
50%	7		4	
		Largest		Largest
75%	36.5	655	25.5	1058
90%	134	766	82	1176
95%	248	775	160	1257
99%	650	882	546	1451
Panel B: Number of Patents except Design				
	treated		control	
	Percentiles	Smallest	Percentiles	Smallest
1%	0	0	0	0
5%	0	0	0	0
10%	0	0	0	0
25%	0	0	0	0
50%	5.5		3	
		Largest		Largest
75%	33	578	22	1058
90%	125	600	73	1176
95%	225	648	139	1257
99%	546	718	476	1397

To check whether there exist overlaps among different heterogeneity sources, we show the observations across different heterogeneity in Table 7, indicating that the heterogeneous effects between firm size, nature of ownership, and regions proposed in this thesis capture different heterogeneity. The results Table 8 includes a description of dependent variables, independent variables, and control variables used for our analysis, which also shows that the number of patents in the treated group has a higher mean than that in the control group. The t-test results indicate that there exist some significant differences between the treated group and the control group. To control for time-invariant differences, fixed effects are used in the models.

Table 7 Observations across Heterogeneity

Panel A: small/large & non-SOEs/SOEs		
	non-SOEs	SOEs
small	783	461
large	485	761
Panel B: small/large & developed/less developed		
	less developed	developed
small	438	806
large	426	820
Panel C: non-SOEs/SOEs & developed/less developed		
	less developed	developed
non-SOEs	313	957
SOEs	553	669

Table 8 Descriptive Statistics for Variables

Panel A: Before Matching											
	total sample			treated group			control group			t test	
VARIABLES	N	mean	sd	N	mean	sd	N	mean	sd	t-stat	p-value
treat×after	30,842	0.13	0.34								
# of patent	30,842	36.79	263.6	4,688	59.07	311.2	26,154	32.80	253.9	-6.29	0.0000
# of invention patent	30,842	17.09	157.0	4,688	33.49	258.2	26,154	14.15	130.7	-7.77	0.0000
# of utility model patent	30,842	15.94	114.0	4,688	20.42	74.93	26,154	15.13	119.7	-2.93	0.0034
# of design patent	30,842	3.75	24.34	4,688	5.14	23.67	26,154	3.51	24.45	-4.23	0.0000
R&D expense	12,390	141	944	2,357	182	1,640	10,033	131	497	-2.62	0.0089
intangible asset	30,817	413.8	2,701	4,685	200.7	949.4	26,132	452.0	2,904	5.87	0.0000
long term loan	30,784	2,070	16,200	4,686	595	3,240	26,098	2,340	17,500	6.81	0.0000
short term loan	30,802	877	3,730	4,685	555	1,550	26,117	935	4,000	6.42	0.0000
net profit	30,842	662.6	7,009	4,688	230	1,523	26,154	740.2	7,581	4.59	0.0000
age	30,842	13.63	6.08	4,688	13.28	5.64	26,154	13.69	6.16	4.29	0.0000
manager	30,644	6.29	2.38	4,665	6.31	2.37	25,979	6.28	2.39	-0.79	0.4296
top 3 salary of manager	25,610	1,599	2169	3,959	1,547	1,819	21,651	1,609	2,227	1.65	0.0992
average GDP growth rate (2nd sector)	30,809	0.14	0.11	4,693	0.15	0.07	26,116	0.14	0.12	-2.47	0.0135
population rate	30,770	5.02	4.80	4,691	6.18	4.92	26,079	4.81	4.75	-18.00	0.0000
Panel B: After Matching											
	total sample			treated group			control group			t test	
VARIABLES	N	mean	sd	N	mean	sd	N	mean	sd	t-stat	p-value
treat×after	1,900	0.12	0.32								
# of patent	1,900	47.4	115.3	335	62.31	122.4	1,565	44.21	113.5	-2.61	0.0091
# of invention patent	1,900	21.11	58.26	335	29.54	58.96	1,565	19.3	57.97	-2.92	0.0035
# of utility model patent	1,900	21.08	54.87	335	25.53	52.25	1,565	20.13	55.38	-1.64	0.1019
# of design patent	1,900	5.2	19.39	335	7.24	26.32	1,565	4.76	17.53	-2.12	0.0340
R&D expense	1,306	140.5	350.6	243	177.3	364.6	1,063	132.06	346.93	-1.87	0.0618
intangible asset	1,900	266.1	680.8	335	245.4	454.3	1,565	270.5	720.1	0.61	0.5396
long term loan	1,900	842	4,410	335	1,330	7,740	1,565	738	3,280	-2.24	0.0254
short term loan	1,900	839	2,250	335	943	2,060	1,565	816	2,290	-0.93	0.3504
net profit	1,900	278.2	881.0	335	292.0	923.9	1,565	275.3	720.1	-0.32	0.7526
age	1,900	15.2	5.29	335	14.82	5.03	1,565	16.97	6.06	6.85	0.0000
manager	1,893	6.4	2.42	334	6.32	2.45	1,559	6.42	2.42	0.68	0.4993
top 3 salary of manager	1,794	1,725	1,794	318	1,805	1,791	1,476	1,707	1795.3	-0.88	0.3787
average GDP growth rate (2nd sector)	1,900	0.15	0.13	335	0.14	0.06	1,565	0.15	0.14	0.50	0.6179
population rate	1,891	6.56	5.89	334	8.25	6.31	1,557	6.19	5.73	-6.22	0.0000

Notes: Data on R&D expense is only available since 2007, and contains missing values

CHAPTER 6 EMPIRICAL RESULTS

6.1 Baseline Regressions

Our empirical design relies on a difference-in-differences approach for each dependent variable that compares the variable after the establishment of high-tech industrial development zones to the variable before the establishment for treated and control firms. The specification is of the following form:

$$y_{ijt} = \beta_0 + \beta_1 treat_{ij} \times after_t + \beta_2 X_{ijt} + \beta_3 R_{jt} + \gamma T_t + \pi \alpha_i + \varepsilon_{ijt} \quad (1)$$

where y_{ijt} is one of the two dependent variables described above, X_{ijt} is a vector of firm-level control variables, R_{jt} is a vector of region-level control variables, T_t is a year fixed effect, and α_i is a firm fixed effect. By including the firm fixed effects, we control for any fixed differences across firms. By including the year dummies, we also control for common macroeconomic shocks that affect all firms. Industry fixed effects is not included since most firms do not change industries over time. We cluster the error terms at the city level to account for autocorrelation in the data within regions and over time.

Columns in Table 9 reports the regression results on the log value of the number of patents and the number of patents except design patent, respectively. Both models include firm and year fixed effects. The coefficients on $treat_{ij} \times after_t$ are positive in both models, though not significant. The results across models are similar.

Table 9 The Effect of High-tech Zone Policy on Firm Patent

	(1)	(2)
	patent	patent (except design)
treat×after	0.2186	0.2188
	(0.1406)	(0.1692)

net profit	-0.0001	-0.0000
	(0.0001)	(0.0001)
intangible asset	0.1372***	0.1443***
	(0.0300)	(0.0314)
manager	0.0222	0.0226
	(0.0224)	(0.0216)
age	0.3073	0.2659
	(0.9405)	(0.8609)
top 3 salary of manager	0.1063	0.0692
	(0.1152)	(0.1045)
parent owner equity	0.2351**	0.2427**
	(0.0734)	(0.0730)
long term loan	0.0107*	0.0071
	(0.0055)	(0.0051)
short term loan	0.0074	0.0065
	(0.0057)	(0.0054)
average GDP growth rate (2^{nd} sector)	-0.2517**	-0.2785**
	(0.1260)	(0.1003)
population rate	0.0072	0.0031
	(0.0096)	(0.0091)
Year FE	Y	Y
Firm FE	Y	Y
constant	-2.3782	-2.0625
	(1.6647)	(1.4409)
N	1749	1749

Notes: ****, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Considering the long-tail distribution of firm patent data, there may be different effects on different percentiles of patents. Since high-tech industrial development zone policy may help firms faced with too many constraints to innovate before to relax the pressure and promote their innovation activities, we assume that the effects are likely to be more significant in the lower percentiles. That is, the effects could be more significant for firms with fewer patents in the ex-ante treatment period.

The quantile regression results are shown in Table 10. This analysis is a repeat of the linear model in Table 9. Firm and year fixed effects are included in all the models as well. We find that the coefficient on $treat_{ij} \times after_t$ is still positive in all the models, while significant at the 5% level in the 25th percentile, significant at the 10% level in the 50th percentile, and not significant in the 75th percentile. The magnitude of the coefficients also decreases as the percentile goes higher. The results are similar between the effects on the log value of the number of patents and the log value of the number of patents except design patent.

The magnitude of the impact of $treat_{ij} \times after_t$ is interpreted by $\exp(\beta_1) - 1$, since it is a dummy variable in a log-linear regression. The results in the first three columns show that the establishment of high-tech industrial development zones increases the number of firm patents by 37.49% in the 25th percentile, and by 24.23% in the 50th percentile. The results in the last three columns show that the establishment of high-tech development zones increases the number of firm invention and utility model patents by 36.63% in the 25th percentile, and by 24.35% in the 50th percentile.

Table 10 The Effect of High-tech Zone Policy on Firm Patent (Quantile Regression)

	(1)	(2)	(3)	(4)	(5)	(6)
	patent			patent (except design)		
	0.25th	0.5th	0.75th	0.25th	0.5th	0.75th
treat×after	0.3184**	0.2170*	0.1139	0.3121**	0.2179*	0.1181
	(0.1607)	(0.1211)	(0.1622)	(0.1587)	(0.1170)	(0.1557)
net profit	-0.0000	-0.0001	-0.0001	-0.0001	-0.0000	-0.0000
	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
intangible asset	0.1230***	0.1374***	0.1522***	0.1343***	0.1444***	0.1552***
	(0.0384)	(0.0290)	(0.0388)	(0.0372)	(0.0274)	(0.0365)
manager	0.0228	0.0222	0.0217	0.0209	0.0227	0.0245
	(0.0225)	(0.0169)	(0.0227)	(0.0216)	(0.0159)	(0.0212)
age	0.4445	0.3050	0.1630	0.4391	0.2643	0.0790
	(0.7300)	(0.5498)	(0.7370)	(0.6790)	(0.5001)	(0.6665)
top 3 salary of manager	0.0792	0.1068	0.1348	0.0565	0.0693	0.0829
	(0.0971)	(0.0731)	(0.0980)	(0.0880)	(0.0648)	(0.0864)
parent owner equity	0.2573***	0.2348***	0.2119***	0.2766***	0.2423***	0.2060***
	(0.0692)	(0.0521)	(0.0698)	(0.0690)	(0.0509)	(0.0677)

long term loan	0.0132***	0.0107***	0.0081	0.0086*	0.0071*	0.0054
	(0.0050)	(0.0038)	(0.0051)	(0.0049)	(0.0036)	(0.0049)
short term loan	0.0087	0.0073	0.0060	0.0075	0.0065	0.0054
	(0.0063)	(0.0048)	(0.0064)	(0.0062)	(0.0045)	(0.0060)
average GDP growth rate (2^{nd} sector)	-0.2017	-0.2526**	-0.3043*	-0.2058	-0.2792***	-0.3570***
	(0.1696)	(0.1277)	(0.1712)	(0.1332)	(0.0982)	(0.1307)
population rate	0.0114	0.0071	0.0028	0.0045	0.0031	0.0016
	(0.0108)	(0.0082)	(0.0109)	(0.0108)	(0.0080)	(0.0106)
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
N		1749			1749	

*Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Next, we investigate the heterogeneous effects of the establishment of high-tech industrial development zones on firm innovation activities. First, we consider the heterogeneity between non-SOEs and SOEs. When it comes to the effect of China's stimulus policy, the heterogeneity between SOEs and non-SOEs has been widely discussed. Previous studies find that stimulus policies barely have an effective impact on SOEs or even have a negative impact. For example, recent research on the launch of a large stimulus program in the autumn of 2008 shows that preferential access to debt financing does not have an incentive for SOEs to improve their performance, and SOEs have significantly worse performance than non-SOEs after the introduction of the stimulus program (Johansson and Feng, 2016).

There are several possible explanations accounting for the heterogeneous effects of the establishment of high-tech development zones on SOEs and non-SOEs. On one hand, as an official government supports, the establishment of high-tech industrial development zones could provide political connections for firms, which is an essential capital in China and could be fundamentally helpful for firms who lack it. On the contrary, SOEs have already had political connections due to their ownership, and additional policy support has few marginal effects to improve their performance. On the other hand, SOE firms have already had better financial situations than non-SOEs before this preference policy was implemented, such as better access to loans. One of the major incentives of high-tech industrial development zone preference policy is tax exemption, greatly relaxing the financial constraint, which could be more helpful for non-SOEs than SOEs. Additionally, the incentives to maximize profits or to showcase innovation is different between non-SOEs and SOEs, because there may exist soft budget constraints in SOEs.

We rerun the linear regression model for SOEs and non-SOEs, respectively, to examine whether the effect is different in SOEs and non-SOEs. Table 11 shows that the coefficients on the interaction, $treat_{ij} \times after_t$, are significant positive in both analyses on patents and patents except design patents in the non-SOEs, indicating that the establishment of high-tech development zone has an effective incentive for non-SOEs patents, while not effective for SOEs. In specific, column 1 and column 3 in Table 11 show that the establishment of high-tech industrial development zones increases the number of patents and the number of invention and utility model patents in non-SOEs by 74.37% and 61.91%, respectively. All these coefficients in non-SOEs are statistically significant at 5% level. However, the coefficients in SOEs are statistically insignificant negative.

Table 11 The Effect of High-tech Zone Policy on Firm Patent (Nature of Ownership)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	non-SOE	SOE	non-SOE	SOE
treat×after	0.5560**	-0.1078	0.4819**	-0.0823
	(0.2103)	(0.1642)	(0.2335)	(0.1997)
net profit	0.0002	-0.0002	0.0002	-0.0002
	(0.0002)	(0.0002)	(0.0002)	(0.0002)
intangible asset	0.1955***	0.0777	0.1876**	0.1064**
	(0.0537)	(0.0509)	(0.0579)	(0.0464)
manager	0.0113	0.0528	0.0175	0.0443

	(0.0213)	(0.0383)	(0.0210)	(0.0351)
age	1.0946	-0.4811	1.6488**	-0.9415
	(1.1411)	(1.1550)	(0.8082)	(1.0775)
top 3 salary of manager	0.2221*	0.0752	0.1785	0.0357
	(0.1257)	(0.1539)	(0.1188)	(0.1274)
parent owner equity	0.2789**	0.2111*	0.3155**	0.2042*
	(0.1083)	(0.1118)	(0.1113)	(0.1110)
long term loan	0.0096	0.0098	0.0050	0.0068
	(0.0058)	(0.0067)	(0.0054)	(0.0068)
short term loan	0.0037	0.0064	-0.0000	0.0086
	(0.0076)	(0.0083)	(0.0064)	(0.0085)
average GDP growth rate (2^{nd} sector)	-0.3400***	1.6807	-0.3297***	0.9736
	(0.0745)	(1.3764)	(0.0724)	(1.3651)
population rate	0.0083	0.0109	-0.0035	0.0149
	(0.0106)	(0.0161)	(0.0095)	(0.0157)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
constant	-4.3143**	-1.1960	-4.9872**	-0.1722
	(2.0257)	(2.1258)	(1.5204)	(1.8650)
N	867	882	867	882

Notes: ****, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

As one of the key preferential policies in high-tech industrial development zones, the financial supports, such as land allocation, tax exemption, favorable loan conditions, etc., which can greatly relax the financial constraints in small firms that are generally faced with a more financial burden, compared with large firms. Therefore, we then explore the heterogeneity between small firms and large firms.

We use the number of employees as a proxy variable of firm size. We divide the total sample into two subsamples, below-median and above-median. We repeat our analysis in both linear regression models. The results show that the coefficient on $treat_{ij} \times after_t$ is significant on total firm patents in small firms. In specific, column 1 in Table 12 shows that the establishment of high-tech industrial development zones leads to an increase in the total number of patents in small firms by 45.66%, and the coefficient is statistically significant at 5% level. However, the coefficients in large firms are not statistically significant and greatly smaller regarding magnitude. This may also because small firms have a smaller base patent application benchmark and the change will be shown as a larger percentage increase.

