The Impact of Internal Incentives vs. Government Subsidies on Corporate Innovation

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Abstract

This paper compares the impact of government R&D subsidy and internal employee incentive plan (EIP) on corporate innovation. Using a large sample of Chinese firms from 2007-2014, we employ propensity score matching (PSM) with difference-in-differences (DiD) approach and show positive and significant effects of both R&D subsidy and EIP on corporate innovation. However, comparing the economic significance, we find that the impact of EIP is greater than that of government subsidies. The results are robust for different innovation measures, both invention patents and utility model patents, after addressing endogeneity concerns.

Keywords: Innovation, R&D subsidy, employee incentive plan

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1. Introduction

Innovation is a highly risky venture wherein the private sector might under-invest their resources. Firstly, the inappropriability problem, which arises from the difference between private and social marginal return of innovation, becomes a constraint for a private firm to devote their resources into research and development (R&D) activity. The positive benefits of their R&D activities are not fully absorbed by the firms themselves, but spill over to their competitors or other market participants. Secondly, innovation activity is highly uncertain in yielding success. Innovation, unlike tangible products, pertains considerable risk of failure due to a high level of unpredictability (Holmstrom, 1989). As a result, the innovation activity would be under-invested if they are left to the hands of private sector alone (Arrow, 1962). Thus, Arrow (1962) argues for the role of external incentive, specifically the government's R&D subsidy, in stimulating innovation activity.[3] Despite numerous empirical research that examined the effectiveness of government subsidies on innovation, the results are quite mixed (Bronzini and Piselli (2016); Guan and Yam (2015)).

In contrast to government incentives, Manso (2011) theoretically shows that optimal incentive contract that motivates innovation rewards long-term success and tolerates early failure, which suggests that internal incentives can drive innovation which is missing in the Arrow's postulation in propelling innovation activity. Yet, there are few empirical studies that examine internal incentives and innovation. Among the few, Lerner and Wulf (2007) find that more heavily cited patents in publicly-listed US firms are strongly associated with long-term stock incentives granted to R&D managers. When CEO compensation has a higher proportion of long-term components, Holthausen, Larcker and Sloan (1995) find evidence, although relatively weak, that the ratio of patent award to sales increases subsequently. Chang, Fu, Low,

[3] It is of note that stock options were first introduced in 1973, which was after the Arrow's (1962) seminal paper had been published. So, it is possible that the crucial role of the firm's internal incentive is missing in the Arrow's theoretical postulation.

and Zhang (2015) show that stock incentives for non-executive employees can well deliver innovation outputs. Such findings suggest that, whether for top management or non-executive employees, internal incentive schemes such as stock options and restricted stock can motivate employees to deliver more innovation outputs. However, it is not clear if internal incentives are more effective than government subsidies in delivering innovation. In this paper, we empirically compare the effectiveness of government R&D subsidy and that of internal incentives on innovation activity.

To this end, we examine corporate innovation in China. Although China's sustained economic growth over the past three decades has been driven by low-cost labour and high savings and investment, this economic development model is generally agreed as unsustainable in the long run (Lin, Lin, Song, & Li, 2011; Wei, Xie, & Zhang, 2017). As economic performance in the recent years has shown, China's economic growth has markedly slowed down from the double-digit rates to single-digit rates as labour costs have risen rapidly. As such, Chinese government considers that innovation is a key for China to maintain its growth and development momentum. The innovation activity in China has flourished markedly in the past decade. According to the data sourced from the World Intellectual Property Organization (WIPO), the number of patent application has dramatically expanded, and the patent stock has experienced explosive growth, surging more than five-folds from 2007-2015. It has now become the second largest patent holder after the United States, surpassing many advanced countries such as Germany and Japan. China has even overtaken the US as the first-ranked country in terms of annual patent application since 2011.As China is now known as the most prolific patent-filing country, one of objectives of this paper is to explain this phenomenon. Concurring Arrow (1962)'s theoretical prediction, previous studies apparently point out the role of government's R&D subsidy, which has grown dramatically over the past decade in China. A huge amount of R&D subsidy by the government is granted to stimulate innovation activity throughout the country by either central or local governments. According to Wei et al (2017), China invested 0.7% of GDP in research and development in 1995, which was below the average of OECD countries, but in line with big developing economies such as India, Brazil or South Africa. By 2014, China's R&D spending had reached 2.05 percent of GDP, which was above the averages of OECD countries. While some studies find positive effects of R&D subsidy on firms' innovation outcomes in China (Deng & Hu, 2014; Guo, Guo, & Jiang, 2014), some other studies are unable to provide any evidence (Wei et al., 2017) or find the contrary results (Guan & Yam, 2015). Hence, the evidence of the effects of R&D subsidy on corporate innovation in China is rather mixed.

Since China Securities Regulatory Commission released guidelines for equity incentives in December 2005, many firms started to introduce internal incentive schemes for employees. Such employee incentive plans (EIP) include incentives not only for top management but also for non-executive employees. Using a survey data of listed Chinese firms, Lin et al (2011) find that CEO incentive schemes significantly increase corporate innovation. Whilst several studies suggest the positive role of the firms' internal incentive schemes in improving the performance of corporate innovation, there remains a small body of literature. Particularly, our paper contributes to the literature by comparing the effect of government R&D subsides with market based incentives on innovation.

In this paper, we investigate the drivers of corporate innovation in China's publicly listed firms using the data gathered from the China Stock Market and Accounting Research (CSMAR) financial database. Chinese government has been providing R&D subsidies using direct government funding. Although Chinese government provide R&D tax incentive as another means of government subsidy, information of R&D tax incentive is only available from 2009 (OECD, 2017). Therefore, we only use direct government funding in our paper. Although there is concern that the co-existence of R&D tax incentives might contaminate our result, as tax incentives are applied universally to firms with R&D expenditure, its impact is considered relatively neutral across different firms under the same tax system (Hall and Van Reenen, 2000).[4]

As our main identification strategy, we combine propensity score matching (PSM) with difference-in-differences (DiD) methods to disentangle the effects of the R&D subsidy on corporate innovation as the government might provide direct R&D support to certain firms. To mitigate endogeneity concerns regarding the EIP, we employ instrumental variable approach within the PSM framework.

Our main result shows that R&D subsidy exerts positive bearing on the performance of corporate innovation. Our empirical analyses also show positive and significant impacts of EIP on firms' innovation outputs, after controlling for R&D expenditure and other determinants. The results remain robust for different innovation measures, estimation methods, and after taking account of endogeneity issues. Most importantly, we compare the economic significance of government subsidy and EIP on innovation. We find that doubling the existing EIP amount (CNY18,400,000) would lead to 2.8% increase in the number of total patents and doubling the existing R&D subsidy (CNY921,751) would lead to 0.61% increase in the number of total patents in next period, suggesting that internal incentive has more efficient impact on innovation compared with direct government subsidy.

The rest of the paper is organized as follows. The next section provides a review of literature related to the determinants of corporate innovation. Section 3 elaborates the study sample, data source, and the definitions of our key variables and control variables. Descriptive statistics and analysis are presented in section 4, followed by empirical strategy in section 5.

[4] Year fixed effects and regional fixed effects is expected to absorb any differences in R&D tax incentives for different years and regions.

Section 6 provides our estimation result. Section 7 describes the economic significance of our model. Section 8 briefly discusses robustness tests. Section 9 concludes.

2. Related Literature

As our study focuses on the effects of the government's R&D subsidy and firms' internal incentive scheme, it is related to two strands of literature. The first literature is related to the impact of R&D subsidies on innovation.

A number of papers point out the positive effects of the government subsidy in improving innovation outcomes. By analyzing the R&D activity in China from 2007-2011, Deng and Hu (2014) find that R&D subsidy plays a beneficial role in increasing patent application. This finding is also in line with Guo et al. (2014), whose study period is from 1999 to 2011, suggesting that the subsidy of the Innovation Fund for Small and Medium Technology-based Firms (Innofund subsidy) positively affects the patent filing. Similarly, Le and Jaffe (2017) find positive effect of R&D subsidy on innovation outcomes for New Zealand firms. The probability of introducing new products or services by the subsidy-receiving firms doubles that of the non-receiving firms; however, the impact is much smaller in terms of the business process innovation. A study that examines the case of Northern Italian firms also finds that the R&D grants positively and significantly affect the innovation outcome as measured as the number of patents (Bronzini & Piselli, 2016). Another case study using a cross-sectional dataset of 2,785 Canadian manufacturing firms and non-parametric matching method also finds the positive effect of R&D subsidy on innovation performance (Bérubé & Mohnen, 2009). For the study carried out in Japan, the government funding plays a beneficial role in increasing the patent filing of the firms that participate in the research consortium (Branstetter & Sakakibara, 2002).