Table 12 The Effect of High-tech Zone Policy on Firm Patent (Firm Sizes)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	small	large	small	large
treat×after	0.3761**	0.0126	0.2857	0.0266
	(0.1851)	(0.1628)	(0.1943)	(0.2258)
net profit	0.0002	-0.0003	0.0002	-0.0002
	(0.0004)	(0.0002)	(0.0003)	(0.0001)
intangible asset	0.1476***	0.0905	0.1368***	0.1489**
	(0.0328)	(0.0603)	(0.0358)	(0.0492)
manager	0.0469	0.0189	0.0452	0.0197
	(0.0334)	(0.0331)	(0.0341)	(0.0319)
age	0.5612	1.1663	1.1282	0.4552
	(0.8814)	(0.8977)	(0.7026)	(0.8312)
top 3 salary of manager	-0.0072	0.1498	-0.0202	0.0874
	(0.1393)	(0.1539)	(0.1374)	(0.1190)
parent owner equity	0.1325*	0.4267**	0.1895**	0.3790**
	(0.0756)	(0.1417)	(0.0838)	(0.1352)
long term loan	0.0129**	0.0046	0.0084	0.0012
	(0.0055)	(0.0082)	(0.0055)	(0.0074)
short term loan	0.0051	-0.0046	0.0040	-0.0087
	(0.0060)	(0.0094)	(0.0055)	(0.0083)
average GDP growth rate (2^{nd} sector)	0.1682	1.1987	0.2282	0.5328
	(0.9182)	(1.0658)	(0.8810)	(0.9535)
population rate	0.0055	0.0131	0.0054	0.0089
	(0.0138)	(0.0143)	(0.0136)	(0.0145)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
constant	-1.5166	-5.7578**	-2.5350*	-3.8359*
	(1.7371)	(2.3416)	(1.3688)	(1.9511)
N	878	871	878	871

*Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Finally, we look into the heterogeneity between developed regions and less developed regions. According to the clustering effects in the agglomeration economies, developed regions have more completed infrastructures and facilities, more skilled-workers, and better other necessary conditions of innovation. The policy of the establishment of high-tech industrial development zones serves as complementary support from another perspective of innovation conditions, which could improve the overall knowledge spillover effects in the area. Therefore, we assume that the establishment of high-tech industrial development zones may have a better and more significant effect on firm innovation activities in the developed regions.

We regard provinces in the east coast region as developed regions, including Shandong, Hebei, Tianjin, Liaoning, Jiangsu, Zhejiang, Fujian, Shanghai, Guangdong, and Hainan, while other provinces as less developed regions[14] (e.g., Jing and Cai, 2010). We split the sample into less developed regions and developed regions and rerun the linear. Table 13 shows that the coefficients on the interaction, $treat_{ij} \times after_t$, are significant positive in both analyses on patents and patents except design patents in the developed regions, which is consistent with our assumptions that the establishment of high-tech industrial development zones have a more positive impact on firm innovation activities in the developed regions, while smaller and not statistically significant effects on firms in less developed regions. Specifically, column 1 and column 3 in Table 13 show that the establishment of high-tech industrial development zones increases the number of patents and the number of invention and utility model patents in firms in developed regions by 45.53% and 45.57%, respectively. Both coefficients in developed regions

[14] https://zh.wikipedia.org/wiki/%E4%B8%AD%E5%9B%BD%E4%B8%9C%E9%83%A8%E7%BB%8F%E6%B5%8E%E5%8C%BA

are statistically significant. However, the coefficients in less developed regions are not statistically significant.

Table 13 The Effect of High-tech Zone Policy on Firm Patent (Regions)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	developed	less developed	developed	less developed
treat×after	0.3752**	0.1536	0.3755*	0.0607
	(0.1786)	(0.2511)	(0.2161)	(0.2599)
net profit	0.0000	-0.0003	0.0000	-0.0002
	(0.0001)	(0.0002)	(0.0002)	(0.0002)
intangible asset	0.1161***	0.2005***	0.1240***	0.2042***
	(0.0270)	(0.0497)	(0.0331)	(0.0516)
manager	-0.0139	0.0796*	-0.0089	0.0717**
	(0.0217)	(0.0402)	(0.0226)	(0.0348)
age	1.7954**	-0.7399	1.6895**	-0.9322
	(0.8388)	(1.6025)	(0.6849)	(1.5956)
top 3 salary of manager	0.0952	0.1979	0.0657	0.1404
	(0.1470)	(0.1426)	(0.1521)	(0.1137)
parent owner equity	0.1685*	0.2759**	0.1763**	0.2890**
	(0.0873)	(0.0867)	(0.0791)	(0.0877)
long term loan	0.0164**	-0.0022	0.0122*	-0.0050
	(0.0071)	(0.0079)	(0.0061)	(0.0078)
short term loan	0.0007	0.0250**	-0.0007	0.0248**
	(0.0071)	(0.0090)	(0.0062)	(0.0098)
average GDP growth rate (2^{nd} sector)	0.9505	-0.2549**	0.2585	-0.2737**
	(1.2058)	(0.1015)	(0.9943)	(0.1016)
population rate	0.0150	0.0053	0.0092	0.0008
	(0.0167)	(0.0120)	(0.0153)	(0.0103)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
constant	-2.0015	-2.4725	-1.8023	-1.7329
	(1.2714)	(3.1686)	(1.1027)	(2.8948)
N	1157	592	1157	592

Notes*: ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

6.2 Robustness Checks

This subsection outlines several potential concerns with our results and the robustness tests undertaken to address each concern. The first concern we address is the special feature of our patent data. Although linear models have several advantages regarding estimating the coefficients and we make some adjustments to the original data, including using binary variables and log values, the distribution of our dependent variables may not be as linear as it is supposed to be. In general, the number of patents is count data, and thus we use a count data model as a robustness check. Since the variance restriction of variance equal to mean in the Poisson model is likely to be violated, we only consider the analysis in a negative binomial model.

Table 14 presents the results of the negative binomial model. We estimate both the main results and the marginal effect. Year dummies and conditional firm fixed effects are included in all the models. We find that the coefficient on $treat_{ij} \times after_t$ is significant positive at the 5% level. The reason why the results become statistically significant compared with those in the linear model may be because the count data model could fit the data distribution better. The estimates of the main results are shown in column 1 and column 3. Since the equation used in a negative binomial model is the same as that in a log-linear model, the magnitude of percentage change is interpreted as $\exp(\beta_1) - 1$. In specific, the establishment of high-tech development zones increases the number of patents and the number of invention and utility model patents by 21.97% and 25.94%, respectively. The estimates of marginal effect are shown in column 2 and column 4. It may be challenging to interpret the marginal effects. On one hand, the patent data have a large mass at zero and long-tail distribution, making it hard to be compared to the mean value of patents in the summary statistics. On the other hand, the results of marginal effects are related to the point at which they are evaluated. Evaluated at mean values, for the number of overall patents, the predicted number of $treat_{ij} \times after_t = 1$ is 0.5821, and of $treat_{ij} \times after_t = 0$ is 0.3835. The percentage change is $\frac{0.5821}{0.3835} - 1 = 51.79\%$. For the number of patents except design patents, the predicted number of $treat_{ij} \times after_t = 1$ is 0.6768, and of $treat_{ij} \times after_t = 0$ is 0.4461. The percentage change is $\frac{0.6768}{0.4461} - 1 = 51.71\%$. The results of Table 14 thus provide us with some confidence that the establishment of high-tech industrial development zones has a significant positive effect on firm patents.

Table 14 The Effect of High-tech Zone Policy on Firm Patent (Negative Binomial)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	main	marginal effect	main	marginal effect
treat×after	0.1986**	0.3893**	0.2306**	0.4872**
	(0.0920)	(0.1812)	(0.0932)	(0.1992)
net profit	-0.0001	-0.0002	-0.0002	-0.0000
	(0.0001)	(0.0002)	(0.0001)	(0.0002)
intangible asset	0.1207***	0.2366***	0.1234***	0.2609***
	(0.0276)	(0.0564)	(0.0283)	(0.0625)
manager	0.0167	0.0328	0.0192	0.0406
	(0.0119)	(0.0234)	(0.0118)	(0.0250)
age	-0.1537	-0.3013	-0.4772**	-1.0084**
	(0.1881)	(0.3687)	(0.1889)	(0.4068)
top 3 salary of manager	0.1456***	0.2854***	0.1275***	0.2694***
	(0.0474)	(0.0930)	(0.0486)	(0.1021)
parent owner equity	0.1238***	0.2427***	0.1907***	0.4029***
	(0.0413)	(0.0824)	(0.0437)	(0.0969)
long term loan	0.0070*	0.0138*	0.0025	0.0054
	(0.0036)	(0.0072)	(0.0036)	(0.0077)
short term loan	0.0133***	0.0261***	0.0065	0.0137
	(0.0047)	(0.0093)	(0.0047)	(0.0100)
average GDP growth rate (2^{nd} sector)	-0.0646	-0.1267	-0.0784	-0.1656
	(0.2112)	(0.4142)	(0.2216)	(0.4686)
population rate	-0.029	-0.0056	-0.0037	-0.0079
	(0.0057)	(0.0112)	(0.0057)	(0.0121)
Year FE	Y	Y	Y	Y

Firm FE	Y	Y	Y	Y
constant	-3.7654*** (0.8230)		-3.1881*** (0.8175)	
N	1655	1655	1645	1655

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Next, we conduct a parallel trend test. We examine whether high-tech development zone policy contributes to an increase in firm patenting prior to the establishment. As noted above, high-tech development zone policy should contribute to firm patent growth only in the post period of the establishment of high-tech development zones.

$$y_{ijt} = \beta_0 + \beta_1 treat_{ij} \times year_{t-3} + \beta_2 treat_{ij} \times year_{t-2} + \beta_3 treat_{ij} \times year_{t-1} + \beta_4 treat_{ij} \times year_t + \beta_5 treat_{ij} \times year_{t+1} + \beta_6 treat_{ij} \times year_{t+2} + \beta_7 treat_{ij} \times year_{t+3} + \beta_8 treat_{ij} \times year_{t+4\ and\ after} + \beta_2 X_{ijt} + \beta_3 R_{jt} + \gamma T_t + \pi\alpha_i + \varepsilon_{ijt} \quad (2)$$

Figure 2 to Figure 7 provide graphical representations of the results of this parallel trend test. Figure 2 to Figure 3 show a repeat of the results in Table 11, Figure 4 to Figure 5 present a replication of the results in Table 12, while Figure 6 to Figure 7 present a replication of the results in Table 13, using a panel of three years in the pre-treatment period as well as three years and after in the post-treatment period. The controls are the same as in Table 11, Table 12, and Table 13. We interact time dummies from t-3 to t+4 and after with the dummy variable of whether a firm is treated or not. This generates a measure of the association between whether the firm get treated and firm patents over the period. We expect no positive relationship between whether a firm gets treated and firm patent differences in non-SOEs, small firms, and firms in developed regions prior to the treatment.

In most figures, in non-SOEs, small firms, and firms in developed regions, although there exist pre-trend differences, these differences are not statistically significant. The pre-trend differences may be because of the pre-announcements or news on high-tech zone plans. Starting from the first year in the post-treatment period, we begin to see an increase in firm patents associated with high-tech industrial development zone policy in non-SOEs, small firms, and developed regions. In those latter years, the association between high-tech industrial development zone policy and firm patents is still positive in most cases in non-SOEs, small firms, and developed regions, while in some cases the coefficient decreases toward zero in the fourth post-treatment year and after, indicating the effect fades over time.

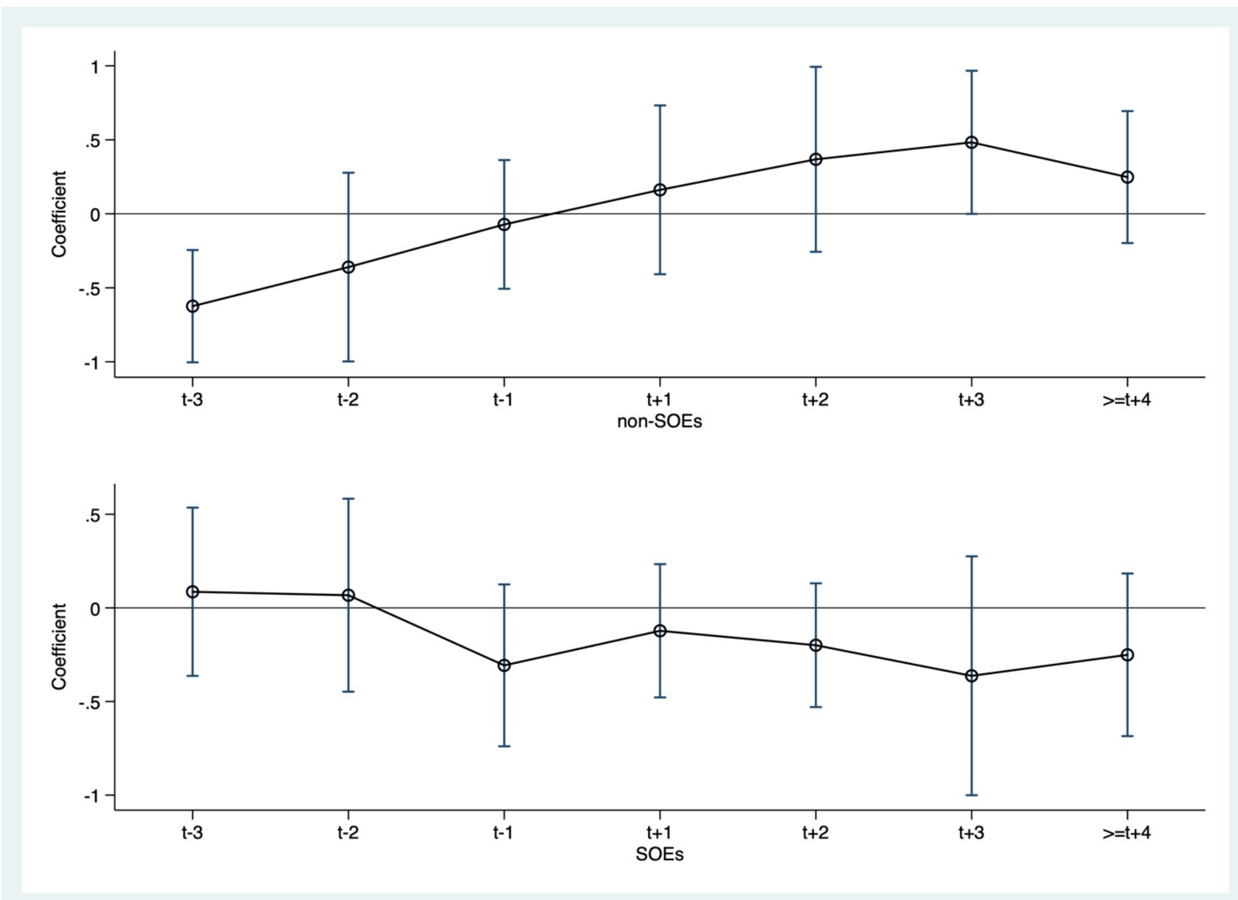

Figure 2 Impacts on Firm Patents before and after High-tech Zone Policy (Nature of Ownership)

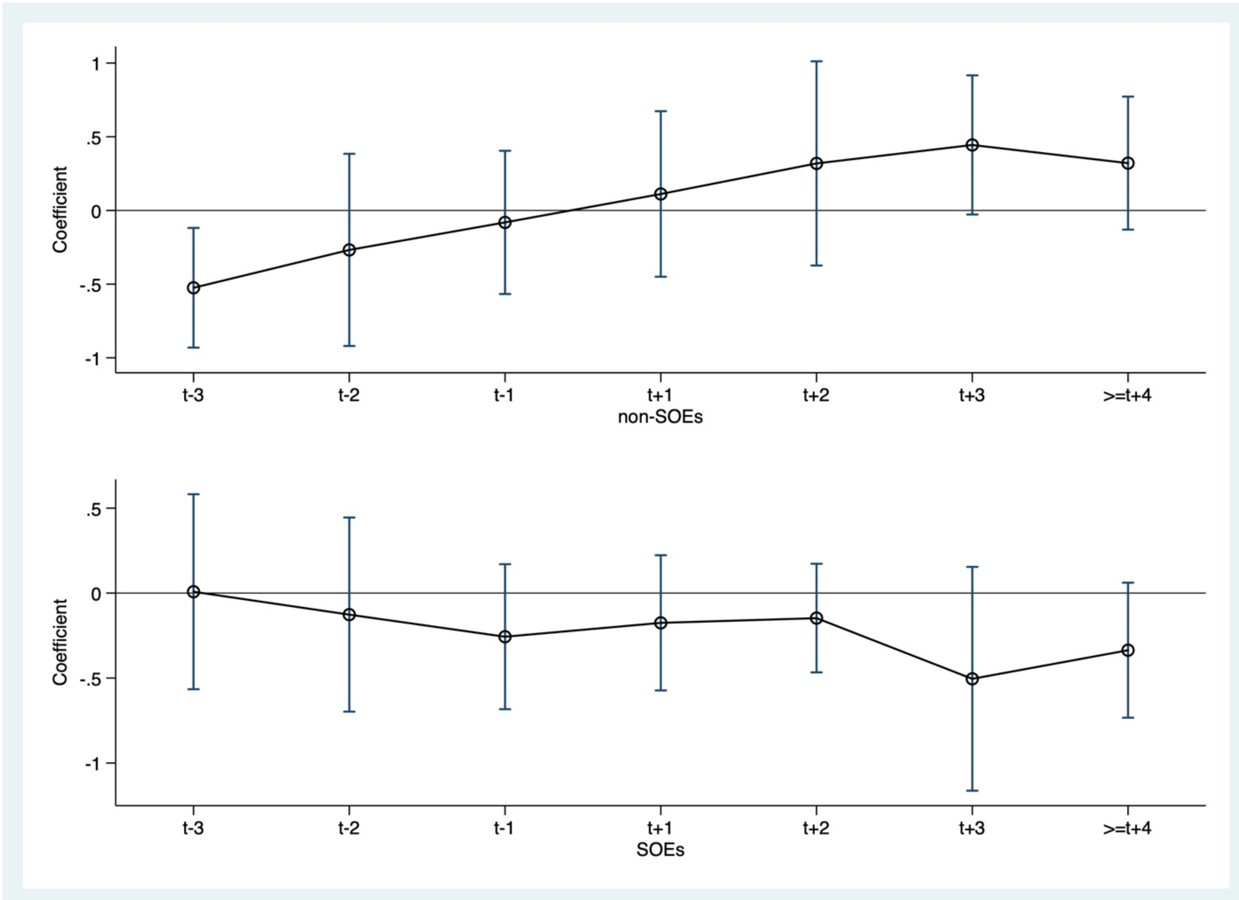

Figure 3 Impacts on Firm Invention and Utility Model Patents before and after High-tech Zone Policy