However, the positive effects of the R&D subsidy are not always observed. In the recent study, Wei et al. (2017) do not find any linkages between R&D subsidy and innovation output. In a similar fashion, Guan and Yam (2015) find that the government incentive supports in the mid-1990s, including R&D grants, tax credits, and special loans, have detrimental or at best neutral effects on innovation outcome as measured by patents. Based on the evaluation studies of the Government Technology Development Funds in Argentina, Brazil, Chile, and Panama, the positive and significant impacts of government subsidy on patents or new products are not observed (Hall & Maffioli, 2008).

The second line of literature relates to the roles played by the firm's internal incentives for executives or non-executives and various factors in linking their performances with innovation. This stream of literature begins with the investigation of the impact of managerial incentives on corporate innovation. The increase in long-term incentive schemes such as stock options and restricted stock provided to corporate R&D managers results in higher number of patents (Lerner & Wulf, 2007). This finding is further confirmed by Francis, Hasan, and Sharma (2011) whose study shows that stock options as incentives for executives ameliorate the innovation performance. As Chief Executive Officers (CEOs) feel secured of their jobs that are ensured by the high level of institutional ownership, firms' innovation productivity increases (Aghion, Van Reenen, & Zingales, 2013). Holthausen, Larcker, and Sloan (1995) document weak evidence that the higher the proportion of the compensation of divisional CEOs is in the form of long-term, the higher the ratio of the patent awards to sales in the division is. For the role of non-executives in corporate innovation, Chang et al. (2015) show that employee stock options for non-executives, whom they are called file-and-rank staff, exhibit positive effects on innovation outcomes. The positive effect is even larger given smaller the free-riding among the staff and longer the duration of the stock options. Using multiple dimensions to measure employee treatment, Chen, Chen, Hsu, and Podolski (2016) find firms with better employee treatment schemes produce more and better patents through improving employee satisfaction and teamwork.

To sum up, the existing literature on the impacts of the government's R&D subsidy or funding is inconclusive. Whereas some studies underline the beneficial role of the R&D subsidy, some other studies do not find any evidence or at worst the contrary results. Regarding the role of the firms' internal incentive plan, there are a number of studies examining the effect of incentive plan for managers, but the effect of incentive plan for employees is less examined. Particularly, the empirical analysis of the impacts of R&D subsidy and employee incentive plan together has never been attempted.

3. Data

3.1 Sample

The sample includes 2,632 publicly listed Chinese companies for the fiscal year from 2007 to 2014. Data were downloaded from the CSMAR financial database. The sample firms include those A-share listed on all three boards (Mainboard, Growth Enterprise Board and Small and Medium-sized Enterprise Board) in mainland Shanghai Stock Exchanges and Shenzhen Stock Exchanges.

3.2 Measuring innovation

We employ patents to measure corporate innovation, which is the dependent variable in our regression analysis. Since innovation is broadly defined, patents are not the perfect measure of innovation.[5] Against this backdrop, the literature extensively uses patents to measure the performance of innovation (Griliches, 1998). Despite being imperfect, patents are most widely

[5] In his seminal work in the 1930s, Joseph Schumpeter classified innovation into five categories including the introduction of new product or service, new production process, new market opening, new sources of raw materials, and changes of industrial organization.

used in the literature. Our patent data is collected from the CSMAR database. The procedure of patent filing in China is similar to countries such as the United States and European countries. The patent applicants are encouraged to search existing and published patents database before filing their applications in order to assure themselves the novelty of patent applications (Fang, Lerner, & Wu, 2017). In China, there are three categories of patents: invention, utility model, and design. As the top patent category, invention patents cover the most innovative contents such as new technologies and creation. The second-ranked patent category is utility model patents that emphasize novel applications of existing technologies or creation. The last patent category is design patents that award the new design or appearance of existing products or creation. Reflecting the level of innovative content, the length of time required to successfully acquire a patent varies across the three categories of patents (Lin et al., 2011). Invention patent applications need to go through two sequential examinations by state officials, including preliminary and detailed examination, which could last from 18 to 36 months. Utility model patent applications involve only one round of examination by state officials, taking the length between three and six months. We exclude the 'design' category in our analysis because the patents in this category have little innovative contents, which are not up to the standards used in other countries such as the United States or Japan.

We use both patent application and patent stock to measure the performance of corporate innovation. In total, there are six innovation variables. The patent application variables include total patent application (*Total patent appl*), invention patent application (*invention patent appl*), and utility model patent application (*utility model patent appl*). The total patent application is the total number of patent application in both invention and utility model categories. Similarly, the patent stock variables include total patent stock (*total patent stock*), invention patent stock (*invention patent stock*), and utility model patent stock (*utility model patent stock*). The total patent stock is the sum of both invention and utility model patents.

R&D subsidy

The data of subsidy is collected from the published statements notes of the listed firms from the CSMAR database. Specifically, we downloaded footnotes to non-operating income account in audited annual consolidated reports. R&D subsidy includes both administrative and operating funding granted by the Chinese government to support basic research, applied research, and experimental development related to patents and innovative products. The subsidy in the sample are restricted to those realized in that given accounting period, excluding those deferred to the subsequent periods.

Measuring employee incentive plan (EIP)

The data of EIP is sourced from the CSMAR's Corporate Governance section. In December 2005, China Securities Regulatory Commission (CSRC) released Measures for the Administration of the Equity Incentives of Listed Companies (MAEILC – Trial version) effective from January 1, 2006.[6] Under this legislation, listed companies can apply for implementation of equity incentive measures and establish comprehensive incentive and regulatory schemes to their employees. For these measures, "equity incentives" means long-term incentives whereby a listed company uses the stock of its own as means to motivate its directors, senior executives and core technicians and other employees, excluding independent directors. If a listed company applies decides to implement, the company must set up the conditions for the incentive grantees to obtain and exercise equities and it is obliged to disclose relevant information.

[6] Ten years after the trial introduction, CSRC formally implemented the MAEILC in 2016 with more detailed conditions and restriction. For example, an employee of foreign nationality who serves as a director, senior executive, core technician or core business specialist of a listed company in China may be the incentive grantee under the 2016 official version but not under the trial version. On the contrary, supervisors cannot be granted incentives under the 2016 official version but they are eligible under the trial version.

There are three incentive rights used in calculating the EIP variable: stock options, restricted stock, and stock appreciation rights. The definitions of the three incentive rights are provided in the *Appendix A*. We construct the EIP variable as the ratio of the number of incentive shares to total shares outstanding for firm *i* in year *t*.

Control variables

Based on the extant literature in corporate innovation, we include a set of variables that control various firm characteristics as follows:

Managerial ownership is constructed as the number of shares owned by managers as a proportion of total share outstanding of firm *i* in year *t*. We expect higher managerial ownership increases innovation as incentives of the management will be aligned with long-term stock performance. The next control variable is firm size (*Size*) measured as the natural logarithm of total asset of the firm *i* in year *t*. As cited by Chang et al. (2015), large firms or capital-abundant firms are expected to produce a higher number of patents and patent applications (Hall & Ziedonis, 2001). The *R&D expense* is a crucial defining force in propelling innovation, and is an important control variable. If the firm's R&D expenditure is not accounted for, the coefficients of the right-hand sided variables would reflect both the increase in R&D expenditure as well as innovation productivity (Aghion et al., 2013) The variable is computed as the proportion of the R&D expenditure to total asset of firm *i* in year *t*.

Overseas is a dummy variable that is coded 1 if the firm has overseas sales for firm *i* in year *t*, and 0 otherwise. Firms that have overseas sales are exposed to competitive global markets; thereby, they are expected to be more innovative. *Coastal* is also a dummy variable which equals 1 if the headquarters of the firm is located in coastal provinces and 0 otherwise. *SOE* is a dummy variable that is coded 1 if the government is the largest shareholder or a nominal agent controlled by the government is the largest shareholder of firm *i* in year *t*, and 0 otherwise. Fang et al (2017) show that SOEs have less innovation activity than private firms. We control for political connection (*rel rank*), which is a category variable. It measures the highest ranked government position the board members have served in the past with rank from 1-below county level to 5-central government level. We also control for employment. According to Lee, Walker, and Zeng (2014), human capital plays a role in receiving a subsidy. Finally, *HHI* refers to the Herfindahl-Hirschman Index which is to measure the level of competition that a firm is exposed to. In other words, it quantifies the market power of the firm. The *HHI* variable is calculated as the sum of the squares of the market share of firm *i* in the market in year *t*. (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005) showed, both theoretically and empirically, that the relation between HHI and innovation has an inverted U-shape since firms can increase profits from innovating when competition is less, while the monopoly rent of innovation decreases when product market competition intensifies Thus, we follow the prior works (Atanassov, 2013; Chang et al., 2015; Chemmanur & Tian, 2017) by including both the HHI and the squared HHI (*HHIsq*). Definitions of all variables are presented in Appendix A.

4. Descriptive Statistics

4.1. The explosive growth of innovation

Descriptive statistics of innovation variables is reported in Table 1. By examining the disaggregated data at the firm level, it is remarkable that the average number of patent application per firm increased dramatically from 29 patents per firm in 2007 to 44 patents per firm in 2014. Consequently, the average number of patent stock per firm surged nearly four-folds from 30 patents per firm in 2007 to 118 in 2014. Among the two types of patents including invention and utility model, the number of utility model patents experienced the fastest growth from 21 utility model patents per firm in 2007 to 79 in 2014. The proportion of patenting firms gradually increased from 35% to 55%. This growing trend appears to be in line with China's economic development process that has been transitioning from a low-income economy to an emerging market economy. For more details on the patenting firms only, Appendix B presents the distribution of patent data across industry sectors.

<Insert Figure 1 and Table 1 here>

4.2. R&D subsidy

We perform a simple examination of the evolution and trend of the government's R&D subsidy, which is one of our main variables of interest that perhaps could explain the performance of corporate innovation in China. The descriptive statistics of the R&D subsidy is reported in Table 2. The number of R&D subsidy receipt for all firms exponentially rose from 122 in 2007 to 1,752 in 2014. In monetary term, total aggregate R&D subsidy rose approximately twenty-folds from less than CNY 600 million in 2007 [equivalent to USD 92 million] to CNY 12,000 million in 2014 [equivalent to USD 1,846 million].[7] The R&D subsidy started to make a tremendous hike in 2011 when the aggregate R&D amount rose to around CNY 10,000 million, rising almost fifteen-folds from an average of CNY 676 million during 2007-2010. Since then, it was maintained above CNY 10,000 million annually. Against the backdrop of rising aggregate R&D subsidy, the average R&D subsidy per firm rose 41 percent from around CNY 4.9 million in 2007 to CNY 6.8 million in 2014. This phenomenal increase in R&D subsidy was in parallel with the sizable growth of patent stock which also began in 2011.

[7] The exchange rate we used is the average of end-of-the year exchange rate at yearly frequency from 2007 to 2014, which is at 1USD=6.5CNY.

Panel B examines the distribution of R&D subsidy across sectors over the sample period. The manufacturing sector absorbed the largest number of R&D subsidy deals. This sector received a total of 5,182 R&D subsidy deals with an average value of CNY 7.6 million per firm. With 464 R&D subsidy deals, the information, technology & telecommunication sector was the second highest, followed by the wholesale & retail trade sector that accounted for 186 deals. Financial sector acquired the lowest number of R&D subsidy deals, totalling 18 deals during the sample period. Considering the average value of R&D subsidy per firm, the construction received the highest average value of R&D subsidy per firm given the average value of CNY 9.9 million. Given the average value of R&D subsidy per firm of CNY 9.5 million, utility sector was the second highest, followed by the manufacturing sector with an average value of CNY 7.6 million per firm.

<Insert Table 2 here>

4.3. Employee incentive plan (EIP)

Descriptive summary of the EIP is reported in Table 3. Since China Securities Regulatory Commission released guidelines for equity incentives in end-2005, percentage of firms that introduced equity incentives for both executive and non-executive employees increased from 12.98 percent in 2006 to 19.98 percent in 2014 (Table 3 Panel A). Among the firms that adopted EIP, the average value of EIP per firm has been around CNY 266 million on average, which amounts to around 9 percent of the total share outstanding, during the sample period from 2007-2014.

Table 3 Panel B shows that the predominant form of EIP is ‘stock options,’ which account for 1,109 deals or 53 percent of the total EIP deals. Whereas the ‘restricted stocks’ comprise 951 deals or 45 percent of the total EIP deals, the ‘stock appreciation rights’ consists of the remaining 46 deals. Among the three types of EIP, the average value of the EIP per deal in the form of stock options is the highest. Its average value is CNY 318 million per deal. It is followed by stock appreciation rights and restricted stocks whose average values per deal are CNY 231 million and CNY 194 million, consecutively.

Panel C of Table 3 shows that nearly half of granted EIPs are not vested, and the average value of vested EIPs is only around 20% of granted EIPs for stock options and restricted stocks. The vested proportion of stock appreciation rights is less than one percent in value. As corporations set high vesting hurdles for EIPs, not all employees can achieve the hurdles, resulting in a lower percentage of vested than granted EIPs. Panel D shows the distribution of EIPs across different industries. We find that the highest percentage (46 percent) of firms adopted EIP in the information technology and telecommunication industry which has the highest concentration of technology incentive firms.

<Insert Table 3 here>

Summary statistics of patent variables and other variables are reported in Table 4. The average value of managerial ownership is 0.3 percent of the firm's total share outstanding, and its maximum value is 13.9 percent. The average R&D expenditure is 0.001 percent of the firm's total assets, and maximum expenditure is 0.216 percent. The average firm size is 6,107 employees while the most employed firm has up to 552,810 employees.

<Insert Table 4 here>

5. Empirical Strategy

5.1. Selection issue of government subsidies

The main challenge in evaluating the effect of government subsidy on corporate innovation is selection bias. We ideally expect firms to be granted subsidy randomly from the government so that the causal relationship between subsidy and corporate innovation performance can be validly inferred. However, the provision of government subsidy may not be random. Some firms may self-select themselves into the government's subsidy application process and then are chosen by the government to receive the subsidy. This self-selection problem would lead to biased estimates of the subsidy's impacts (See survey article by David, Hall, and Toole (2000).) To address this selection bias problem, we carry out the analysis in two steps by combining propensity score matching (PSM) with difference-in-differences (DiD) methods. The combination of PSM with DiD methods can arguably help enhance the accuracy of the impact evaluation (Blundell & Costa Dias, 2000; Görg & Strobl, 2007). The first step is the implementation of PSM to match treated and non-treated firms. The PSM method allows us to match the treated firms that receive government R&D subsidy with non-treated firms on the basis of 'common support'(Caliendo & Kopeinig, 2008), where treated firms and non-treated firms are matched to create a new sample based on observable covariates. We can thus compare the difference in their innovation performances based on the same conditions or characteristics. The undertaking of PSM helps address a fundamental requirement of the DiD method whose important assumption is that both the treated and non-treated firms are supposed to respond identically to common macro or country-level policy shocks or changes. After obtaining the matched sample, we use the DiD approach to disentangle the impact of subsidy on corporate innovation. The method computes the difference of innovation between the treated firms and non-treated firms and compares the difference before and after the granting of the subsidy.

We define the treatment group as firms that receive R&D subsidy at least once in our sample period. Then, this firm is coded as 1 in all sample period. The control group is firms that never receive R&D subsidy during the whole sample period. Then the firm is coded as 0 in all sample period. When performing the propensity score matching, we select control firms within the same industry and year that have similar R&D expense ratio, employment, SOE status, political connection, managerial ownership, size, and overseas sales. The firms in the control group are matched based on all available firms included in our treatment group. By using a calliper of the 0.1 specification, the nearest neighbour for each treatment firm is then included in the control group.

Prior to the matching, we examine the differences in the variables for treatment versus non-treatment groups. The left panel of Table 5 shows that the differences in firm characteristics including *R&D expense, employment, size, rel rank, and managerial ownership*, are all statistically significant at the 0.01 significance level. After the PSM, the right panel of the table shows that the differences between the treatment and control groups in the five covariates have become economically small and statistically insignificant. Using the matched sample, we proceed to conduct the DiD analysis.