(Nature of Ownership)

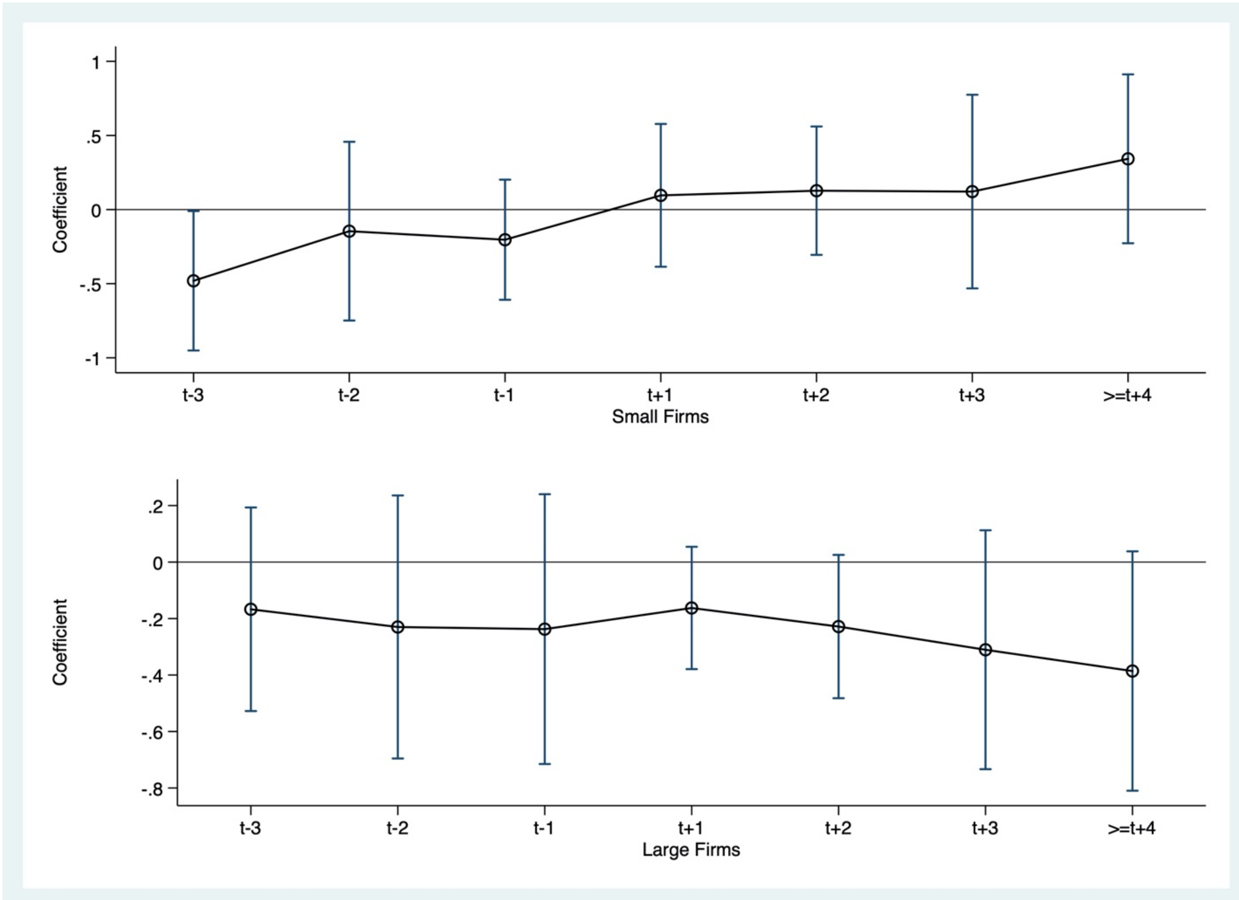

Figure 4 Impacts on Firm Patents before and after High-tech Zone Policy (Firm Size)

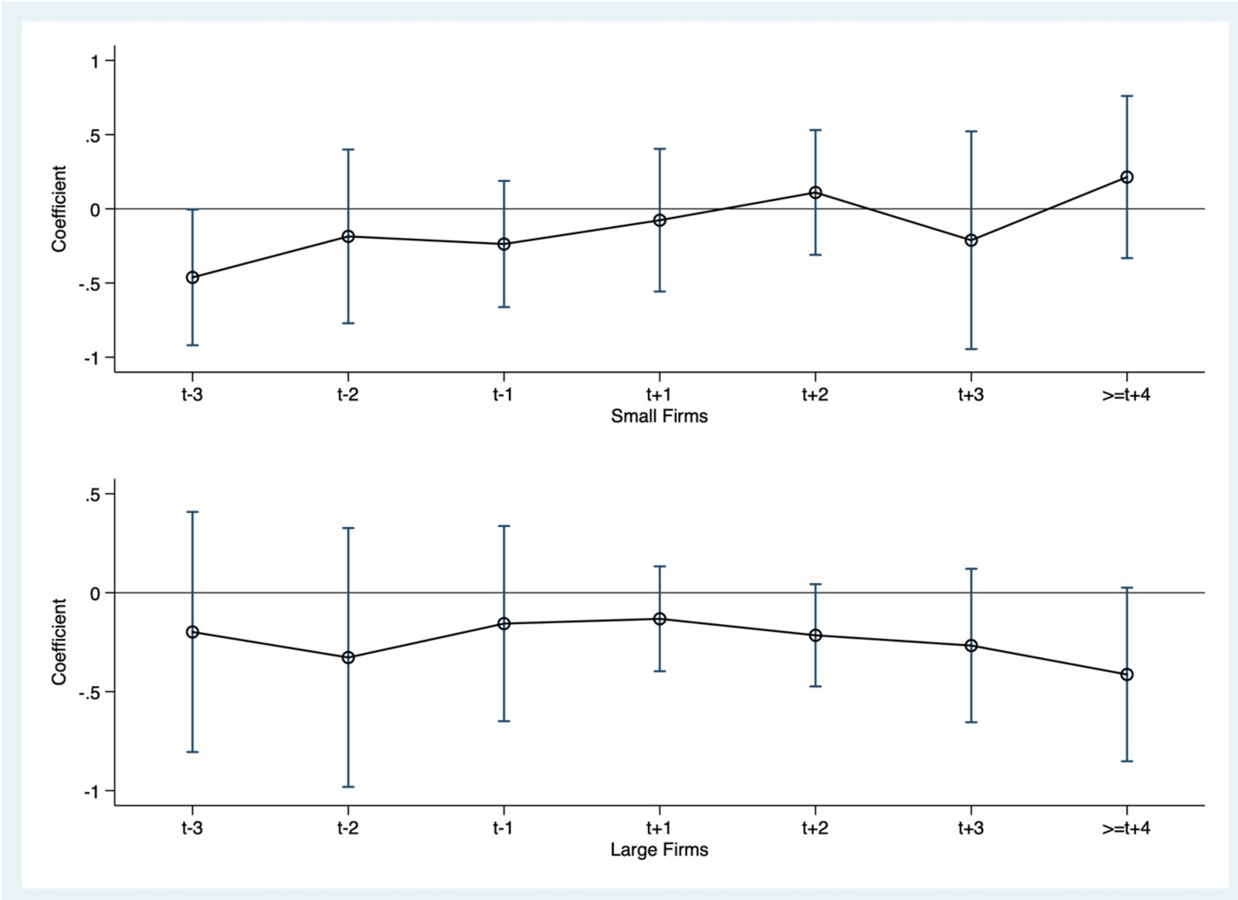

Figure 5 Impacts on Firm Invention and Utility Model Patents before and after High-tech Zone Policy

(Firm Size)

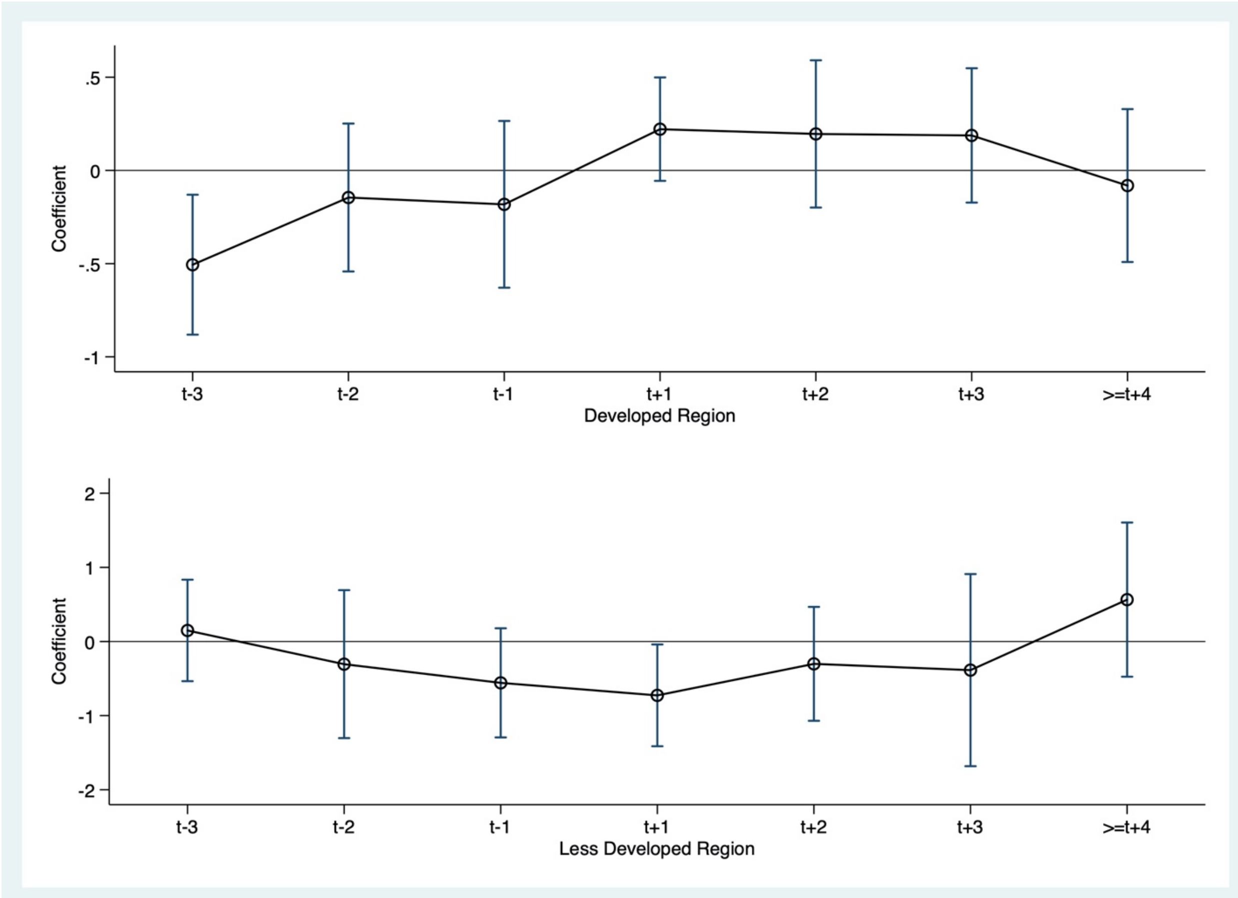

Figure 6 Impacts on Firm Patents before and after High-tech Zone Policy (Region)

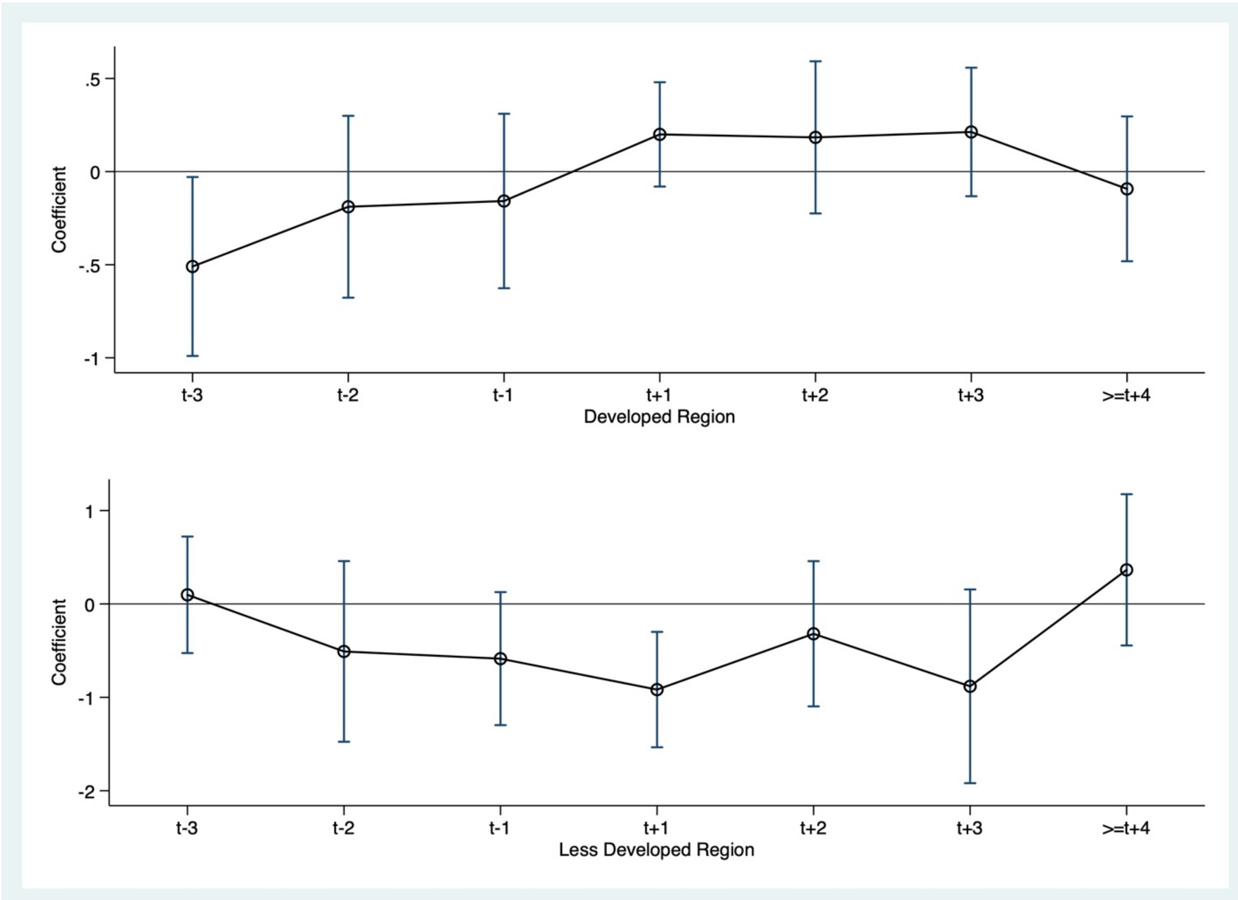

Figure 7 Impacts on Firm Invention and Utility Model Patents before and after High-tech Zone Policy (Region)

6.3 Extensions

Our analysis so far has focused on impacts in the number of firm patents, while firm innovation activities may go beyond patent quantity. We extend our research by investigating how the establishment of high-tech industrial development zones affects firm patent quality and R&D expenditure.

Patent quality is always a concern all over the world (e.g., Hall et al., 2001). In spite of the fact that China has experienced an explosive surge in terms of the number of patent applications filed, it is generally assumed by both domestic and foreign experts that patent quality could be relatively low compared to the patent quantity (e.g., Thoma, 2013; Liu et al., 2014; Dang and Motohashi, 2015). First, from the perspective of Intellectual Property Rights, one potential motivation of firms filing more patents is about patent thicket (Wen and Forman, 2016). In this way, owning more patents enables firms to have more foundations to build on and fewer constraints to be limited for their further innovation activities. Second, the number of patents filed by the firms may also serve as a market signal that the firm has strong technical foundations, while few people would dig into what the quality of these patents is. Third, since one of the score measurements of the certification of high-tech enterprises is the number of patent applications, rather than patent quality, it makes firms have incentives to focus on increasing patent quantity instead of patent quality to get benefit from high-tech industrial development zone policy. Hence, we expect that the establishment of high-tech industrial development zones may not be effective when it comes to improving patent quality in China.

To test this hypothesis, we rerun a set of regressions similar to Equation (1) by replacing the dependent variable. First, along with previous studies on Chinese patents focusing on the originality of patents, we use the number of invention patents as an alternative measurement of patent quality, since invention patents are the most original type compared with utility model patent and design patent (Yuan and Wen, 2018; Pang and Wang, 2020)[15]. We rerun the regressions for the total sample and subsamples split by owner property, firm size, and regions. The results on the log value of the number of invention patents are shown in Table 15. After limiting the number of patents to invention patents alone, although the directions of the impact of high-tech industrial development zone policy are still positive in non-SOEs, small firms, and firms in developed regions, the coefficients are not statistically significant. The insignificant

[15] We also use the share of invention patents as an alternative measure. The results are shown in the appendix and quite similar to those using the number of invention patents.

results indicate that such a program may not necessarily improve firms' capacity involved with high originality and creativity, such as new technical solutions.

Table 15 The Effect of High-tech Zone Policy on Firm Invention Patent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.1161	0.2614	-0.0566	0.1309	0.0682	0.2762	-0.1689
	(0.1576)	(0.2409)	(0.1881)	(0.1892)	(0.2057)	(0.1942)	(0.2341)
net profit	-0.0000	0.0002	-0.0001	0.0002	-0.0002	-0.0000	0.0001
	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
intangible asset	0.1203***	0.1349**	0.1098**	0.1024**	0.1549**	0.1111**	0.1656**
	(0.0297)	(0.0463)	(0.0437)	(0.0302)	(0.0474)	(0.0313)	(0.0511)
manager	0.0232	0.0301	0.0242	0.0420	0.0128	-0.0053	0.0662*
	(0.0219)	(0.0208)	(0.0348)	(0.0370)	(0.0297)	(0.0219)	(0.0375)
age	-0.2984	0.8795	-1.5206	0.5465	-0.3046	1.2415*	-1.9150
	(0.8812)	(0.8308)	(1.1206)	(0.7094)	(1.0043)	(0.6300)	(1.6911)
top 3 salary of manager	-0.0228	0.1573*	-0.1298	-0.0676	-0.0012	0.0085	-0.0073
	(0.1068)	(0.0880)	(0.1449)	(0.1128)	(0.1250)	(0.1386)	(0.1348)
parent owner equity	0.1617**	0.1944*	0.1607*	0.0718	0.3243**	0.0942	0.1889**
	(0.0672)	(0.1048)	(0.0952)	(0.0554)	(0.1450)	(0.0739)	(0.0799)
long term loan	0.0066	0.0068	0.0046	0.0096**	0.0021	0.0112*	-0.0026
	(0.0049)	(0.0057)	(0.0062)	(0.0041)	(0.0071)	(0.0055)	(0.0080)
short term loan	0.0054	0.0004	0.0061	0.0024	-0.0030	-0.0009	0.0193*
	(0.0049)	(0.0059)	(0.0080)	(0.0048)	(0.0079)	(0.0046)	(0.0107)
average GDP growth rate	-0.3014**	-0.2726***	0.3088	0.0359	0.5699	-0.4552	-0.2744**
(2^{nd} sector)	(0.0907)	(0.0539)	(1.3350)	(0.9079)	(1.0027)	(1.0262)	(0.0981)
population rate	0.0047	0.0046	0.0089	0.0058	0.0105	0.0130	0.0011
	(0.0076)	(0.0079)	(0.0124)	(0.0112)	(0.0124)	(0.0116)	(0.0098)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.3905	-3.0026**	1.8238	-0.7577	-2.2386	-0.8503	1.2633
	(1.3987)	(1.4839)	(1.8124)	(1.2372)	(2.0590)	(0.9944)	(3.0109)
N	1749	867	882	878	871	1157	592

Notes*: ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Although invention patents could partially reflect patent quality in China, patent citations is considered as a proxy variable to measure patent quality more generally (e.g., Hall et al., 2005; Qian, 2007; Moser and Nicholas, 2013), since citations reflect knowledge spillovers and can be used as indicators of the importance of individual patents (Hall et al., 2001). Therefore, we collect data on Chinese patent citations from Google Patents. Following Trajtenberg (1990), we construct citation-weighted patents as another proxy variable of patent quality to further investigate whether the establishment of high-tech industrial development zones affect firm patent quality in China. In specific, for a given firm *i* in a given year *t*, the citation-weighted patents (CWP) are calculated using the following formula,

$$CWP_{it} = \sum_{j=1}^{n_t}(1 + C_j) \qquad (3)$$

where n_t is the number of patents applied during year *t* in firm *i*, and C_j is the number of citations of patent *j* to the end of the sample period. The data is from Google Patents. The results of the total number of patent citations are shown in Table 16.

Table 16 The Effect of High-tech Zone Policy on Firm Patent Citation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.1216	0.5157*	-0.2713	0.2809	-0.1060	0.3548	0.0024
	(0.1888)	(0.2749)	(0.1922)	(0.2510)	(0.2045)	(0.2376)	(0.3108)
net profit	0.0000	0.0004	-0.0003	0.0002	-0.0001	0.0002	-0.0003
	(0.0002)	(0.0006)	(0.0003)	(0.0005)	(0.0003)	(0.0002)	(0.0003)
intangible asset	0.1444***	0.2068***	0.0876	0.1551***	0.0572	0.1111***	0.2180***
	(0.0318)	(0.0423)	(0.0551)	(0.0304)	(0.1059)	(0.0281)	(0.0601)
manager	-0.0149	-0.0196	0.0071	0.0292	-0.0380	-0.0374	0.0252
	(0.0276)	(0.0378)	(0.0437)	(0.0312)	(0.0438)	(0.0341)	(0.0404)
age	-0.5046	0.7631	-1.4754	-0.2902	0.3480	1.2095	-2.0631
	(0.9767)	(1.1109)	(1.1817)	(0.6398)	(1.5189)	(0.8784)	(1.5301)
top 3 salary of manager	0.1231	0.0955	0.2177	0.0856	0.0998	0.1445	0.1708
	(0.1149)	(0.1784)	(0.1538)	(0.1373)	(0.1714)	(0.1670)	(0.1316)
parent owner equity	0.1588**	0.1490	0.1692	0.0531	0.2707*	0.0785	0.1971**
	(0.0641)	(0.1085)	(0.1082)	(0.0870)	(0.1420)	(0.0541)	(0.0869)
long term loan	0.0131*	0.0077	0.0167**	0.0166**	0.0114	0.0214**	-0.0036
	(0.0072)	(0.0084)	(0.0077)	(0.0062)	(0.0107)	(0.0093)	(0.0093)
short term loan	0.0062	0.0030	0.0070	0.0015	-0.0046	-0.0017	0.0278**
	(0.0056)	(0.0083)	(0.0080)	(0.0053)	(0.0135)	(0.0070)	(0.0089)
average GDP growth rate (2^{nd} sector)	-0.1369	-0.2320*	1.2739	1.8070*	0.7220	1.1585	-0.1767
	(0.1751)	(0.1171)	(1.4731)	(1.0666)	(1.3015)	(0.7300)	(0.1073)
population rate	-0.0016	0.0003	0.0002	0.0007	0.0010	0.0050	0.0030
	(0.0095)	(0.0119)	(0.0167)	(0.0136)	(0.0125)	(0.0161)	(0.0127)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.4197	-1.9939	0.2232	-0.0308	-2.9431	-0.6953	0.6552
	(1.7081)	(1.9095)	(2.1537)	(1.2156)	(3.3792)	(1.4324)	(3.0862)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Similar to the distribution of the number of patents, the number of patent citations also reveals the features of a great many of zero values and a very long tail distribution. The distributions of the number of patent citations at both the patent level and the firm level are shown in Table 17. Both panels show a zero median value of the number of patent citations. Following Kleis et al. (2012), we construct variables to measure citation counts above a certain percentile threshold so as to investigate the impact on high-cited patents. Based on the distribution of patent citations in our data, the percentiles of patent citations below 50% are basically 0. Thus, we consider the citation counts using above 75th percentile, 90th percentile, 95th percentile, and 99th percentile of the overall patents within the sample. The corresponding results are shown in Table 18, Table 19, Table 20, and Table 21, respectively.

Table 17 Distributions of Patent Citation

Panel A: patent level				
	Percentiles	Smallest	Obs	41,300
1%	0	0	Sum of Wgt.	41,300
5%	0	0	Mean	1.888
10%	0	0	Std. Dev.	3.709
25%	0	0	Variance	13.756
50%	0		Skewness	4.565
		Largest	Kurtosis	39.212
75%	2	61		
90%	5	62		
95%	8	68		
99%	17	77		
Panel B: firm level				
	Percentiles	Smallest	Obs	1,900
1%	0	0	Sum of Wgt.	1,900
5%	0	0	Mean	40.286
10%	0	0	Std. Dev.	171.261
25%	0	0	Variance	29330.26
50%	0		Skewness	10.427

		Largest	Kurtosis	142.232
75%	19	2180		
90%	74.5	2324		
95%	183.5	2809		
99%	620.5	3063		

Table 18 The Effect of High-tech Zone Policy on Firm Patent Citation (above 75th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0974	-0.0235	-0.2318	-0.0801	-0.0306	-0.0255	-0.3659*
	(0.1620)	(0.2266)	(0.1838)	(0.1895)	(0.2362)	(0.2024)	(0.1858)
net profit	0.0002	0.0007	-0.0000	0.0001	0.0003	0.0004*	0.0000
	(0.0002)	(0.0004)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)
intangible asset	0.0285	0.0388	0.0252	0.0409**	-0.0019	0.0382*	0.0157
	(0.0177)	(0.0261)	(0.0310)	(0.0183)	(0.0360)	(0.0208)	(0.0304)
manager	-0.0142	-0.0210	-0.0078	0.0086	-0.0481*	-0.0175	-0.0149
	(0.0209)	(0.0362)	(0.0256)	(0.0283)	(0.0281)	(0.0293)	(0.0261)
age	0.8992**	1.6554**	0.4668	0.0070	2.5315***	1.9917***	0.4515
	(0.4173)	(0.6723)	(0.4813)	(0.2561)	(0.5882)	(0.3861)	(0.6201)
top 3 salary of manager	0.0919	0.0907	0.1157	0.1898**	0.0435	0.0683	0.1307
	(0.0880)	(0.1385)	(0.0821)	(0.0851)	(0.1275)	(0.1487)	(0.0890)
parent owner equity	0.0371	0.0480	0.0285	0.0162	0.0784	0.0485	0.0290
	(0.0253)	(0.0645)	(0.0533)	(0.0415)	(0.0562)	(0.0378)	(0.0382)
long term loan	0.0047*	0.0040	0.0031	0.0023	0.0097**	0.0045	0.0048
	(0.0025)	(0.0040)	(0.0033)	(0.0028)	(0.0044)	(0.0033)	(0.0043)
short term loan	0.0002	-0.0058	0.0054	0.0004	0.0016	-0.0022	0.0061
	(0.0032)	(0.0059)	(0.0050)	(0.0033)	(0.0093)	(0.0037)	(0.0057)
average GDP growth rate (2^{nd} sector)	-0.1677**	-0.1453*	0.3610	0.2367	-0.8598	-1.4917**	-0.1198*
	(0.0614)	(0.0746)	(0.7957)	(0.4354)	(0.7299)	(0.6652)	(0.0626)
population rate	0.0098	0.0000	0.0234*	0.0055	0.0166	0.0232*	0.0043
	(0.0071)	(0.0074)	(0.0127)	(0.0055)	(0.0119)	(0.0135)	(0.0068)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-1.9460**	-2.9910**	-1.6456	-0.8999*	-5.7792***	-1.8759**	-1.8452
	(0.9180)	(0.8723)	(1.1909)	(0.4910)	(1.6205)	(0.7055)	(1.5776)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 19 The Effect of High-tech Zone Policy on Firm Patent Citation (above 90th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0348	0.0632	-0.1560	0.0471	-0.0275	0.0433	-0.2097*
	(0.1297)	(0.1710)	(0.1131)	(0.1303)	(0.1476)	(0.1720)	(0.1222)
net profit	0.0002*	0.0005	0.0000	0.0002**	0.0003	0.0004**	-0.0000
	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
intangible asset	0.0141	0.0173	0.0179	0.0259	-0.0325	0.0129	0.0166
	(0.0142)	(0.0206)	(0.0226)	(0.0162)	(0.0317)	(0.0192)	(0.0201)
manager	-0.0152	-0.0237	-0.0107	-0.0001	-0.0308	-0.0181	-0.0127
	(0.0136)	(0.0254)	(0.0225)	(0.0133)	(0.0239)	(0.0170)	(0.0247)
age	0.3432	1.1465*	-0.1648	-0.2756	1.4265*	0.9546**	0.1123
	(0.3475)	(0.5812)	(0.3193)	(0.2646)	(0.8063)	(0.4621)	(0.4721)
top 3 salary of manager	0.0484	0.0180	0.0819	0.1223**	-0.0172	0.0473	0.0642
	(0.0518)	(0.0947)	(0.0607)	(0.0595)	(0.0881)	(0.0950)	(0.0467)
parent owner equity	0.0332*	0.0398	0.0289	0.0088	0.0385	0.0477*	0.0174
	(0.0175)	(0.0430)	(0.0357)	(0.0327)	(0.0449)	(0.0274)	(0.0256)
long term loan	0.0032	0.0013	0.0037	0.0026	0.0066	0.0028	0.0036
	(0.0025)	(0.0033)	(0.0027)	(0.0025)	(0.0041)	(0.0032)	(0.0032)
short term loan	0.0012	-0.0013	0.0027	-0.0005	0.0058	0.0002	0.0035
	(0.0024)	(0.0045)	(0.0032)	(0.0026)	(0.0100)	(0.0032)	(0.0032)
average GDP growth rate (2^{nd} sector)	-0.1527***	-0.1302**	0.3044	0.5699	-0.7083	-0.5577	-0.1368**
	(0.0426)	(0.0419)	(0.7669)	(0.3541)	(0.7033)	(0.5405)	(0.0476)
population rate	0.0054	0.0000	0.0111	0.0032	0.0088	0.0168*	0.0004
	(0.0048)	(0.0053)	(0.0081)	(0.0040)	(0.0085)	(0.0092)	(0.0049)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.8890	-1.8875**	-0.4272	-0.1520	-3.1812	-0.9895	-0.8368
	(0.7708)	(0.7970)	(0.8244)	(0.4963)	(1.9207)	(0.7665)	(1.1797)

N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 20 The Effect of High-tech Zone Policy on Firm Patent Citation (above 95th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0175	0.0495	-0.1035	0.0825	-0.0464	0.0538	-0.1415
	(0.1180)	(0.1469)	(0.0997)	(0.0943)	(0.1529)	(0.1581)	(0.1128)
net profit	0.0002	0.0004	0.0000	0.0002**	0.0002	0.0004**	-0.0001
	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
intangible asset	0.0167	0.0252	0.0151	0.0257*	-0.0237	0.0141	0.0200
	(0.0116)	(0.0164)	(0.0214)	(0.0132)	(0.0260)	(0.0160)	(0.0160)
manager	-0.0199*	-0.0357	-0.0082	-0.0023	-0.0328	-0.0223	-0.0176
	(0.0115)	(0.0240)	(0.0171)	(0.0071)	(0.0209)	(0.0155)	(0.0182)
age	0.1298	0.9398*	-0.3196	-0.3630	1.0760	0.4110	0.2955
	(0.3113)	(0.4898)	(0.3586)	(0.2275)	(0.8158)	(0.5024)	(0.4646)
top 3 salary of manager	0.0211	-0.0226	0.0608	0.0702**	-0.0667	0.0541	0.0034
	(0.0401)	(0.0753)	(0.0581)	(0.0311)	(0.0934)	(0.0664)	(0.0400)
parent owner equity	0.0154	0.0068	0.0177	-0.0069	0.0161	0.0027	0.0307
	(0.0133)	(0.0304)	(0.0238)	(0.0264)	(0.0342)	(0.0211)	(0.0225)
long term loan	0.0021	-0.0005	0.0041	0.0027	0.0031	0.0023	0.0008
	(0.0022)	(0.0027)	(0.0025)	(0.0020)	(0.0037)	(0.0028)	(0.0024)
short term loan	-0.0003	-0.0034	0.0021	-0.0010	-0.0011	-0.0005	0.0018
	(0.0016)	(0.0032)	(0.0026)	(0.0021)	(0.0089)	(0.0024)	(0.0025)
average GDP growth rate (2nd sector)	-0.0957**	-0.1112**	0.4411	0.2741	-0.4234	-0.5542	-0.0783
	(0.0367)	(0.0330)	(0.8355)	(0.2437)	(0.7019)	(0.5667)	(0.0470)
population rate	0.0020	-0.0006	0.0044	-0.0015	0.0063	0.0059	0.0005
	(0.0036)	(0.0039)	(0.0067)	(0.0031)	(0.0065)	(0.0069)	(0.0037)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.2978	-1.1382*	-0.0480	0.3318	-1.9536	-0.2530	-0.8805
	(0.6343)	(0.6430)	(0.7775)	(0.3800)	(1.7574)	(0.7351)	(1.0697)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 21 The Effect of High-tech Zone Policy on Firm Patent Citation (above 99th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0969	-0.1364	-0.0827	-0.0258	-0.0834	-0.0928	-0.0578
	(0.0679)	(0.0831)	(0.0677)	(0.0379)	(0.1029)	(0.0902)	(0.0694)
net profit	0.0001	0.0002	-0.0000	0.0000	0.0001	0.0002	-0.0002
	(0.0001)	(0.0002)	(0.0001)	(0.0000)	(0.0002)	(0.0001)	(0.0001)
intangible asset	0.0010	-0.0035	0.0061	0.0013	-0.0259	-0.0009	0.0021
	(0.0060)	(0.0104)	(0.0080)	(0.0045)	(0.0245)	(0.0088)	(0.0045)
manager	-0.0139**	-0.0273*	-0.0039	0.0004	-0.0213**	-0.0167**	-0.0103
	(0.0058)	(0.0143)	(0.0073)	(0.0032)	(0.0095)	(0.0082)	(0.0073)
age	0.0739	0.6259	-0.2364	-0.2717**	0.7453	0.2121	0.1557
	(0.2120)	(0.3957)	(0.2580)	(0.1101)	(0.5047)	(0.3486)	(0.2332)
top 3 salary of manager	0.0012	-0.0230	0.0180	0.0099	-0.0467	0.0187	0.0010
	(0.0184)	(0.0461)	(0.0242)	(0.0122)	(0.0465)	(0.0295)	(0.0121)
parent owner equity	0.0115	0.0148	0.0125	0.0002	0.0186	0.0150	0.0178
	(0.0103)	(0.0161)	(0.0175)	(0.0042)	(0.0328)	(0.0156)	(0.0152)
long term loan	-0.0003	-0.0014	0.0011	0.0013	-0.0010	-0.0013	0.0007
	(0.0015)	(0.0015)	(0.0018)	(0.0010)	(0.0030)	(0.0019)	(0.0007)
short term loan	-0.0014	-0.0028**	-0.0006	-0.0009	-0.0035	-0.0024	0.0017
	(0.0010)	(0.0013)	(0.0014)	(0.0008)	(0.0035)	(0.0015)	(0.0014)
average GDP growth rate (2nd sector)	-0.0158	-0.0086	-0.0069	0.0832	-0.0902	-0.2574	-0.0002
	(0.0244)	(0.0208)	(0.4730)	(0.1665)	(0.5146)	(0.5352)	(0.0128)
population rate	0.0001	0.0000	-0.0008	0.0003	0.0002	0.0006	0.0013