<Insert Table 5 here>

5.2 Endogeneity of workers' equity incentives

The second problem of endogeneity arises if some unobservable firm characteristics jointly affect equity incentives and innovations. For example, a firm that has identified an (unobservable) growth potential will increase innovation in the related technology, at the same time providing greater equity incentives for its employees to enhance the innovation. Although our regression controls for various firm-level variables, we use "i*ndustry-location"* variable as the instrumental to mitigate such endogeneity issues. Developed by Fisman and Svensson (2007) and used by Lin et al. (2011) in the context of incentives and innovation, they point out that if the endogeneity problem is specific for firms, but not for industry or location, then taking out firm-specific component makes the instrument variable only dependent on the underlying characteristic to particular industries and/or locations which is exogenous to the firm. For example, Kedia and Rajgopal (2009) shows the similarity of employee stock options policies among firms in the same local geography. In our case, since a firm in the same location and industry may compete for similar talents, this instrument is expected to be positively correlated with EIP of the firm, while EIP offered by individual competitors should not have a direct impact on the firm's innovative outputs. The *industry-location* variable is calculated as the average value of the EIP for all firms within the same year, industry, and location. We augment our DiD analysis with two-stage least squares (2SLS) using the industry-location variable as the instrument.

6. Estimation

In this section, we estimate the effects of subsidy and EIP on corporate innovation outputs using the following baseline model using the PSM sample:

$$Ln(1+Innovation_{it}) = \alpha + \beta Treatment_{it} * Post_{it} + \varphi Treatment_{it} + \gamma Post_{it} + \lambda EIP_{i,t-1} + \delta X_{i,t-1} + \varepsilon_{it} \quad (1)$$

Where, subscripts i and t denote firm and year, respectively. *Innovation* refers to the six measures of innovation including # *Total patent appl,* # *Invention patent appl,* # *Utility model patent appl,* # *Total patent stock,* # *Invention patent stock,* and # *Utility model patent stock.* Following previous literature, we apply natural logarithm of one plus the values of innovation variables to mitigate the variables' skewness as well as to allow firm-years that have zero innovation. *EIP* is the employee incentive plan (EIP), measured as the ratio of number of incentive shares to total shares outstanding. X is a vector of control variables including *managerial ownership, overseas, size, coastal, R&D expense, SOE, HHI,* and *HHI sq*. The EIP and control variables enter the model with one-year lag. According to prior work, it is postulated that the innovation outputs in a given year are affected by subsidy, EIP, and other explanatory variables that are measured at the end of the prior year. Moreover, the use of one-year lagged explanatory variables can mitigate simultaneity concern. *Treatment* is a dummy variable that is coded as unity if a firm receives R&D subsidy from the government in any particular year in the sample period, and 0 otherwise. *Post* is a dummy variable that is coded as unity after a firm receives the latest R&D subsidy from the government, and 0 otherwise. *Treatment* * *Post* denotes the difference-in-difference variable whose coefficient β captures the average treatment effect of the subsidy on innovation. Also, λ is the parameter of interest that captures the effect of EIP on innovation.

First, we use the ordinary least squares (OLS) method to estimate the DiD baseline model (*Equation 1*), where the results are reported in Table 6. The DiD coefficient (Treatment*Post variable) is statistically significant at the 5% significance level for the invention patent application and at the 1% significance level across other five measures of innovation. The EIP is positively associated with all innovation variables at the 1% significance level. The coefficient estimates of the DiD and EIP are positively and statistically significant across different measures of innovation, suggesting strong evidence of the positive effects of the subsidy and EIP on innovation performance.

The other control factors also exert influence on firm's innovation outputs. The coefficients of the managerial ownership, overseas, and size variables are positively and significantly associated with all the six innovation measures at the 1% level. The coastal and SOE variables have strongly significant, but negative, effects on the six measures of innovation. Being a SOE tends to have poor performance in innovation, compared to non-SOE firms as its coefficient is negative and significant at the 1% level across the six measures of innovation. Similar to the findings in the previous literature, the relationship between HHI and innovation variables is inverted u-shaped. The coefficient of the HHI is negatively significant at the 1% level, and the HHI square is positively significant at the 1% level.

<Insert Table 6 here>

The results of the two-stage least squares (2SLS) regression are presented in Table 7. The first-stage regression is reported in column 1. The variable ‘industry-location’ is positively and strongly associated with EIP at the 1% significance level. The instrumental variable is also confirmed of its appropriateness, for it passes relevant tests. The *F*-statistic obtained from the joint test of excluded instruments is 170 and significant at the 1% level, which indicate the models do not have weak instrument problems.

The second-stage results of the 2SLS regression for each of the six measures of innovation are presented in column 2-7. The results are generally in line with our baseline results. The EIP exerts a positive and significant effect on firm’s innovation outputs. The EIP coefficient is statistically significant at the 1% level across the six measures of innovation. It is important to note that the magnitudes of the EIP coefficients, ranging from 4.459 to 8.499, are larger than those of the baseline OLS regression whose range is 3.491 – 5.900. In short, firms that have the incentive plan for employees have better innovation outputs than the firms that do not implement the employee incentive plan.

The average treatment effect of the R&D subsidy which is captured through the coefficient of the ‘Treatment*Post’ variable under this DiD 2SLS regression remains positive and significant. The coefficients are positively and statistically significant at the 1% level across the six measures of innovation. The sizes of the coefficients range from 0.193 to 0.487. Hence, firms receiving R&D subsidy from the government has better innovation performance than the firms that do not.

Similar to the baseline results, the control variables, except the R&D expense, remain statistically significant and are strongly associated with the six measures of innovation. The coefficients of managerial ownership, overseas, and size are positively and significantly related to the six measures of innovation. While coastal and SOE coefficients are negatively but strongly significant at the 1% level, the coefficients on HHI and HHI square are negatively and positively significant, respectively.

<Insert Table 7 here>

7. Economic Significance

In this section, we extend our econometric analysis to investigate the economic significance of the R&D subsidy and EIP on corporate innovation. In an attempt to derive the economic impacts of the R&D subsidy and EIP, we conduct the 2SLS regression by using the actual EIP amounts (EIP) and R&D subsidy amount in Chinese Yuan instead of EIP (in percentage) and a R&D dummy variable that we used in our PSM sample. By including the actual EIP amount and actual R&D subsidy value in regression, we estimate the coefficients to calculate how much Chinese Yuan would contribute to the number of patents for listed firms. *EIP* variable is calculated as natural logarithm of one plus the amount of employee incentive plan in Chinese Yuan. All other variables remain the same as discussed in the DiD baseline model in Section 6. We report the results for the 2SLS regression in Table 8, and we summarize the economic significance of EIP and R&D subsidy in Table 9.

Since we use the log-log specification in Table 8 the coefficients represent elasticity of patent application (or stock) with respect to increase in EIP or R&D subsidy. In Table 8, the coefficients of EIP are positively and strongly significant at the 1% level across the six measures of innovation. The R&D coefficients are positively significant for various measures of innovation, except for invention patent application and invention patent stock. The R&D coefficient is statistically significant at the 1% level only for total patent stock and utility model patent stock, while they are significant at the 10% and 5% levels for total patent application and utility model patent application, respectively. The coefficients of other explanatory variables, except *R&D expense* are generally significant across the six measures of innovation.

<Insert Table 8 >

To examine the economic significance of EIP and R&D subsidies, we use the result for total patent application in column 2 to illustrate the impact. Suppose we take two values of *EIP(amount)*, EIP1 and EIP2, and hold the other variables constant. *Innovation* represents the number of patent measures. The equation yields to

$\ln(1+Innovation)_{EIP1} - \ln(1+Innovation)_{EIP2} = 0.0394*[\ln(1+EIP1)-\ln(1+EIP2)]$

$=0.0394*\ln(EIP1/EIP2)$.