	(0.0015)	(0.0016)	(0.0029)	(0.0011)	(0.0031)	(0.0037)	(0.0012)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.1359	-0.8278	0.1479	0.4044**	-1.2699	-0.1265	-0.5116
	(0.4050)	(0.5967)	(0.5014)	(0.1682)	(1.0389)	(0.4973)	(0.5836)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively*.
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

For the 90th percentile and 95th percentile, the estimated coefficients are directionally similar to the findings in the main results in section 6.1, while the standard errors are large. This may be due to specifying a small part of the patent distribution. For the 75th percentile and 99th percentile, the results do not show a clear pattern. In summary, the overall results above show that the establishment of high-tech industrial development zones does not have a significant positive impact on firm patent quality. In addition to firms paying more attention to patent quantity rather than patent quality, another possible explanation of the increase in patent quantity while not in patent quality is because of the changes in the distributions of patents across industries. Previous studies find that patent citations are relatively high in some industries, while relatively low in others (e.g., Gilbert et al., 2003). We present both the proportion of each industry among the total patents each year and the average patent citations in each industry in each year in our data in Table 22. The industries are grouped based on the patent classification in Cooperative Patent Classification (CPC). Table 19 shows that the shares of "Operations and Transport", "Textile", and "Electricity" are generally increasing over time, while the average number of citations of these categories has decreased since 2009, which indicates that the overall insignificant impact on increasing patent citations could be because the industries having increasingly large proportions in the total patents have a decrease in citations. Moreover, since the average number of citations in other industries has decreased after 2009, the right truncation in the years after 2009 may also be a concern for our results. Unfortunately, it is not feasible to limit the sample period till 2009 since it will leave few treated firms and a short post-treatment period. As an additional robustness check to the right truncation problem, we try to only use the first five-year forward citations to circumvent the potential problem that recent patents may have fewer citations than past patents because of different time lengths.

Table 22 Patent Share and Average Patent Citation by Patent Classification

Panel A: patent share								
year	Human Necessities	Operations and Transport	Chemistry and Metallurgy	Textiles	Fixed Constructions	Mechanical Engineering	Physics	Electricity
1999	1.63%	14.63%	15.45%	0.00%	0.00%	30.08%	30.08%	8.13%
2000	2.48%	24.38%	18.18%	0.00%	8.26%	22.31%	17.36%	7.02%
2001	5.18%	31.10%	13.72%	0.00%	3.66%	21.95%	15.55%	8.84%
2002	8.59%	25.57%	15.27%	0.19%	5.53%	19.27%	16.79%	8.78%
2003	12.43%	28.37%	17.16%	0.88%	4.55%	13.66%	10.68%	12.26%
2004	5.06%	25.44%	20.11%	0.68%	5.47%	7.80%	14.77%	20.66%
2005	6.03%	25.19%	18.66%	1.00%	3.93%	5.19%	17.07%	22.93%
2006	5.21%	21.72%	21.78%	0.73%	2.80%	8.12%	12.54%	27.10%
2007	6.35%	21.92%	16.99%	0.55%	2.97%	7.08%	16.39%	27.76%
2008	8.75%	20.13%	16.45%	0.95%	4.34%	8.39%	15.49%	25.49%
2009	7.72%	21.82%	15.19%	0.89%	3.90%	9.10%	20.70%	20.67%
2010	7.35%	25.41%	15.03%	0.98%	6.09%	10.06%	15.58%	19.51%
2011	6.99%	31.52%	13.98%	1.06%	8.38%	11.24%	12.88%	13.96%
2012	4.80%	29.74%	15.14%	1.09%	9.90%	13.06%	13.45%	12.82%
2013	5.22%	31.18%	17.80%	1.35%	6.72%	8.58%	12.66%	16.50%
2014	4.72%	32.02%	17.71%	1.81%	5.89%	9.47%	13.66%	14.71%
2015	5.18%	32.66%	16.24%	1.26%	4.03%	7.92%	14.17%	18.53%
2016	5.24%	34.29%	14.20%	1.15%	3.85%	8.22%	16.11%	16.93%

Panel B: avg. number of citations								
year	Human Necessities	Operations and Transport	Chemistry and Metallurgy	Textiles	Fixed Constructions	Mechanical Engineering	Physics	Electricity
1999	2	1.909	2	0	0	2.75	2.406	1.556
2000	3	3.085	3.909	0	2.05	3.185	3.139	3.353
2001	1.647	3.951	4.511	0	3.417	3.778	3.02	1.586
2002	3.156	4.157	3.4	10	3.655	2.327	2.852	0.826
2003	2.612	2.704	3.51	9.8	2.5	2.962	2.525	1.729
2004	6.838	3.366	3.503	6.6	4.3	2.07	2.694	3.596
2005	3.028	4.113	3.857	5.917	2.767	2.726	3.912	2.339
2006	2.333	3.938	4.625	3.385	3.44	2.69	4.152	2.725
2007	4.367	3.879	5.11	3.667	3.4	3.477	4.028	3.447
2008	3.895	4.168	4.966	5.586	3.182	3.114	4.393	3.175
2009	2.878	3.374	4.748	4.057	4.183	3.353	3.878	3.3
2010	2.557	2.93	3.837	2.271	3.334	2.747	3.507	3.18
2011	2.295	2.485	3.286	3.439	2.102	2.038	3.449	2.944
2012	1.385	2.027	3.071	2.535	1.852	1.9	2.446	2.538
2013	1.287	1.613	2.325	2.6	1.409	1.12	2.233	1.857
2014	0.874	1.367	1.757	1.757	1.625	1.207	1.469	1.591
2015	0.747	0.982	1.374	1.247	1.069	0.716	1.382	1.227
2016	0.373	0.666	0.783	0.939	0.62	0.446	0.714	0.637

We redo the regressions above for the total sample, above 75th percentile, 90th percentile, 95th percentile, and 99th percentile of the overall patents within the sample, and the corresponding results are shown in Table 23, Table 24, Table 25, Table 26, and Table 27, respectively. The coefficients in those tables are similar to the previous analyses using citations to the end of the sample year, which do not show a clear pattern of a significant positive impact on firm high-quality patents.

Table 23 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.1563	0.6744*	-0.2920	0.3285	-0.1607	0.4187	0.1510
	(0.2099)	(0.3431)	(0.2295)	(0.2768)	(0.2868)	(0.2752)	(0.3008)
net profit	-0.0000	-0.0001	-0.0000	0.0005	-0.0001	0.0002	-0.0002
	(0.0003)	(0.0007)	(0.0003)	(0.0005)	(0.0004)	(0.0004)	(0.0004)
intangible asset	0.1421***	0.2258**	0.0570	0.1609***	0.0547	0.1038**	0.2099**
	(0.0367)	(0.0659)	(0.0585)	(0.0388)	(0.0886)	(0.0368)	(0.0701)
manager	-0.0326	-0.0291	-0.0024	-0.0085	-0.0218	-0.0586	0.0194
	(0.0349)	(0.0492)	(0.0561)	(0.0301)	(0.0572)	(0.0435)	(0.0447)
age	-1.8162*	-1.4585	-2.0775	-1.1351	-2.3109	-0.9399	-3.2321**
	(0.9922)	(1.3676)	(1.3014)	(0.7266)	(2.1881)	(1.2780)	(1.4846)
top 3 salary of manager	0.1113	-0.0733	0.3443**	0.0429	0.0119	0.1176	0.1675
	(0.1313)	(0.2125)	(0.1567)	(0.1796)	(0.1734)	(0.2054)	(0.1278)
parent owner equity	0.2195**	0.2180**	0.2116**	0.0886	0.3353**	0.1850**	0.1991**
	(0.0673)	(0.1032)	(0.1026)	(0.0901)	(0.1495)	(0.0639)	(0.0891)
long term loan	0.0094	0.0015	0.0173*	0.0104	0.0107	0.0135	0.0026
	(0.0083)	(0.0096)	(0.0088)	(0.0065)	(0.0137)	(0.0119)	(0.0107)
short term loan	0.0084	0.0120	0.0049	0.0024	0.0015	0.0037	0.0186
	(0.0073)	(0.0099)	(0.0095)	(0.0048)	(0.0202)	(0.0099)	(0.0117)
average GDP growth rate (2^{nd} sector)	-0.0757	-0.2360	1.1715	1.2942	1.5835	3.2385**	-0.1910*
	(0.1968)	(0.1501)	(1.8278)	(1.2047)	(1.6445)	(1.5499)	(0.1097)
population rate	-0.0202	-0.0217	-0.0157	-0.0110	-0.0220	-0.0271	-0.0058
	(0.0130)	(0.0178)	(0.0185)	(0.0159)	(0.0164)	(0.0250)	(0.0138)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	1.4457	2.1016	0.4467	1.5285	1.5470	0.9355	2.8826
	(1.8315)	(2.6218)	(2.3602)	(1.5372)	(4.4021)	(1.9890)	(3.0762)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 24 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 75^{th} percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0582	0.0093	-0.1773	-0.1314	0.1188	0.0013	-0.1076
	(0.1376)	(0.1030)	(0.1936)	(0.1130)	(0.2301)	(0.1759)	(0.1662)
net profit	0.0001	0.0006	-0.0002	0.0003**	0.0002	0.0005*	-0.0004
	(0.0003)	(0.0004)	(0.0003)	(0.0001)	(0.0003)	(0.0003)	(0.0005)
intangible asset	0.0097	0.0031	0.0301	0.0143	-0.0363	0.0087	0.0127
	(0.0156)	(0.0311)	(0.0289)	(0.0114)	(0.0501)	(0.0226)	(0.0239)
manager	-0.0139	-0.0236	-0.0086	0.0203	-0.0481	-0.0150	-0.0049
	(0.0209)	(0.0383)	(0.0340)	(0.0175)	(0.0398)	(0.0280)	(0.0264)
age	0.0781	0.8651	-0.3356	-0.4342	1.0158	0.2487	0.5173
	(0.3544)	(0.7178)	(0.5060)	(0.3973)	(1.0610)	(0.5372)	(0.7124)
top 3 salary of manager	0.0704	-0.0442	0.1741*	0.1207	-0.0416	0.0458	0.1044
	(0.0778)	(0.1329)	(0.0895)	(0.0863)	(0.1443)	(0.1116)	(0.0819)
parent owner equity	0.0333	0.0108	0.0490	-0.0118	0.0928*	0.0396	0.0471
	(0.0245)	(0.0449)	(0.0417)	(0.0291)	(0.0481)	(0.0381)	(0.0444)
long term loan	0.0022	-0.0007	0.0044	0.0005	0.0046	0.0016	0.0024
	(0.0037)	(0.0039)	(0.0055)	(0.0028)	(0.0072)	(0.0053)	(0.0036)
short term loan	-0.0009	-0.0041	0.0022	0.0002	-0.0057	-0.0005	-0.0001
	(0.0042)	(0.0068)	(0.0042)	(0.0038)	(0.0182)	(0.0057)	(0.0047)
average GDP growth rate (2^{nd} sector)	-0.1654**	-0.1906**	0.6404	0.2456	-0.2838	-1.3675	-0.1363**
	(0.0528)	(0.0560)	(1.3092)	(0.4632)	(1.0825)	(0.8214)	(0.0662)
population rate	-0.0022	-0.0139**	0.0107	-0.0014	-0.0007	0.0059	-0.0027
	(0.0076)	(0.0069)	(0.0137)	(0.0048)	(0.0132)	(0.0143)	(0.0064)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.3051	-0.6605	-0.6033	0.2782	-1.9321	0.1088	-1.6118

	(0.7122)	(1.0145)	(1.0965)	(0.7406)	(2.0553)	(0.6090)	(1.7291)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 25 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 90th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0849	0.0097	-0.2051	-0.0226	-0.0230	-0.0286	-0.1367
	(0.1026)	(0.0642)	(0.1354)	(0.0604)	(0.1633)	(0.1323)	(0.1267)
net profit	0.0002	0.0005	-0.0001	0.0002**	0.0002	0.0004*	-0.0003
	(0.0002)	(0.0003)	(0.0002)	(0.0001)	(0.0003)	(0.0002)	(0.0003)
intangible asset	0.0059	0.0110	0.0095	0.0177*	-0.0487**	0.0010	0.0164
	(0.0100)	(0.0201)	(0.0197)	(0.0094)	(0.0242)	(0.0144)	(0.0167)
manager	-0.0192	-0.0347	-0.0063	0.0004	-0.0376	-0.0236	-0.0067
	(0.0128)	(0.0242)	(0.0213)	(0.0077)	(0.0241)	(0.0152)	(0.0167)
age	-0.0057	0.6541	-0.3375	-0.3097	0.6562	0.1805	0.1645
	(0.2914)	(0.5139)	(0.4039)	(0.2025)	(0.8089)	(0.4728)	(0.4842)
top 3 salary of manager	0.0305	-0.0748	0.1271**	0.0653	-0.0460	0.0194	0.0606*
	(0.0473)	(0.0915)	(0.0503)	(0.0536)	(0.0887)	(0.0706)	(0.0352)
parent owner equity	0.0241	-0.0022	0.0334	-0.0132	0.0584	0.0181	0.0416
	(0.0169)	(0.0317)	(0.0277)	(0.0198)	(0.0494)	(0.0239)	(0.0309)
long term loan	0.0014	0.0004	0.0015	0.0010	0.0037	0.0013	0.0004
	(0.0030)	(0.0038)	(0.0032)	(0.0017)	(0.0059)	(0.0044)	(0.0025)
short term loan	-0.0002	-0.0013	0.0002	0.0006	-0.0033	0.0003	0.0005
	(0.0030)	(0.0047)	(0.0028)	(0.0021)	(0.0123)	(0.0042)	(0.0030)
average GDP growth rate (2nd sector)	-0.1431***	-0.1747***	0.1858	0.2200	-0.6295	-0.9629	-0.1259**
	(0.0329)	(0.0439)	(0.8742)	(0.2470)	(0.7448)	(0.6544)	(0.0409)
population rate	-0.0002	-0.0055	0.0051	-0.0018	0.0044	0.0005	0.0016
	(0.0046)	(0.0044)	(0.0078)	(0.0030)	(0.0077)	(0.0092)	(0.0039)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.0682	-0.3360	-0.2329	0.2972	-1.1052	0.2008	-0.8811
	(0.5553)	(0.6420)	(0.8386)	(0.3800)	(1.6382)	(0.6204)	(1.1276)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 26 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 95th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0873	-0.0770	-0.1211	-0.0175	-0.0861	-0.0489	-0.1016
	(0.0835)	(0.0752)	(0.0992)	(0.0442)	(0.1497)	(0.1103)	(0.0963)
net profit	0.0001	0.0004	-0.0000	0.0001*	0.0002	0.0003**	-0.0002
	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0002)
intangible asset	0.0051	0.0098	0.0046	0.0140*	-0.0416	0.0040	0.0102
	(0.0081)	(0.0165)	(0.0135)	(0.0076)	(0.0276)	(0.0113)	(0.0119)
manager	-0.0243**	-0.0359*	-0.0141	-0.0081	-0.0368**	-0.0315**	-0.0118
	(0.0084)	(0.0186)	(0.0140)	(0.0055)	(0.0151)	(0.0098)	(0.0091)
age	0.0123	0.5023	-0.2250	-0.3687**	0.6957	0.2154	-0.0179
	(0.2178)	(0.4441)	(0.3264)	(0.1517)	(0.5756)	(0.3595)	(0.2706)
top 3 salary of manager	0.0039	-0.0655	0.0632*	0.0336*	-0.0570	0.0197	0.0125
	(0.0260)	(0.0646)	(0.0318)	(0.0170)	(0.0525)	(0.0395)	(0.0274)
parent owner equity	0.0185	-0.0038	0.0324	-0.0017	0.0350	0.0081	0.0356*
	(0.0126)	(0.0246)	(0.0220)	(0.0164)	(0.0459)	(0.0197)	(0.0206)
long term loan	0.0001	-0.0019	0.0018	0.0007	0.0004	-0.0011	0.0014
	(0.0020)	(0.0029)	(0.0019)	(0.0011)	(0.0039)	(0.0027)	(0.0015)
short term loan	-0.0003	-0.0011	0.0000	0.0011	-0.0048	0.0001	-0.0008
	(0.0020)	(0.0028)	(0.0022)	(0.0014)	(0.0068)	(0.0028)	(0.0026)
average GDP growth rate	-0.0926**	-0.1106**	-0.1677	-0.0671	-0.5203	-0.5575	-0.0767**