If the ratio of the two EIPs, is 10%, the expected ratio of the outcome variable, ln(1+*Innovation*), $e^{0.0394*\ln(1+10\%)}$=1.00376228. Thus, a 10% increase in EIP increases in innovation by 0.38%. Similarly, 100% increase in EIP (double the EIP), we get 2.8% increase in *Innovation* (i.e., $e^{0.0394*\ln(1+100\%)}$ =1.02768)]. We also note the exponential function has a decreasing marginal effect. For the effect of R&D subsidy, the coefficient is 0.00881 [column 2, table 8], a 10% increase in *R&D* subsidy increases total innovation application by 0.084% (i.e., $e^{0.00881*\ln(1+10\%)}$=1.00084004). With a 100% increase in *R&D* (double the R&D subsidy amount), total innovation application increases by 0.61% (i.e., [$e^{0.00881*\ln(1+100\%)}$ =1.0061]) In general, we find that for different innovation measures innovation is more sensitive to increase in EIP than that in government subsidies.

Next we compare how much increase in EIP or R&D subsidies increase innovation. To this end, we apply the elasticity coefficients to our PSM sample where the average value of EIPs is CNY18,400,000, that of R&D subsidy is CNY921,751 and the average number of total patent is 17.8. As shown above, a 10% increase in EIP amount would lead to 0.38% increase in number of total patent, which is 0.067 total patent applications (see Table 9 Panel A, row 2). To achieve the same increase in total patent application, our estimate show that an increase of

53 percent of R&D subsidy is required, which is 5.3 times compared to 10% increase in EIP (see table 9 Panel B, last row).

In Table 9, we use this line of calculation for all our six models and present the results of economic significance Table 9. We find that EIP has a bigger effect on innovation than R&D subsidy in all innovation measures. Although not many listed firms have EIPs and even for those that have one, they do not offer EIP frequently. However, our results suggest that internal incentives are effective way to foster corporate innovation activities compared with government subsidies.

<Insert Table 9 >

8. Robustness tests

8.1. Interaction effect of R&D subsidy and EIP on innovation

In the analysis of internal and external incentives on innovation, we have shown each has a positive impact on innovation. It remains to examine if R&D subsidy and EIP substitute or complement each other. We interact the *R&D* variable with *EIP (amount)*. If there is a substitution effect, we expect to have a negative and significant coefficient on the interaction term. If there is a complementary effect, we expect to have a positive coefficient on the interaction term. Table 10 shows that the coefficients on the interaction term are not significant for all models. It suggests that the internal and external incentives work individually on corporate innovation.

<Insert Table 10 >

8.2. Interaction effect of SOE with R&D subsidy

The impact of R&D subsidy may vary across the ownership status. Here, we interact the SOE dummy with the R&D subsidy. Table 11 shows that SOE's effect (main effect) on innovation remains negative and statistically significant across all models. R&D subsidy's effect (main effect) on innovation is positive and significant for column 5 and 7. Yet, the interaction of SOE and R&D is not statistically significant across all models.

<Insert Table 11 >

9. Conclusion

Innovation activity would be under-invested from the perspective of optimal resource allocation if it is shouldered by private sector alone (Arrow, 1962) because innovation carries considerable risk of failure (Holmstrom, 1989). In this respect, Arrow (1962) underlines the important role of external incentive such as government's R&D subsidy or R&D public funding in stimulating innovation activity. However, recent research have found that firm's internal incentive (i.e. employee incentive plan) could enhance innovation. In this paper we compare its effectiveness with that of R&D subsidy in affecting corporate innovation.

Using a large sample of listed Chinese firms from 2007 to 2014, our study focuses on corporate innovation in China where R&D activity has substantially increased since 2005. Coincidently, during the same period, the China Securities Regulatory Commission Chinese released guidelines for equity incentives used in corporations which resulted in a relatively wide use of equity incentives, which provides us to compare the effectiveness of government subsidy and internal incentives on innovation. Therefore, this paper also provides insights to the large increase of patenting activities in China during the recent period. Our empirical analyses show positive and significant impacts of subsidy as well as of EIP on firms' innovation outputs, after controlling for R&D expenditure and other determinants. After taking account of endogeneity issues, we find that firms that obtain government subsidies generate more innovation outputs than those that do not. However, we find that firms that provide incentive schemes to their employees are also associated with better innovation performance. Our results show that internal equity incentives are more effective than government subsidies in increasing patent activity for Chinese firms.

The findings underline the important role of the incentive schemes that reward highly-performing employees in innovation. The study delineates several important implications in promoting corporate innovation. Although government subsidy continues to be an important policy tool in spurring innovation outcomes, internal incentives that reward highly-performing employees is also essential.

Table 1. Average number of patents per firm per year in raw data

This table reports average number of patents per firm per year for a sample of 2,632 Chinese listed firms between 2007 and 2014. # *Invention patent appl* is the number of invention patent application. # *Utility model patent appl* is the number of utility model patent application. # *Total patent appl* is the sum of invention and utility model patent applications. # *Invention patent stock* is the number of invention patent stock. # *Utility model patent stock* is the number of utility model patent stock. # *Total patent stock* is the sum of invention and utility model patent stock. *Proportion of patenting firms* is the ratio of the number of firms that hold patents to the total number of firms.

Variables	2007	2008	2009	2010	2011	2012	2013	2014
# Total patent appl	29.3	29.0	32.3	32.0	35.8	40.2	42.7	43.8
# Invention patent appl	19.2	17.9	19.6	18.3	19.0	20.6	22.4	21.4
# Utility model patent appl	10.0	11.2	12.6	13.7	16.8	19.6	20.4	22.4
# Total patent stock	29.7	37.3	44.6	49.1	62.3	78.5	98.8	117.9
# Invention patent stock	8.8	11.2	14.5	15.9	20.6	26.2	32.6	39.1
# Utility model patent stock	20.9	26.2	30.1	33.2	41.7	52.3	66.3	78.8
Proportion of patenting firms (patent application)	0.3	0.3	0.4	0.5	0.5	0.5	0.6	0.5
Proportion of patenting firms (patent stock)	0.4	0.4	0.4	0.5	0.6	0.6	0.6	0.6

Table 2. Descriptive summary of subsidy variables for the listed firms in China

This table reports the summary statistics of R&D subsidy for a sample of 2,632 Chinese listed firms between 2007 and 2014. *Panel A* presents total aggregate R&D subsidy amount in Chinese Yuan, the number of firms receiving R&D subsidy, and the average R&D subsidy per firm in Chinese Yuan by year. *Panel B* shows the number of R&D subsidy deals and the average R&D subsidy per firm in Chinese Yuan by sector over the 2007-2014 period.

Panel A: R&D subsidy by year

Variables	2007	2008	2009	2010	2011	2012	2013	2014
Total aggregate R&D subsidy (CNY)	592,000	1,390,000	388,000	332,000	10,000,000	11,700,000	11,200,000	12,000,000
# of firms receiving R&D subsidy	122	266	104	76	1,245	1,473	1,621	1,752
# of firms in the sample	1,549	1,603	1,753	2,107	2,341	2,470	2,515	2,632
Average R&D subsidy (CNY) per firm	4,855	5,227	3,733	4,364	8,050	7,935	6,879	6,831

Note: Total aggregate R&D subsidy and R&D subsidy per firm are measured in 1,000 Chinese Yuan (CNY).

Panel B: R&D subsidy by industry (for firms with positive R&D subsidy)

	# R&D subsidy deal	R&D subsidy per firm (CNY)
Agriculture, forestry, fishing & hunting	131	2,397
Mass Communication	40	2,905
Conglomerate	109	3,684
Construction	120	9,940
Finance	18	2,476
Manufacturing	5,182	7,639
Mining	112	7,281
Real estate	72	3,760
Social service	74	2,153
Information technology & telecommunication	464	6,273
Transportation & warehousing	64	1,687
Utilities	87	9,531
Wholesale & retail trade	186	4,224

Note: R&D subsidy per firm is measured in 1,000 Chinese Yuan (CNY).