(2nd sector)	(0.0307)	(0.0321)	(0.5186)	(0.1785)	(0.4955)	(0.5838)	(0.0278)
population rate	0.0002	-0.0036	0.0042	-0.0015	0.0031	-0.0014	0.0028
	(0.0027)	(0.0029)	(0.0044)	(0.0021)	(0.0049)	(0.0053)	(0.0027)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	0.0216	-0.2071	-0.0796	0.4859*	-0.9137	0.0911	-0.2943
	(0.4007)	(0.5904)	(0.7008)	(0.2657)	(1.2799)	(0.4431)	(0.6925)
N	1749	867	882	878	871	1157	592

Notes*: ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table 27 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 99th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0760	-0.1440*	-0.0404	0.0000	-0.0901	-0.0901	0.0160
	(0.0592)	(0.0784)	(0.0564)	(0.0163)	(0.0935)	(0.0748)	(0.0124)
net profit	0.0000	0.0001	-0.0000	-0.0000	0.0000	0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
intangible asset	0.0040	0.0089	0.0001	0.0063**	-0.0110	0.0066	0.0010
	(0.0038)	(0.0093)	(0.0058)	(0.0031)	(0.0149)	(0.0057)	(0.0036)
manager	-0.0103**	-0.0215*	-0.0005	-0.0021	-0.0114**	-0.0145**	-0.0031
	(0.0043)	(0.0112)	(0.0054)	(0.0020)	(0.0054)	(0.0055)	(0.0037)
age	0.2227	0.6247*	0.0998	-0.0948	0.7899**	0.4523*	0.0944
	(0.1515)	(0.3420)	(0.1760)	(0.0640)	(0.3508)	(0.2271)	(0.0974)
top 3 salary of manager	-0.0071	-0.0339	0.0122	0.0040	-0.0454	-0.0066	0.0104
	(0.0155)	(0.0370)	(0.0103)	(0.0069)	(0.0326)	(0.0247)	(0.0124)
parent owner equity	0.0141	0.0013	0.0229	-0.0018	0.0297	0.0173	0.0143
	(0.0086)	(0.0136)	(0.0148)	(0.0036)	(0.0285)	(0.0125)	(0.0114)
long term loan	-0.0015	-0.0019	-0.0012	-0.0003	-0.0020	-0.0026*	-0.0001
	(0.0011)	(0.0013)	(0.0013)	(0.0006)	(0.0024)	(0.0015)	(0.0003)
short term loan	-0.0012	-0.0018	-0.0012	-0.0008	-0.0032	-0.0019	0.0001
	(0.0010)	(0.0016)	(0.0014)	(0.0005)	(0.0036)	(0.0016)	(0.0005)
average GDP growth rate	-0.0078	-0.0163	-0.0162	-0.0451	0.1580	-0.0737	0.0007
(2nd sector)	(0.0207)	(0.0200)	(0.2463)	(0.0737)	(0.3535)	(0.4700)	(0.0123)
population rate	-0.0008	-0.0014	-0.0008	-0.0003	-0.0010	0.0001	0.0002
	(0.0013)	(0.0015)	(0.0019)	(0.0005)	(0.0028)	(0.0033)	(0.0006)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.3179	-0.7703	-0.3150	0.1712	-1.2434*	-0.3600	-0.3224
	(0.2811)	(0.5485)	(0.3632)	(0.1274)	(0.7150)	(0.3407)	(0.3221)
N	1749	867	882	878	871	1157	592

Notes*: ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

As another extension, we investigate the impact of the establishment of high-tech industrial development zones on firm R&D expenditure in China. According to high-tech industrial development zone policy, firms in the zones are required to have the certification as a high-tech firm to enjoy the preferential policies. One of the requirements to be identified as a high-tech firm is that the ratio of total R&D expenditure to total sales revenue in the same period is not less than 5%[16]. Because of this requirement, firms have more incentives to increase their R&D expenditure after the establishment of high-tech industrial development zones since it is directly associated with the policy. In addition, the incentives may be more effective for firms whose ratio is below 5%.

We rerun the regressions by replacing the dependent variable with the log value of R&D expenditure for both the total sample and subsamples split by the ratio before treatment is implemented below and above 5%. The results are shown in Table 28. All three models show that there is a significant positive impact of the establishment of high-tech industrial development zones on firm R&D expenditure, especially for firms whose ratio is below 5%. In specific, high-tech industrial development zone policy increases firm R&D expenditure by 24.05%, while increases R&D expenditure in firms whose ratio is below 5% by 45.27%, and those whose ratio is above 5% by 23.31%. Although it is hard to draw a conclusion, R&D expenditure has a more significant increase than patenting for both sub-sample groups, especially for the firms whose ratio is below 5%.

Table 28 The Effect of High-tech Zone Policy on Firm R&D Expenditure

	(1)	(2)	(3)
	total sample	below 5%	above 5%
treat×after	0.2155*	0.3734**	0.2095**

[16] http://www.gov.cn/gongbao/content/2001/content_60688.htm

	(0.1104)	(0.1493)	(0.0907)
net profit	0.0006***	0.0006**	0.0006***
	(0.0001)	(0.0002)	(0.0001)
intangible asset	0.0192	0.0564	0.0240
	(0.0544)	(0.0701)	(0.0272)
manager	-0.0192	-0.0191	-0.0043
	(0.0173)	(0.0224)	(0.0173)
age	0.5573	0.8353	0.3516
	(0.5360)	(0.6734)	(0.7511)
top 3 salary of manager	0.1749*	0.1499	0.3442**
	(0.0918)	(0.0993)	(0.1425)
parent owner equity	0.1695*	0.1779	0.3621**
	(0.0991)	(0.1328)	(0.1218)
long term loan	0.0014	0.0003	0.0048
	(0.0035)	(0.0043)	(0.0055)
short term loan	0.0076	0.0062	0.0063**
	(0.0056)	(0.0080)	(0.0030)
average GDP growth rate (2^{nd} sector)	1.7266	2.0710	0.5701
	(1.2210)	(1.3171)	(1.0929)
population rate	0.0042	0.0084	0.0080
	(0.0064)	(0.0069)	(0.0095)
Year FE	Y	Y	Y
Firm FE	Y	Y	Y
constant	12.8822***	11.9919***	11.5537***
	(1.4974)	(1.8093)	(1.1105)
N	1125	802	323

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity, R&D expenditure are log values.
R&D Expenditure data starts from 2007, interpolated for firms missing 1 or 2 years.

We also try the heterogeneous effects on firm R&D expenditure. The results in Table 29 show similar heterogeneous effects for small firms and large firms, firms in developed regions and less developed regions to those on firm patents, but different for non-SOEs and SOEs. The coefficients for both SOEs and non-SOEs become insignificant, and the magnitude for SOEs become larger than non-SOEs. One of the possible explanation for the magnitude might be that SOEs could get more subsidies for R&D expenditure from the policy than non-SOEs (Wu,

2017) , but these investments may not necessarily turn into actual innovation outputs or may need a quite long time, like decades, to get actual innovation outputs.

Table 29 Heterogeneous Effects of High-tech Zone Policy on Firm R&D Expenditure

	(1)	(2)	(3)	(4)	(5)	(6)
	nature of owner		firm size		region	
	non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.1147	0.2851	0.2317**	0.1512	0.2709**	-0.2094
	(0.0705)	(0.2199)	(0.1076)	(0.2606)	(0.1240)	(0.3160)
net profit	0.0005***	0.0009**	0.0008**	0.0006***	0.0004**	0.0012**
	(0.0001)	(0.0003)	(0.0003)	(0.0001)	(0.0001)	(0.0004)
intangible asset	0.0412	0.0485	0.0765	-0.0044	0.0430	0.0315
	(0.0299)	(0.1381)	(0.0470)	(0.0600)	(0.0368)	(0.1309)
manager	0.0062	-0.0437	-0.0392*	0.0125	-0.0069	-0.0424
	(0.0122)	(0.0353)	(0.0228)	(0.0202)	(0.0163)	(0.0375)
age	1.4242**	0.2735	0.2697	1.5984	0.6895	1.6048
	(0.6238)	(1.2874)	(0.7656)	(1.0728)	(0.4458)	(2.2714)
top 3 salary of manager	0.1560	0.2459	0.2410*	0.0406	0.1613	0.1739
	(0.0964)	(0.1561)	(0.1343)	(0.1073)	(0.1004)	(0.1776)
parent owner equity	0.2005**	0.1187	0.1042	0.1979	0.1563**	0.0704
	(0.0725)	(0.2311)	(0.0935)	(0.1302)	(0.0684)	(0.2125)
long term loan	0.0012	-0.0018	-0.0003	0.0032	-0.0015	0.0134
	(0.0046)	(0.0102)	(0.0036)	(0.0053)	(0.0027)	(0.0091)
short term loan	0.0126***	0.0023	0.0045	0.0079	0.0045	0.0157**
	(0.0030)	(0.0140)	(0.0083)	(0.0059)	(0.0057)	(0.0069)
average GDP growth rate (2^{nd} sector)	0.1147	0.2851	0.2317**	0.1512	0.2709**	-0.2094
	(0.0705)	(0.2199)	(0.1076)	(0.2606)	(0.1240)	(0.3160)
population rate	0.0005***	0.0009**	0.0008**	0.0006***	0.0004**	0.0012**
	(0.0001)	(0.0003)	(0.0003)	(0.0001)	(0.0001)	(0.0004)
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
constant	10.9181***	13.9662***	13.1118***	12.1677***	13.1276***	11.1522**
	(1.3078)	(3.3298)	(1.5710)	(2.6177)	(1.5916)	(5.4802)
N	655	475	539	591	823	307

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity, R&D expenditure are log values.
R&D Expenditure data starts from 2007, interpolated for firms missing 1 or 2 years.

CHAPTER 7 CONCLUSION

This thesis investigates whether high-tech industrial development zone policy affects firm innovation activities in China. Our findings generally support the four hypotheses proposed in the Chapter 4. We provide evidence that the impact of high-tech industrial development zone policy on firm patents is more significant in firms with fewer patents in the ex-ante treatment period. We also find that high-tech industrial development zone policy has more effective impacts on firm patents in small firms, non-SOEs, and developed regions. In addition, we provide two extensions. First, we show that high-tech industrial development zone policy has little effect on the increase in the number of high-quality patents in China. Second, we show that high-tech industrial development zone policy has a significant positive influence on firm R&D expenditure, especially for firms whose ratio is below 5%, and the impact is more significant than on successful firm patent applications. The results above indicate that high-tech industrial development zone policy in China may have effective impacts on increasing innovation activities in certain firms, but the effects could be limited to meeting the requirements of enjoying the policy and may have a relatively little influence on increasing firms' high-quality innovation outputs.

This thesis provides empirical evidence in China on the influence of place-based policy as an incentive on firm innovation activities. Because of the different market environment and development stages, developing countries may have a different story from developed countries on effective impacts for improving innovation. Our study provides evidence from China and further examines the heterogeneous effects on firms with different characteristics and in different regions to complement existing studies on policy incentives for firm innovation activities. Our work may shed light on policymakers in developing countries when it comes to issues on firm innovation activities and uneven development across firms and regions.

Our research also provides empirical evidence that high-tech industrial development zone policy in China does not have an effective incentive for improving firm patent quality. Patent quality has always been a concern in both developing countries and developed countries. With the explosive surge of Chinese patent applications filed, researchers and policymakers pay more attention to patent quality. They realize that although China has the most patent applications filed in the world, there is still a gap between China and developed countries in terms of patent quality and production value of the patent. More generally, our study helps build a preliminary understanding of potential elements that may affect patent quality. It provides empirical evidence on patent quality using citation-weighted patents, a more general and well-recognized method. Our findings show policymakers that in spite of the fact that the impact could be significant positive on firm patent quantity, it is not necessary to have a similar effective influence on firm patent quality.

Although we are able to show findings on whether the establishment of high-tech industrial development zones affects firm innovation activities in China, a few limitations remain. First, we observe that high-tech industrial development zone policy has effective impacts for existing firms in the designated areas to improve their patent counts and R&D expenditure, but due to the limitation of the geographical and time period information in our data, we cannot explore whether and how this place-based policy affects new firm entries to the designated high-tech zones in the long run. In general, place-based policies could form agglomeration economies and further improve productivity in the local economy. Previous studies have shown that place-based policies have a significant positive impact on increasing the local economy. It is worth further investigation on whether and how it affects new firm entries to the designated zones.

Second, our pre- and post- trend analyses show the coefficient decreases toward zero in the fourth post-treatment year and after, indicating the effect of the policy fades over time. Since the policy does not end in the sample period in our sample, we have not figured out the possible explanations for this.

Third, we use both the number of invention patents and citation-weighted patents as two alternative measurements of patent quality. Both measures show that there is no significant positive impact of high-tech industrial development policy on firm patent quality. For the citation-weighted patents, the data presents a right truncation problem, citations decreasing after 2009. Unfortunately, it is not feasible to limit our sample period till 2009 since it will leave fewer treated firms and a short post-treatment period. We attempt to use the first five-year forward citations as a robustness check, while the results are quite similar to the previous analyses using citations to the end of the sample period. It might also occur that firms focus more on firm patent quantity rather than patent quality. Possible mechanisms could be that, for example, based on the patent thicket, firms would like to accumulate patents to benefit their further patenting behavior and break limitations. Firms may also use the number of patents as a market signal to show their strong technical foundation. We are not able to test the possible mechanisms behind the insignificant impact on firm patent quality, but it is worth further investigating.

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APPENDIX

Table A1 The Effect of High-tech Zone Policy on Firm Patent

	(1)	(2)
	patent	patent (except design)
treat×after	0.0553	0.0500
	(0.0350)	(0.0341)
net profit	-0.0001*	-0.0001*
	(0.0000)	(0.0000)
intangible asset	0.0345**	0.0387**
	(0.0113)	(0.0113)
manager	-0.0034	-0.0022
	(0.0072)	(0.0060)
age	-0.0735	-0.0726
	(0.2020)	(0.1843)
top 3 salary of manager	0.0287	0.0275
	(0.0331)	(0.0319)
parent owner equity	0.0366*	0.0546**
	(0.0212)	(0.0219)
long term loan	0.0026	0.0012
	(0.0016)	(0.0016)
short term loan	0.0020	0.0014
	(0.0017)	(0.0020)
average GDP growth rate (2^{nd} sector)	0.0557	0.0648
	(0.0419)	(0.0393)
population rate	0.0007	-0.0004
	(0.0028)	(0.0027)
Year FE	Y	Y
Firm FE	Y	Y
constant	0.0671	-0.0342
	(0.4077)	(0.3899)
N	1749	1749

Notes: ****, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A2 The Effect of High-tech Zone Policy on Firm Patent (Nature of Ownership)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	non-SOE	SOE	non-SOE	SOE
treat×after	0.1409**	-0.0190	0.1560**	-0.0375
	(0.0542)	(0.0413)	(0.0562)	(0.0422)
net profit	-0.0000	-0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
intangible asset	0.0603***	0.0050	0.0602***	0.0132
	(0.0146)	(0.0161)	(0.0148)	(0.0157)
manager	-0.0164**	0.0138	-0.0117	0.0094
	(0.0077)	(0.0095)	(0.0074)	(0.0084)
age	0.0947	-0.1950	0.1559	-0.2331
	(0.2920)	(0.1774)	(0.2107)	(0.2164)
top 3 salary of manager	0.0064	0.0598	-0.0011	0.0600
	(0.0416)	(0.0529)	(0.0418)	(0.0516)
parent owner equity	0.0565**	0.0269	0.0902**	0.0274
	(0.0260)	(0.0348)	(0.0293)	(0.0354)
long term loan	0.0020	0.0031	0.0004	0.0020
	(0.0017)	(0.0021)	(0.0018)	(0.0024)
short term loan	0.0016	0.0009	0.0004	0.0017
	(0.0022)	(0.0028)	(0.0026)	(0.0029)
average GDP growth rate (2^{nd} sector)	0.0275	0.2806	0.0436	0.3573
	(0.0325)	(0.4470)	(0.0324)	(0.4886)
population rate	0.0021	-0.0027	-0.0014	-0.0018
	(0.0037)	(0.0044)	(0.0033)	(0.0045)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
constant	-0.2796	0.1676	-0.5103	0.2061
	(0.7156)	(0.4845)	(0.6401)	(0.5071)
N	867	882	867	882