Table 3. Descriptive summary of Employee Incentive Plan (EIP) variables

This table reports summary statistics of employee incentive plan for a sample of 2,632 Chinese listed firms between 2007 and 2014. *Panel A* shows, by year, the average EIP (%) and EIP (CNY) per firm in Chinese Yuan for the sample of firms with positive EIP (%) only. *EIP (%)* is the ratio of number of incentive shares to total shares outstanding for firm *i* in year t. *EIP (CNY)* is the amount of employee incentive plan in Chinese Yuan for firm *i* in year *t*. *Proportion of EIP firms* is the ratio of firms adopting EIP to the total number of firms. *Panel B* shows the number of granted EIP deals for listed firms and the average value of the granted EIP per deal by different types of EIP including stock options, restricted stocks, and stock appreciation rights. *Panel C* shows the number of vested EIP deals for listed firms and the average value of the vested EIP per deal by different types of EIP. The granted EIP is the equity incentive plan which is already given to employees while the vested EIP is the incentive plan that is yet to realize. *Panel D* shows the percentage of the firms that have EIP plan out of the total sample, EIP (%) per firm, and EIP per firm in Chinese Yuan by sector. *EIP (%)* is the ratio of number of incentive shares to total shares outstanding. *EIP (CNY)* is the amount of employee incentive plan in Chinese Yuan. *A stock option* is a privilege, sold by one party to another that gives the buyer the right, but not the obligation, to buy or sell a stock at an agreed-upon price within a certain period of time. *Restricted stocks* refer to stock of a company that is not fully transferable (from the stock-issuing company to the person receiving the stock award) until certain conditions (restrictions) have been met. *A stock appreciation right (SAR)* is a bonus given to employees that is equal to the appreciation of company stock over an established time period.

Panel A: EIP per firms that adopt employee incentive plan

Variables	2007	2008	2009	2010	2011	2012	2013	2014
EIP (%)	0.106	0.119	0.095	0.082	0.08	0.086	0.08	0.065
EIP (CNY)	285,000	307,000	224,000	308,000	286,000	253,000	240,000	227,000
Proportion of EIP firms	12.98%	13.91%	16.54%	19.36%	20.72%	20.93%	20.87%	19.98%

Note: EIP (CNY) is measured in 1,000 Chinese Yuan.

Panel B: Types of granted EIP and the value of granted EIP per deal

Types of EIP	# granted EIP deals for all firms	Average Granted EIP (CNY) per deal
Stock options	1,109	318,000
Restricted stocks	951	194,000
Stock appreciation rights	46	231,000

Note: EIP (CNY) per deal is measured in 1,000 Chinese Yuan.

Panel C. Types of vested EIP and the value of vested EIP per deal

Types of EIP	# vested EIP deals for all firms	Average vested EIP (CNY) per deal

Stock options	663	69,500
Restricted stocks	491	40,000
Stock appreciation rights	17	1,697

Note: EIP (CNY) per deal is measured in 1,000 Chinese Yuan.

Panel D. Industry distribution for granted EIP per firms that adopt employee incentive plan

	% of firms have EIP	EIP (%) per firm	EIP (CNY) per firm
Agriculture, forestry, fishing & hunting	15.83%	0.025	101,000
Mass Communication	16.22%	0.112	267,000
Conglomerate	22.88%	0.070	438,000
Construction	19.34%	0.080	315,000
Finance	2.69%	0.001	133,000
Manufacturing	20.71%	0.076	217,000
Mining	0.00%	0.000	0
Real estate	14.46%	0.059	523,000
Social service	17.32%	0.105	621,000
Information technology & telecommunication	45.97%	0.102	229,000
Transportation & warehousing	4.93%	0.037	55,000
Utilities	4.28%	0.056	170,000
Wholesale & retail trade	11.10%	0.056	220,000

Note: EIP (CNY) is measured in 1,000 Chinese Yuan.

Table 4. Descriptive statistics of patent variables and other variables

The table reports summary statistics of variables that are used in regression analysis. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. *Size* is the natural logarithm of the firm's total assets. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *HHI* is the Herfindahl-Hirschman Index calculated as the sum of the squares of the market share of each firm in the market. *Employment* is the number of employees in a firm divided by its assets and then scaled by 10^6. *Invention patent appl* is the natural logarithm of one plus the number of invention patent application. *Utility model patent appl* is the natural logarithm of one plus the number of utility model patent application. *Total patent appl* is the natural logarithm of one plus the number of total patent application in both invention and utility model categories. *Invention patent stock* is the natural logarithm of one plus the number of invention patent stock. *Utility model patent stock* is the natural logarithm of the one plus the number of utility model patent stock. *Total patent stock* is the natural logarithm of one plus the number of total patent stock in both invention and utility model categories.

Variable	Obs	Mean	Std.Dev.	Min	Max
Managerial ownership	16,970	0.295	0.700	0.000	13.851
Size	16,966	21.779	1.504	10.842	30.657
R&D expense	16,970	0.001	0.007	0.000	0.216
HHI	16,969	0.059	0.106	0.008	0.568
Employment	16,915	0.995	1.328	0.002	78.226
Total patent appl	16,970	1.166	1.488	0	8.704
Invention patent appl	16,970	0.829	1.209	0	8.664
Utility model patent appl	16,970	0.800	1.265	0	7.513
Total patent stock	16,970	1.611	1.797	0	9.727
Invention patent stock	16,970	0.896	1.265	0	9.616
Utility model patent stock	16,970	1.324	1.703	0	8.558

Table 5. Differences in firm characteristics before and after PSM matching

This table reports the results of the application of propensity score matching (PSM) based on the firms that obtain R&D subsidy from government. We define the treatment group as firms that receives R&D subsidy at least once in our sample period. When performing the propensity score matching, we select control firms within the same industry and year that have similar R&D expense ratio, employment, SOE status, political connection, managerial ownership, size, and overseas sales. The firms are matched based on all available firms included in our sample except for the treatment group. By using a calliper of the 0.1 specification, the nearest neighbour for each treatment firm is then included in the control group. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *Employment* is the number of employees in a firm divided by its assets and then scaled by 10^6. *Size* is the natural logarithm of the firm's total assets. *Rel (Rank)* is the highest ranked government position the board members have served in the past, with rank from 1-below county level to 5-central government level. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Before matching			After PSM matching		
Variables	Mean treatment	Mean unmatched control	Differences	Mean treatment	Mean matched control	Differences
	(1)	(2)	(3)	(4)	(5)	(6)
R&D expense	0.0178	0.00379	0.01401***	0.00058	0.00052	0.00006
Employment	1.064	0.765	0.299***	0.940	0.903	0.037
Size	21.658	22.178	-0.51***	21.916	21.928	-0.012
Rel (Rank)	3.8	3.7	0.1***	3.711	3.729	-0.018
Managerial Ownership	0.358	0.085	0.273***	0.12	0.107	0.013

Table 6. DiD OLS regression baseline results in PSM sample

In this table, we report the baseline results of the difference-in-differences regression in the PSM sample which is the sample after being matched by using propensity score matching (PSM) method. *Invention patent appl* is the natural logarithm of one plus the number of invention patent application. *Utility model patent appl* is the natural logarithm of one plus the number of utility model patent application. *Total patent appl* is the natural logarithm of one plus the number of total patent application in both invention and utility model categories. *Invention patent stock* is the natural logarithm of one plus the number of invention patent stock. *Utility model patent stock* is the natural logarithm of the one plus the number of utility model patent stock. *Total patent stock* is the natural logarithm of one plus the number of total patent stock in both invention and utility model categories. *Treatment*Post* denotes the difference-in-difference variable that captures the average treatment effect of the subsidy on innovation. *EIP (%)* is the ratio of number of incentive shares to total shares outstanding. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. *Overseas* is a dummy variable which equals one if the firm has overseas sales. *Size* is the natural logarithm of the firm's total assets. *Coastal* is a dummy variable that equals 1 if the headquarters of a listed firm is located in coastal provinces. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *HHI* is the Herfindahl-Hirschman Index calculated as the sum of the squares of the market share of each firm in the market. *HHI sq* is the square of the HHI index. *SOE* is a dummy variable which equals one if the government is the largest shareholder, or a nominal agent controlled by the government is the largest shareholder. *Treatment* is a dummy variable that is coded one if a firm receives R&D subsidy from the government in any particular year in the sample period, and 0 otherwise. *Post* is a dummy variable that is coded one after a firm receives the latest R&D subsidy from the government, and 0 otherwise. Robust standard errors are in parentheses. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Total patent appl (1)	Invention patent appl (2)	Utility model patent appl (3)	Total patent stock (4)	Invention patent stock (5)	Utility model patent stock (6)
Treatment*Post	0.285***	0.155**	0.244***	0.458***	0.225***	0.417***
	(0.0794)	(0.0630)	(0.0667)	(0.0991)	(0.0681)	(0.0907)
L.EIP (%)	5.632***	4.718***	3.491***	5.900***	4.513***	4.867***
	(1.613)	(1.405)	(1.291)	(1.910)	(1.619)	(1.742)
L.Managerial ownership	0.335***	0.223***	0.237***	0.381***	0.131**	0.369***
	(0.0725)	(0.0557)	(0.0642)	(0.0854)	(0.0526)	(0.0827)
L.Overseas	0.460***	0.347***	0.324***	0.657***	0.419***	0.578***
	(0.0592)	(0.0486)	(0.0487)	(0.0742)	(0.0538)	(0.0683)
L.Size	0.250***	0.207***	0.198***	0.287***	0.198***	0.255***
	(0.0193)	(0.0175)	(0.0168)	(0.0216)	(0.0187)	(0.0198)

Coastal	-0.149***	-0.0991***	-0.150***	-0.151***	-0.0815**	-0.171***
	(0.0367)	(0.0293)	(0.0306)	(0.0451)	(0.0321)	(0.0411)
L.R&D expense	4.073	8.047	-0.389	12.17	18.50	4.197
	(9.988)	(10.22)	(5.972)	(13.50)	(13.68)	(9.442)
L.HHI	-4.362***	-3.594***	-2.379***	-5.754***	-4.239***	-4.229***
	(0.757)	(0.624)	(0.606)	(0.898)	(0.641)	(0.805)
L.HHI sq	12.91***	10.73***	7.849***	16.08***	11.78***	12.12***
	(1.763)	(1.466)	(1.377)	(2.091)	(1.502)	(1.840)
SOE	-0.119***	-0.0768**	-0.114***	-0.254***	-0.182***	-0.195***
	(0.0415)	(0.0344)	(0.0345)	(0.0491)	(0.0352)	(0.0452)
Treatment	-0.256***	-0.232***	-0.203***	-0.236***	-0.187***	-0.231***
	(0.0408)	(0.0327)	(0.0335)	(0.0513)	(0.0356)	(0.0462)
Post	-0.224***	-0.151***	-0.169***	-0.335***	-0.207***	-0.270***
	(0.0605)	(0.0514)	(0.0505)	(0.0695)	(0.0521)	(0.0635)
Constant	-4.740***	-3.982***	-3.788***	-5.272***	-3.686***	-4.753***
	(0.401)	(0.366)	(0.348)	(0.448)	(0.392)	(0.411)
Observations	3,601	3,601	3,601	3,601	3,601	3,601
R-squared	0.195	0.193	0.166	0.188	0.172	0.174
F test	29.59	23.86	23.13	35.31	22.89	31.93
Adjusted R square	0.192	0.191	0.164	0.185	0.169	0.172

Table 7. DiD multivariate analysis with two-stage least squares (2SLS) estimation in PSM sample

In this table, we report the estimation results of the DiD multivariate model using 2SLS to address the concern that the *EIP (%)* is an endogenous variable. The *EIP (%)* is instrumented by the *industry location* variable, which is measured as the average value of the EIP for all firms within the same year, industry, and location. *Invention patent appl* is the natural logarithm of one plus the number of invention patent application. *Utility model patent appl* is the natural logarithm of one plus the number of utility model patent application. *Total patent appl* is the natural logarithm of one plus the number of total patent application in both invention and utility model categories. *Invention patent stock* is the natural logarithm of one plus the number of invention patent stock. *Utility model patent stock* is the natural logarithm of the one plus the number of utility model patent stock. *Total patent stock* is the natural logarithm of one plus the number of total patent stock in both invention and utility model categories. *Treatment*Post* denotes the difference-in-difference variable that captures the average treatment effect of the subsidy on innovation. *EIP (%)* is the ratio of number of incentive shares to total shares outstanding. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. *Overseas* is a dummy variable which equals one if the firm has overseas sales. *Size* is the natural logarithm of the firm's total assets. *Coastal* is a dummy variable that equals 1 if the headquarters of a listed firm is located in coastal provinces. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *HHI* is the Herfindahl-Hirschman Index calculated as the sum of the squares of the market share of each firm in the market. *HHI sq* is the square of the HHI index. *SOE* is a dummy variable which equals one if the government is the largest shareholder, or a nominal agent controlled by the government is the largest shareholder. *Treatment* is a dummy variable that is coded one if a firm receives R&D subsidy from the government in any particular year in the sample period, and 0 otherwise. *Post* is a dummy variable that is coded one after a firm receives the latest R&D subsidy from the government, and 0 otherwise. Robust standard errors are in parentheses. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	1st Stage	2nd Stage					
	EIP (%)	Total patent appl	Invention patent appl	Utility model patent appl	Total patent stock	Invention patent stock	Utility model patent stock
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry location	0.875***						
	(0.0249)						
Fitted EIP (%)		7.400***	5.858***	4.459***	8.499***	4.787***	7.605***
		(1.978)	(1.614)	(1.641)	(2.434)	(1.747)	(2.224)
Treatment*Post		0.328***	0.193***	0.268***	0.487***	0.244***	0.437***
		(0.0873)	(0.0713)	(0.0725)	(0.107)	(0.0771)	(0.0982)
L.Managerial ownership	0.00357***	0.315***	0.210***	0.225***	0.356***	0.121***	0.344***
	(0.000700)	(0.0498)	(0.0406)	(0.0413)	(0.0612)	(0.0439)	(0.0560)
L.Overseas	0.00116	0.460***	0.349***	0.324***	0.655***	0.419***	0.576***

	(0.000722)	(0.0506)	(0.0413)	(0.0420)	(0.0623)	(0.0447)	(0.0569)
L.Size	0.000489***	0.256***	0.213***	0.201***	0.291***	0.200***	0.258***
	(0.000169)	(0.0120)	(0.00976)	(0.00992)	(0.0147)	(0.0106)	(0.0135)
Coastal	0.000273	-0.154***	-0.103***	-0.153***	-0.156***	-0.0824**	-0.176***
	(0.000558)	(0.0386)	(0.0315)	(0.0320)	(0.0475)	(0.0341)	(0.0434)
L.R&D expense	0.516***	2.221	6.793	-1.479	9.450	17.75***	1.436
	(0.0804)	(5.729)	(4.675)	(4.752)	(7.048)	(5.059)	(6.442)
L.HHI	0.0274***	-4.597***	-3.770***	-2.518***	-6.016***	-4.376***	-4.464***
	(0.00890)	(0.638)	(0.521)	(0.529)	(0.785)	(0.563)	(0.717)
L.HHI sq	-0.0504**	13.31***	11.00***	8.089***	16.52***	12.02***	12.52***
	(0.0205)	(1.465)	(1.196)	(1.215)	(1.803)	(1.294)	(1.648)
SOE	-0.00106*	-0.133***	-0.0928**	-0.122***	-0.265***	-0.188***	-0.203***
	(0.000616)	(0.0446)	(0.0364)	(0.0370)	(0.0548)	(0.0394)	(0.0501)
Treatment		-0.263***	-0.239***	-0.206***	-0.236***	-0.186***	-0.229***
		(0.0483)	(0.0394)	(0.0401)	(0.0594)	(0.0427)	(0.0543)
Post		-0.217***	-0.146***	-0.165***	-0.329***	-0.206***	-0.266***
		(0.0617)	(0.0504)	(0.0512)	(0.0759)	(0.0545)	(0.0694)
Constant	-0.0125***	-4.806***	-4.040***	-3.822***	-5.296***	-3.720***	-4.758***
	(0.00367)	(0.258)	(0.210)	(0.214)	(0.317)	(0.228)	(0.290)
Observations	3,601	3,601	3,601	3,601	3,601	3,601	3,601
R-squared	0.299	0.190	0.189	0.164	0.185	0.167	0.173
Year effect	No	Yes	Yes	Yes	Yes	Yes	Yes
F test	170	46.80	46.28	39.04	45.30	40.01	41.55
Adjusted R-squared	0.297	0.186	0.185	0.160	0.181	0.163	0.169

Table 8. Two-stage least squares (2SLS) estimation in PSM sample using the Chinese Yuan amounts of EIP and R&D