Notes: ****, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A3 The Effect of High-tech Zone Policy on Firm Patent (Firm Size)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	small	large	small	large
treat×after	0.1550**	-0.0480	0.1317**	-0.0426
	(0.0489)	(0.0428)	(0.0483)	(0.0412)
net profit	0.0000	-0.0001**	-0.0000	-0.0001**
	(0.0002)	(0.0001)	(0.0002)	(0.0000)
intangible asset	0.0449**	0.0033	0.0434**	0.0137
	(0.0132)	(0.0199)	(0.0128)	(0.0176)
manager	0.0000	0.0036	-0.0013	0.0013
	(0.0081)	(0.0081)	(0.0094)	(0.0073)
age	-0.2301	0.0894	-0.0392	0.2705
	(0.3274)	(0.3111)	(0.2557)	(0.2582)
top 3 salary of manager	-0.0502	0.0860*	-0.0428	0.0788*
	(0.0533)	(0.0479)	(0.0511)	(0.0465)
parent owner equity	0.0351	0.0656	0.0677**	0.0568
	(0.0269)	(0.0528)	(0.0317)	(0.0515)
long term loan	0.0027	0.0022	0.0010	0.0013
	(0.0022)	(0.0024)	(0.0025)	(0.0024)
short term loan	0.0018	-0.0048	0.0022	-0.0082*
	(0.0018)	(0.0032)	(0.0017)	(0.0044)
average GDP growth rate (2^{nd} sector)	-0.0753	0.2928	0.0643	0.2067
	(0.3786)	(0.4041)	(0.3553)	(0.3905)
population rate	0.0035	-0.0008	0.0032	-0.0031
	(0.0051)	(0.0027)	(0.0049)	(0.0036)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
constant	0.6832	-0.6419	0.2028	-0.8296
	(0.5723)	(0.7006)	(0.4520)	(0.6562)
N	878	871	878	871

Notes: ****, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A4 The Effect of High-tech Zone Policy on Firm Patent (Regions)

	(1)	(2)	(3)	(4)
	patent		patent (except design)	
	developed	less developed	developed	less developed
treat×after	0.0821**	0.0829	0.0841**	0.0303
	(0.0340)	(0.0844)	(0.0358)	(0.0778)
net profit	-0.0000	-0.0002**	-0.0000	-0.0002**
	(0.0000)	(0.0001)	(0.0000)	(0.0001)
intangible asset	0.0191**	0.0585**	0.0207**	0.0663**
	(0.0082)	(0.0229)	(0.0076)	(0.0225)
manager	-0.0092	0.0010	-0.0048	-0.0030
	(0.0075)	(0.0132)	(0.0063)	(0.0113)
age	0.1143	-0.1409	0.0635	-0.0678
	(0.2950)	(0.2753)	(0.2475)	(0.3380)
top 3 salary of manager	0.0476	0.0306	0.0417	0.0311
	(0.0293)	(0.0584)	(0.0282)	(0.0579)
parent owner equity	0.0374**	0.0395	0.0568***	0.0605
	(0.0172)	(0.0371)	(0.0154)	(0.0385)
long term loan	0.0045*	-0.0017	0.0035*	-0.0041*
	(0.0022)	(0.0024)	(0.0021)	(0.0023)
short term loan	0.0002	0.0071**	-0.0005	0.0072**
	(0.0020)	(0.0028)	(0.0024)	(0.0028)
average GDP growth rate (2^{nd} sector)	0.5318	0.0414	0.4127	0.0544
	(0.3701)	(0.0382)	(0.3303)	(0.0385)
population rate	0.0011	-0.0001	0.0003	-0.0018
	(0.0041)	(0.0046)	(0.0040)	(0.0036)
Year FE	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y
constant	0.2321	-0.1159	0.1879	-0.3612
	(0.3568)	(0.7288)	(0.3498)	(0.8050)
N	1157	592	1157	592

Notes: ****, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A5 The Effect of High-tech Zone Policy on the Share of Firm Invention Patent

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.0043	0.0150	-0.0019	0.0432	-0.0304	0.0300	-0.0591
	(0.0312)	(0.0451)	(0.0497)	(0.0467)	(0.0267)	(0.0231)	(0.1020)
net profit	-0.0000	-0.0000	-0.0000	0.0000	-0.0001**	-0.0001*	0.0000
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0001)
intangible asset	0.0187**	0.0197*	0.0121	0.0151	0.0226	0.0147**	0.0252
	(0.0079)	(0.0114)	(0.0103)	(0.0110)	(0.0175)	(0.0054)	(0.0179)
manager	-0.0039	-0.0072	-0.0039	-0.0041	-0.0041	-0.0036	-0.0074
	(0.0052)	(0.0070)	(0.0065)	(0.0077)	(0.0060)	(0.0066)	(0.0100)
age	-0.3592**	-0.2635	-0.5521**	-0.2841	-0.4978**	-0.2780**	-0.6188**
	(0.1372)	(0.1995)	(0.1631)	(0.2075)	(0.2427)	(0.1258)	(0.2628)
top 3 salary of manager	-0.0151	-0.0156	-0.0137	-0.0448	0.0205	0.0203	-0.0541*
	(0.0201)	(0.0242)	(0.0266)	(0.0314)	(0.0195)	(0.0181)	(0.0321)
parent owner equity	0.0088	0.0225	0.0043	0.0145	0.0140	0.0070	0.0039
	(0.0147)	(0.0206)	(0.0238)	(0.0153)	(0.0283)	(0.0099)	(0.0249)
long term loan	0.0002	0.0012	-0.0003	0.0016	0.0003	0.0021*	-0.0033
	(0.0012)	(0.0016)	(0.0019)	(0.0016)	(0.0020)	(0.0012)	(0.0023)
short term loan	-0.0003	-0.0003	-0.0010	-0.0005	-0.0052**	-0.0016	0.0028
	(0.0015)	(0.0021)	(0.0021)	(0.0022)	(0.0020)	(0.0016)	(0.0033)
average GDP growth rate (2^{nd} sector)	-0.0675**	-0.0390	-0.1122	-0.1186	0.0335	-0.2009	-0.0695**
	(0.0270)	(0.0234)	(0.2454)	(0.2965)	(0.2274)	(0.2502)	(0.0326)
population rate	0.0002	0.0020	-0.0039	0.0040	-0.0013	0.0008	-0.0006
	(0.0024)	(0.0031)	(0.0033)	(0.0046)	(0.0028)	(0.0039)	(0.0038)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	0.8458**	0.7341	1.1803**	0.8994**	0.8704**	0.4930**	1.5134**
	(0.2570)	(0.4447)	(0.3495)	(0.3444)	(0.4301)	(0.2009)	(0.5428)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A6 The Effect of High-tech Zone Policy on Firm Patent Citation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0803**	-0.0800*	-0.1018*	-0.0646	-0.0802	-0.0653*	-0.1528*
	(0.0355)	(0.0475)	(0.0536)	(0.0469)	(0.0572)	(0.0380)	(0.0765)
net profit	-0.0000	0.0001	-0.0001*	-0.0002*	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
intangible asset	0.0049	-0.0005	0.0151	0.0022	0.0060	0.0048	0.0096
	(0.0080)	(0.0104)	(0.0122)	(0.0080)	(0.0180)	(0.0099)	(0.0132)
manager	0.0025	0.0022	-0.0022	0.0189	-0.0177**	0.0031	-0.0001
	(0.0078)	(0.0141)	(0.0088)	(0.0128)	(0.0065)	(0.0117)	(0.0107)
age	0.2838**	0.6194**	0.0521	0.1084	0.7307**	0.4573**	0.5279*
	(0.1405)	(0.2704)	(0.2009)	(0.1788)	(0.2520)	(0.1674)	(0.3075)
top 3 salary of manager	0.0646**	0.0665	0.0651*	0.0568	0.0909**	0.0632	0.0626
	(0.0308)	(0.0530)	(0.0371)	(0.0367)	(0.0449)	(0.0473)	(0.0419)
parent owner equity	0.0007	-0.0082	0.0097	-0.0118	0.0342	-0.0039	0.0089
	(0.0130)	(0.0254)	(0.0217)	(0.0157)	(0.0226)	(0.0189)	(0.0193)
long term loan	0.0005	0.0016	-0.0010	-0.0001	0.0014	0.0006	0.0002
	(0.0013)	(0.0020)	(0.0018)	(0.0020)	(0.0020)	(0.0018)	(0.0021)
short term loan	-0.0000	-0.0012	0.0003	0.0013	-0.0033	-0.0004	0.0016
	(0.0012)	(0.0026)	(0.0015)	(0.0013)	(0.0029)	(0.0014)	(0.0025)
average GDP growth rate (2^{nd} sector)	0.0093	0.0011	0.3674	0.1156	-0.3528	-0.4840*	0.0272
	(0.0266)	(0.0351)	(0.3252)	(0.2272)	(0.3102)	(0.2663)	(0.0343)
population rate	0.0026	0.0004	0.0055	0.0044	0.0021	0.0083**	-0.0002
	(0.0024)	(0.0024)	(0.0036)	(0.0032)	(0.0040)	(0.0036)	(0.0030)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.6050*	-1.1456**	-0.3222	-0.3130	-1.7847**	-0.3344	-1.3053*

	(0.3163)	(0.4195)	(0.4579)	(0.2639)	(0.6451)	(0.2755)	(0.7002)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A7 The Effect of High-tech Zone Policy on Firm Patent Citation (above 75th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0705**	-0.0536	-0.1024*	-0.0718	-0.0449	-0.0411	-0.1764**
	(0.0338)	(0.0460)	(0.0572)	(0.0489)	(0.0577)	(0.0361)	(0.0658)
net profit	-0.0000	0.0001	-0.0001	-0.0001	-0.0000	0.0000	0.0000
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0000)
intangible asset	0.0057	0.0026	0.0104	0.0063	-0.0019	0.0054	0.0088
	(0.0082)	(0.0105)	(0.0134)	(0.0071)	(0.0182)	(0.0102)	(0.0146)
manager	0.0007	-0.0017	-0.0023	0.0128	-0.0172**	0.0045	-0.0047
	(0.0081)	(0.0151)	(0.0086)	(0.0148)	(0.0076)	(0.0119)	(0.0103)
age	0.2147*	0.4469*	0.0421	-0.0082	0.6737**	0.3877**	0.3425
	(0.1266)	(0.2627)	(0.1979)	(0.1520)	(0.2674)	(0.1711)	(0.2761)
top 3 salary of manager	0.0688**	0.0639	0.0786**	0.0795*	0.0936**	0.0513	0.0727
	(0.0270)	(0.0441)	(0.0377)	(0.0404)	(0.0393)	(0.0347)	(0.0449)
parent owner equity	0.0105	0.0108	0.0158	0.0060	0.0388*	0.0095	0.0120
	(0.0135)	(0.0288)	(0.0230)	(0.0183)	(0.0223)	(0.0201)	(0.0194)
long term loan	0.0009	0.0017	-0.0003	0.0004	0.0020	0.0009	0.0011
	(0.0012)	(0.0017)	(0.0018)	(0.0020)	(0.0017)	(0.0017)	(0.0021)
short term loan	-0.0016	-0.0030	-0.0008	-0.0005	-0.0039	-0.0012	-0.0022
	(0.0013)	(0.0028)	(0.0018)	(0.0012)	(0.0026)	(0.0014)	(0.0038)
average GDP growth rate (2nd sector)	0.0419	0.0543*	0.4483	0.1798	-0.1293	-0.4579	0.0548
	(0.0254)	(0.0323)	(0.2705)	(0.2354)	(0.2751)	(0.2873)	(0.0336)
population rate	0.0038	0.0010	0.0069*	0.0078**	-0.0001	0.0085**	0.0020
	(0.0024)	(0.0022)	(0.0039)	(0.0031)	(0.0041)	(0.0041)	(0.0029)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.5581*	-0.8911**	-0.4236	-0.3219	-1.7279**	-0.3057	-0.9825
	(0.2991)	(0.4062)	(0.4540)	(0.2809)	(0.6566)	(0.2368)	(0.6825)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A8 The Effect of High-tech Zone Policy on Firm Patent Citation (above 90th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0336	-0.0536	-0.1024*	-0.0718	-0.0449	-0.0411	-0.1764**
	(0.0387)	(0.0460)	(0.0572)	(0.0489)	(0.0577)	(0.0361)	(0.0658)
net profit	-0.0000**	0.0001	-0.0001	-0.0001	-0.0000	0.0000	0.0000
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0000)
intangible asset	-0.0040	0.0026	0.0104	0.0063	-0.0019	0.0054	0.0088
	(0.0088)	(0.0105)	(0.0134)	(0.0071)	(0.0182)	(0.0102)	(0.0146)
manager	0.0032	-0.0017	-0.0023	0.0128	-0.0172**	0.0045	-0.0047
	(0.0064)	(0.0151)	(0.0086)	(0.0148)	(0.0076)	(0.0119)	(0.0103)
age	0.0897	0.4469*	0.0421	-0.0082	0.6737**	0.3877**	0.3425
	(0.1655)	(0.2627)	(0.1979)	(0.1520)	(0.2674)	(0.1711)	(0.2761)
top 3 salary of manager	0.0652**	0.0639	0.0786**	0.0795*	0.0936**	0.0513	0.0727
	(0.0237)	(0.0441)	(0.0377)	(0.0404)	(0.0393)	(0.0347)	(0.0449)
parent owner equity	0.0223*	0.0108	0.0158	0.0060	0.0388*	0.0095	0.0120
	(0.0122)	(0.0288)	(0.0230)	(0.0183)	(0.0223)	(0.0201)	(0.0194)
long term loan	0.0018	0.0017	-0.0003	0.0004	0.0020	0.0009	0.0011
	(0.0012)	(0.0017)	(0.0018)	(0.0020)	(0.0017)	(0.0017)	(0.0021)
short term loan	0.0022	-0.0030	-0.0008	-0.0005	-0.0039	-0.0012	-0.0022
	(0.0014)	(0.0028)	(0.0018)	(0.0012)	(0.0026)	(0.0014)	(0.0038)
average GDP growth rate (2nd sector)	-0.0929**	0.0543*	0.4483	0.1798	-0.1293	-0.4579	0.0548
	(0.0304)	(0.0323)	(0.2705)	(0.2354)	(0.2751)	(0.2873)	(0.0336)

population rate	0.0032	0.0010	0.0069*	0.0078**	-0.0001	0.0085**	0.0020
	(0.0030)	(0.0022)	(0.0039)	(0.0031)	(0.0041)	(0.0041)	(0.0029)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.5040	-1.0032**	-0.0924	-0.4011	-1.3975*	-0.5478*	-0.4651
	(0.3169)	(0.4719)	(0.3121)	(0.2897)	(0.7063)	(0.3033)	(0.5773)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A9 The Effect of High-tech Zone Policy on Firm Patent Citation (above 95th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.0145	0.0777	-0.0437	0.0250	0.0375	0.0759	-0.1238
	(0.0510)	(0.0683)	(0.0578)	(0.0648)	(0.0584)	(0.0594)	(0.0953)
net profit	0.0000	0.0001	-0.0000	0.0002**	0.0000	0.0001	-0.0000
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0001)
intangible asset	0.0125	0.0143	0.0156	0.0204**	0.0031	0.0094	0.0127
	(0.0099)	(0.0122)	(0.0147)	(0.0088)	(0.0180)	(0.0143)	(0.0126)
manager	-0.0044	-0.0070	-0.0064	-0.0018	-0.0061	0.0011	-0.0145
	(0.0039)	(0.0079)	(0.0069)	(0.0054)	(0.0076)	(0.0054)	(0.0097)
age	-0.1381	0.2737	-0.4030**	-0.2978	0.1934	-0.2417	0.2513
	(0.1598)	(0.2698)	(0.1712)	(0.2049)	(0.3445)	(0.2710)	(0.3065)
top 3 salary of manager	0.0511**	0.0653**	0.0400	0.0854***	0.0175	0.0823**	0.0083
	(0.0220)	(0.0258)	(0.0357)	(0.0245)	(0.0392)	(0.0286)	(0.0290)
parent owner equity	0.0131	0.0104	0.0159	0.0107	-0.0045	0.0009	0.0229
	(0.0110)	(0.0232)	(0.0145)	(0.0225)	(0.0205)	(0.0147)	(0.0159)
long term loan	0.0022*	0.0009	0.0033**	0.0029	0.0025	0.0037**	-0.0005
	(0.0013)	(0.0021)	(0.0014)	(0.0022)	(0.0019)	(0.0015)	(0.0020)
short term loan	0.0002	-0.0006	0.0006	-0.0013	0.0029	0.0004	0.0013
	(0.0013)	(0.0027)	(0.0019)	(0.0017)	(0.0052)	(0.0017)	(0.0023)
average GDP growth rate (2nd sector)	-0.0887**	-0.0827***	0.4340	0.2266	0.1720	-0.0642	-0.0888**
	(0.0296)	(0.0185)	(0.3859)	(0.2475)	(0.3420)	(0.2200)	(0.0394)
population rate	0.0003	0.0012	-0.0016	0.0003	-0.0009	0.0023	-0.0019
	(0.0024)	(0.0030)	(0.0038)	(0.0026)	(0.0045)	(0.0040)	(0.0027)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.0128	-0.6843	0.3668	0.0357	-0.5323	0.0350	-0.5890
	(0.2849)	(0.4469)	(0.2846)	(0.3219)	(0.7531)	(0.3536)	(0.5900)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A10 The Effect of High-tech Zone Establishment on Firm Patent Citation (above 99th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0418	-0.0323	-0.0541	-0.0301	-0.0261	-0.0207	-0.0723
	(0.0371)	(0.0320)	(0.0562)	(0.0445)	(0.0482)	(0.0454)	(0.0738)
net profit	0.0001	0.0001	0.0000	-0.0000	0.0001	0.0001	-0.0000
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0000)
intangible asset	0.0023	-0.0054	0.0112*	0.0013	-0.0180	-0.0011	0.0043
	(0.0052)	(0.0087)	(0.0065)	(0.0060)	(0.0164)	(0.0076)	(0.0050)
manager	-0.0072**	-0.0134*	-0.0041	0.0026	-0.0141**	-0.0064	-0.0086
	(0.0035)	(0.0078)	(0.0056)	(0.0044)	(0.0068)	(0.0053)	(0.0056)
age	-0.1961	0.0913	-0.4280*	-0.3470**	0.1158	-0.2762	0.0183
	(0.1433)	(0.2302)	(0.2223)	(0.1475)	(0.3229)	(0.2647)	(0.1580)
top 3 salary of manager	0.0163	0.0097	0.0211	0.0116	-0.0028	0.0349	-0.0029
	(0.0138)	(0.0280)	(0.0240)	(0.0154)	(0.0327)	(0.0214)	(0.0161)
parent owner equity	0.0016	0.0110	-0.0035	0.0022	-0.0072	0.0016	0.0053
	(0.0055)	(0.0117)	(0.0117)	(0.0054)	(0.0175)	(0.0082)	(0.0063)
long term loan	0.0002	-0.0008	0.0017	0.0014	-0.0007	-0.0003	0.0008

	(0.0010)	(0.0012)	(0.0012)	(0.0013)	(0.0020)	(0.0014)	(0.0007)
short term loan	-0.0011	-0.0027**	0.0003	-0.0014	-0.0002	-0.0018	0.0013
	(0.0009)	(0.0010)	(0.0012)	(0.0011)	(0.0025)	(0.0011)	(0.0013)
average GDP growth rate (2nd sector)	-0.0263**	-0.0199	0.0647	0.1217	-0.1418	-0.1546	-0.0146**
	(0.0128)	(0.0151)	(0.2635)	(0.2142)	(0.2863)	(0.1604)	(0.0061)
population rate	-0.0009	-0.0010	-0.0020	0.0003	-0.0020	-0.0022	0.0009
	(0.0013)	(0.0010)	(0.0028)	(0.0014)	(0.0029)	(0.0030)	(0.0012)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	0.2726	-0.0947	0.5358	0.5028**	-0.2018	0.3123	-0.1437
	(0.2518)	(0.3500)	(0.3483)	(0.2241)	(0.6435)	(0.3529)	(0.3036)
N	1749	867	882	878	871	1157	592

Notes*: ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A11 The Effect of High-tech Zone Establishment on Firm Patents' First Five-Year Citation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0041	0.0150	-0.0275	-0.0210	0.0359	0.0366	-0.1132
	(0.0416)	(0.0373)	(0.0630)	(0.0483)	(0.0554)	(0.0476)	(0.0792)
net profit	-0.0001	0.0001	-0.0002*	0.0000	-0.0001	0.0000	-0.0001
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)
intangible asset	0.0038	-0.0047	0.0163	0.0028	0.0013	-0.0010	0.0075
	(0.0084)	(0.0122)	(0.0149)	(0.0064)	(0.0225)	(0.0118)	(0.0120)
manager	0.0033	0.0045	-0.0054	0.0133	-0.0096	0.0111	-0.0077
	(0.0073)	(0.0131)	(0.0108)	(0.0115)	(0.0108)	(0.0101)	(0.0103)
age	-0.1423	0.0460	-0.3166	-0.2758	-0.0842	-0.2626	0.2845
	(0.1754)	(0.2471)	(0.2619)	(0.2102)	(0.3249)	(0.2654)	(0.3320)
top 3 salary of manager	0.0867**	0.0609	0.1056**	0.0925**	0.0827*	0.0912**	0.0569
	(0.0283)	(0.0520)	(0.0432)	(0.0341)	(0.0493)	(0.0431)	(0.0370)
parent owner equity	0.0068	0.0118	0.0164	-0.0049	0.0236	0.0170	0.0047
	(0.0114)	(0.0187)	(0.0190)	(0.0148)	(0.0163)	(0.0183)	(0.0150)
long term loan	-0.0001	-0.0002	0.0006	-0.0000	0.0003	-0.0006	0.0011
	(0.0014)	(0.0017)	(0.0024)	(0.0018)	(0.0023)	(0.0020)	(0.0013)
short term loan	-0.0011	-0.0023	-0.0002	-0.0011	-0.0014	-0.0009	-0.0013
	(0.0016)	(0.0021)	(0.0020)	(0.0022)	(0.0059)	(0.0020)	(0.0023)
average GDP growth rate (2nd sector)	0.0088	-0.0034	0.4851	-0.0162	-0.0366	-0.6999*	0.0129
	(0.0223)	(0.0278)	(0.4845)	(0.2766)	(0.4012)	(0.3528)	(0.0338)
population rate	-0.0019	-0.0067*	0.0021	-0.0000	-0.0036	0.0014	-0.0019
	(0.0029)	(0.0035)	(0.0039)	(0.0030)	(0.0037)	(0.0064)	(0.0027)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.0480	-0.2522	0.0171	0.0975	-0.1958	0.1139	-0.7142
	(0.3058)	(0.4015)	(0.4762)	(0.3709)	(0.6622)	(0.3359)	(0.6936)
N	1749	867	882	878	871	1157	592

Notes*: ∗∗∗, ∗∗, and ∗ denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A12 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 75th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.0054	0.0509	-0.0386	-0.0334	0.0774	0.0550	-0.1085
	(0.0411)	(0.0350)	(0.0632)	(0.0489)	(0.0560)	(0.0462)	(0.0800)
net profit	-0.0001	0.0001	-0.0002**	0.0000	-0.0001	0.0000	-0.0001
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
intangible asset	0.0015	-0.0082	0.0146	0.0026	-0.0056	-0.0027	0.0043
	(0.0082)	(0.0115)	(0.0149)	(0.0058)	(0.0226)	(0.0117)	(0.0116)
manager	0.0034	0.0022	-0.0031	0.0157	-0.0106	0.0127	-0.0069
	(0.0079)	(0.0140)	(0.0112)	(0.0107)	(0.0118)	(0.0111)	(0.0097)
age	-0.1348	0.0455	-0.2882	-0.2510	0.0163	-0.2747	0.2873
	(0.1687)	(0.2514)	(0.2596)	(0.2073)	(0.3231)	(0.2460)	(0.3354)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
top 3 salary of manager	0.0826**	0.0420	0.1161**	0.0872**	0.0713	0.0688*	0.0663*
	(0.0255)	(0.0450)	(0.0409)	(0.0360)	(0.0485)	(0.0360)	(0.0375)
parent owner equity	0.0084	0.0121	0.0167	-0.0003	0.0213	0.0142	0.0089
	(0.0109)	(0.0166)	(0.0186)	(0.0154)	(0.0153)	(0.0172)	(0.0157)
long term loan	-0.0001	-0.0003	0.0001	-0.0005	0.0008	-0.0006	0.0009
	(0.0014)	(0.0015)	(0.0024)	(0.0018)	(0.0022)	(0.0019)	(0.0016)
short term loan	-0.0012	-0.0019	-0.0006	-0.0017	-0.0000	-0.0006	-0.0022
	(0.0016)	(0.0021)	(0.0021)	(0.0022)	(0.0061)	(0.0019)	(0.0033)
average GDP growth rate (2^{nd} sector)	0.0447*	0.0586**	0.4654	0.0047	0.1881	-0.5820	0.0493*
	(0.0226)	(0.0199)	(0.5132)	(0.2868)	(0.4020)	(0.3598)	(0.0293)
population rate	-0.0019	-0.0070**	0.0024	0.0019	-0.0065*	0.0005	-0.0012
	(0.0027)	(0.0033)	(0.0037)	(0.0026)	(0.0038)	(0.0055)	(0.0028)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.0322	-0.0782	-0.0845	0.0703	-0.3209	0.2247	-0.7565
	(0.3115)	(0.3881)	(0.4603)	(0.3742)	(0.6909)	(0.3252)	(0.6978)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A13 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 90th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0128	0.0790**	-0.0967	-0.0117	0.0486	0.0446	-0.1370
	(0.0421)	(0.0308)	(0.0677)	(0.0497)	(0.0591)	(0.0364)	(0.1022)
net profit	-0.0000	0.0001	-0.0001*	0.0001*	0.0000	0.0001	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
intangible asset	0.0016	-0.0010	0.0084	0.0113	-0.0183	-0.0010	0.0017
	(0.0083)	(0.0110)	(0.0119)	(0.0076)	(0.0175)	(0.0122)	(0.0132)
manager	-0.0016	-0.0031	-0.0043	-0.0025	-0.0051	0.0059	-0.0111
	(0.0056)	(0.0064)	(0.0100)	(0.0056)	(0.0103)	(0.0068)	(0.0096)
age	-0.2207	0.0211	-0.3992*	-0.2515	-0.0575	-0.3523	0.0980
	(0.1498)	(0.2318)	(0.2000)	(0.1723)	(0.3440)	(0.2408)	(0.3117)
top 3 salary of manager	0.0719***	0.0506	0.0962**	0.0941**	0.0517	0.0647**	0.0670**
	(0.0198)	(0.0332)	(0.0283)	(0.0340)	(0.0355)	(0.0266)	(0.0274)
parent owner equity	0.0084	0.0030	0.0125	-0.0018	0.0040	-0.0011	0.0237*
	(0.0102)	(0.0159)	(0.0126)	(0.0129)	(0.0221)	(0.0156)	(0.0138)
long term loan	0.0013	0.0022	-0.0002	0.0007	0.0038	0.0018	0.0002
	(0.0015)	(0.0021)	(0.0019)	(0.0016)	(0.0027)	(0.0020)	(0.0022)
short term loan	0.0008	0.0009	0.0005	0.0002	0.0036	0.0012	0.0015
	(0.0016)	(0.0026)	(0.0017)	(0.0019)	(0.0057)	(0.0020)	(0.0035)
average GDP growth rate (2^{nd} sector)	-0.1073***	-0.1052***	0.1857	0.1741	-0.1496	-0.3861	-0.1103***
	(0.0176)	(0.0210)	(0.4307)	(0.2332)	(0.3796)	(0.2420)	(0.0261)
population rate	-0.0003	-0.0016	0.0003	0.0005	-0.0015	-0.0009	0.0007
	(0.0019)	(0.0023)	(0.0030)	(0.0021)	(0.0033)	(0.0038)	(0.0021)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	0.0558	-0.1639	0.1831	-0.0060	-0.1888	0.2831	-0.5859
	(0.2707)	(0.3852)	(0.3348)	(0.2882)	(0.7082)	(0.3188)	(0.6169)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A14 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 95th percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	0.0062	0.0564	-0.0349	-0.0229	0.0974*	0.0708*	-0.1231
	(0.0429)	(0.0376)	(0.0625)	(0.0398)	(0.0555)	(0.0375)	(0.0985)
net profit	0.0000	0.0001	-0.0000	0.0001	0.0000	0.0001**	-0.0001
	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)

intangible asset	0.0046	0.0096	0.0024	0.0107	-0.0178	0.0020	0.0070
	(0.0058)	(0.0101)	(0.0082)	(0.0075)	(0.0166)	(0.0077)	(0.0111)
manager	-0.0099*	-0.0103	-0.0098	-0.0067	-0.0161*	-0.0087	-0.0119
	(0.0056)	(0.0095)	(0.0076)	(0.0048)	(0.0090)	(0.0079)	(0.0083)
age	-0.2497*	-0.1066	-0.3469**	-0.3245**	0.0594	-0.3544	-0.0597
	(0.1305)	(0.2734)	(0.1621)	(0.1584)	(0.2621)	(0.2446)	(0.2008)
top 3 salary of manager	0.0369**	0.0305	0.0461*	0.0690**	0.0003	0.0573**	0.0111
	(0.0154)	(0.0287)	(0.0252)	(0.0259)	(0.0236)	(0.0213)	(0.0208)
parent owner equity	0.0132	-0.0018	0.0236*	0.0114	0.0115	-0.0033	0.0307**
	(0.0103)	(0.0169)	(0.0140)	(0.0169)	(0.0221)	(0.0132)	(0.0138)
long term loan	0.0018*	0.0003	0.0032**	0.0008	0.0034*	0.0019	0.0014
	(0.0011)	(0.0020)	(0.0010)	(0.0015)	(0.0019)	(0.0013)	(0.0016)
short term loan	-0.0009	-0.0017	-0.0002	-0.0001	-0.0019	-0.0002	-0.0020
	(0.0016)	(0.0021)	(0.0021)	(0.0017)	(0.0043)	(0.0019)	(0.0031)
average GDP growth rate (2^{nd} sector)	-0.0982***	-0.1052***	-0.0508	-0.0280	-0.1936	-0.2661	-0.0982***
	(0.0154)	(0.0192)	(0.2658)	(0.1878)	(0.2573)	(0.3083)	(0.0200)
population rate	-0.0014	-0.0018	-0.0011	0.0000	-0.0041	-0.0049	0.0014
	(0.0018)	(0.0022)	(0.0030)	(0.0019)	(0.0035)	(0.0034)	(0.0022)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	0.2556	0.1956	0.2652	0.1612	-0.0714	0.3564	-0.0992
	(0.2196)	(0.4216)	(0.3316)	(0.2332)	(0.5816)	(0.2712)	(0.4089)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.

Table A15 The Effect of High-tech Zone Policy on Firm Patents' First Five-Year Citation (above 99^{th} percentile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	total	nature of owner		firm size		region	
		non-SOEs	SOEs	small	large	developed	less developed
treat×after	-0.0107	-0.0443	0.0052	-0.0017	0.0071	-0.0083	0.0200
	(0.0202)	(0.0316)	(0.0174)	(0.0230)	(0.0345)	(0.0301)	(0.0145)
net profit	0.0000	0.0001	-0.0001	-0.0000	0.0000	0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)	(0.0001)	(0.0001)
intangible asset	0.0073*	0.0112	0.0045	0.0084**	-0.0002	0.0103*	0.0024
	(0.0037)	(0.0076)	(0.0059)	(0.0041)	(0.0105)	(0.0052)	(0.0047)
manager	-0.0068**	-0.0128**	-0.0011	-0.0024	-0.0093**	-0.0088**	-0.0033
	(0.0030)	(0.0063)	(0.0041)	(0.0027)	(0.0045)	(0.0037)	(0.0043)
age	0.0525	0.2311	0.0189	-0.1222	0.3984**	0.1023	0.0743
	(0.0749)	(0.1825)	(0.0841)	(0.0815)	(0.1865)	(0.1215)	(0.0962)
top 3 salary of manager	-0.0008	-0.0173	0.0118	0.0060	-0.0261	-0.0033	0.0108
	(0.0104)	(0.0253)	(0.0118)	(0.0084)	(0.0211)	(0.0160)	(0.0137)
parent owner equity	0.0074	0.0001	0.0112	-0.0009	0.0161	0.0065	0.0119
	(0.0051)	(0.0095)	(0.0085)	(0.0043)	(0.0168)	(0.0063)	(0.0091)
long term loan	-0.0012**	-0.0015	-0.0009	-0.0006	-0.0015	-0.0020**	-0.0002
	(0.0006)	(0.0009)	(0.0010)	(0.0007)	(0.0016)	(0.0007)	(0.0004)
short term loan	-0.0008	-0.0016	-0.0001	-0.0011	0.0001	-0.0011	0.0000
	(0.0009)	(0.0015)	(0.0009)	(0.0007)	(0.0031)	(0.0012)	(0.0006)
average GDP growth rate (2^{nd} sector)	-0.0161	-0.0307*	0.2229	-0.0634	0.2250	-0.0491	-0.0060
	(0.0123)	(0.0166)	(0.2088)	(0.0964)	(0.2004)	(0.1770)	(0.0107)
population rate	-0.0011	-0.0015	-0.0011	-0.0006	-0.0015	-0.0016	0.0004
	(0.0013)	(0.0012)	(0.0022)	(0.0006)	(0.0027)	(0.0029)	(0.0008)
Year FE	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y
constant	-0.0700	-0.2108	-0.1752	0.2072	-0.7088	0.0009	-0.2749
	(0.1535)	(0.2672)	(0.1987)	(0.1590)	(0.4327)	(0.1584)	(0.3027)
N	1749	867	882	878	871	1157	592

Notes*: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*
The robust standard error is reported in parentheses, clustered at the city level.
net profit is winsorized by 0.05. intangible asset, age, top 3 salary of manager, long term loan, short term loan, parent owner equity are log values.