In this table, we report the results of the 2SLS regression in estimating the economic impacts of R&D subsidy and EIP on innovation. In this model, we use *EIP* instead of the *EIP (%)* and we also include *R&D* variable. *EIP* is the natural logarithm of one plus the amount of employee incentive plan in Chinese Yuan. *Industry location*, which is measured as the average value of the EIP for all firms within the same year, industry, and location, serves as an instrumental variable for *EIP*. *R&D* is the natural logarithm of one plus the amount of R&D subsidy from government in Chinese Yuan. *Invention patent appl* is the natural logarithm of one plus the number of invention patent application. *Utility model patent appl* is the natural logarithm of one plus the number of utility model patent application. *Total patent appl* is the natural logarithm of one plus the number of total patent application in both invention and utility model categories. *Invention patent stock* is the natural logarithm of one plus the number of invention patent stock. *Utility model patent stock* is the natural logarithm of the one plus the number of utility model patent stock. *Total patent stock* is the natural logarithm of one plus the number of total patent stock in both invention and utility model categories. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. *Overseas* is a dummy variable which equals one if the firm has overseas sales. *Size* is the natural logarithm of the firm's total assets. *Coastal* is a dummy variable that equals 1 if the headquarters of a listed firm is located in coastal provinces. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *HHI* is the Herfindahl-Hirschman Index calculated as the sum of the squares of the market share of each firm in the market. *HHI sq* is the square of the HHI index. *SOE* is a dummy variable which equals one if the government is the largest shareholder, or a nominal agent controlled by the government is the largest shareholder. Robust standard errors are in parentheses. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	1st Stage	2nd Stage					
	EIP (amount)	Total patent appl	Invention patent appl	Utility model patent appl	Total patent stock	Invention patent stock	Utility model patent stock
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry location	0.960***						
	(0.0254)						
Fitted EIP		0.0394***	0.0314***	0.0224***	0.0429***	0.0241***	0.0344***
		(0.00903)	(0.00738)	(0.00749)	(0.0111)	(0.00797)	(0.0101)
L.R&D		0.00881*	0.000425	0.00815**	0.0181***	0.00543	0.0163***
		(0.00462)	(0.00378)	(0.00383)	(0.00567)	(0.00408)	(0.00518)
L.Managerial ownership	0.669***	0.336***	0.228***	0.242***	0.379***	0.140***	0.370***
	(0.145)	(0.0493)	(0.0403)	(0.0409)	(0.0604)	(0.0435)	(0.0553)

L.Overseas	0.407***	0.483***	0.370***	0.346***	0.677***	0.441***	0.599***
	(0.150)	(0.0507)	(0.0415)	(0.0421)	(0.0622)	(0.0448)	(0.0569)
L.Size	0.175***	0.248***	0.206***	0.196***	0.282***	0.195***	0.251***
	(0.0350)	(0.0121)	(0.00986)	(0.01000)	(0.0148)	(0.0106)	(0.0135)
Coastal	0.00520	-0.171***	-0.118***	-0.165***	-0.174***	-0.0956***	-0.191***
	(0.116)	(0.0387)	(0.0316)	(0.0321)	(0.0475)	(0.0341)	(0.0434)
L.R&D expense	54.45***	4.875	8.934*	0.526	12.73*	19.89***	4.827
	(16.66)	(5.621)	(4.598)	(4.662)	(6.895)	(4.961)	(6.306)
L.HHI	3.571*	-5.490***	-4.543***	-3.219***	-6.892***	-5.062***	-5.245***
	(1.843)	(0.618)	(0.505)	(0.512)	(0.757)	(0.545)	(0.693)
L.HHI sq	-5.913	15.36***	12.79***	9.692***	18.51***	13.59***	14.30***
	(4.244)	(1.422)	(1.163)	(1.179)	(1.744)	(1.255)	(1.595)
SOE	-0.248*	-0.114**	-0.0776**	-0.108***	-0.246***	-0.175***	-0.188***
	(0.128)	(0.0447)	(0.0366)	(0.0371)	(0.0548)	(0.0394)	(0.0501)
Constant	-4.097***	-4.721***	-3.974***	-3.778***	-5.204***	-3.666***	-4.695***
	(0.760)	(0.260)	(0.213)	(0.216)	(0.319)	(0.229)	(0.292)
Observations	3,601	3,601	3,601	3,601	3,601	3,601	3,601
R-squared	0.327	0.184	0.180	0.158	0.182	0.162	0.169
Year effect	No	Yes	Yes	Yes	Yes	Yes	Yes
F test	194.2	50.65	49.10	42.15	49.84	43.20	45.49
Adjusted R-squared	0.326	0.181	0.176	0.155	0.178	0.158	0.165

Table 9. Impact of EIP and R&D subsidy on innovation

Panel A reports the economic significance of employee incentive plan (EIP) and R&D subsidy based on the estimation results in Table 8. We apply the elasticity coefficients to our PSM sample where the average value of EIPs is CNY18,400,000, that of R&D subsidy is CNY921,751 and the average number of total patent is 17.8. In Panel A, when there are 10% (100%) increase in EIP and R&D subsidy amount, we estimate how much more patent would be generated. Invention patent application is the number of invention patent application. Utility model patent application is the number of utility model patent application. Total patent application is the sum of invention and utility model patent applications. Invention patent stock is the number of invention patent stock. Utility model patent stock is the number of utility model patent stock. Total patent stock is the sum of invention and utility model patent stock. *EIP* is the amount of employee incentive plan in Chinese Yuan. *R&D* is the amount of R&D subsidy from government in Chinese Yuan. Panel B list % increase in EIP and R&D subsidy amount if one aims to achieve the same increase in the number of patents. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	Δ increase in CNY	# Total patent appl	# Invention patent appl	# Utility model patent appl	# Total patent stock	# Invention patent stock	# Utility model patent stock
10% increase in EIP amount	CNY1,840,000	0.067***	0.036***	0.012***	0.160***	0.048***	0.060***
100% increase in EIP amount	CNY18,400,000	0.493***	0.268***	0.088***	1.180***	0.351***	0.441***
10% increase in R&D subsidy amount	CNY92,175	0.015*	0.000	0.004**	0.067***	0.011	0.028***
100% increase in R&D subsidy amount	CNY921,751	0.110*	0.004	0.032**	0.494***	0.078	0.208***

Panel B reports the economic significance of employee incentive plan (EIP) and R&D subsidy based on the estimation results in Table 8. It lists % increase in EIP and R&D subsidy amount if one aims to achieve the same increase in the number of patents.

	Total patent application	Invention patent application	Utility model patent application	Total patent stock	Invention patent stock	Utility model patent stock
Coefficient on EIP	0.0394	0.0314	0.0224	0.0429	0.0241	0.0344
Coefficient on R&D subsidy	0.0088	n/a	0.0082	0.0181	n/a	0.0163
% increase in EIP (a)	10%	10%	10%	10%	10%	10%
% increase in innovation from 10% increase in EIP (b)	0.376%	0.300%	0.214%	0.410%	0.230%	0.328%
Necessary % increase of R&D subsidy to achieve (b)	53.2%	n/a	30.0%	25.4%	n/a	22.3%
Ratio of R&D subsidy %increase / %Increase in EIP	5.32	n/a	2.99	2.53	n/a	2.23

Table 10. Two-stage least squares (2SLS) estimation in PSM sample: The interaction effect of *EIP(amount)* and *R&D*

In this table, we report the 2SLS regression results of the PSM sample by including the interaction effect of EIP and R&D on innovation. *EIP* is the natural logarithm of one plus the amount of employee incentive plan in Chinese Yuan. *Industry location*, which is measured as the average value of the EIP for all firms within the same year, industry, and location, serves as an instrumental variable for *EIP*. *R&D* is the natural logarithm of one plus the amount of R&D subsidy from government in Chinese Yuan. *Invention patent appl* is the natural logarithm of one plus the number of invention patent application. *Utility model patent appl* is the natural logarithm of one plus the number of utility model patent application. *Total patent appl* is the natural logarithm of one plus the number of total patent application in both invention and utility model categories. *Invention patent stock* is the natural logarithm of one plus the number of invention patent stock. *Utility model patent stock* is the natural logarithm of the one plus the number of utility model patent stock. *Total patent stock* is the natural logarithm of one plus the number of total patent stock in both invention and utility model categories. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. *Overseas* is a dummy variable which equals one if the firm has overseas sales. *Size* is the natural logarithm of the firm's total assets. *Coastal* is a dummy variable that equals 1 if the headquarters of a listed firm is located in coastal provinces. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *HHI* is the Herfindahl-Hirschman Index calculated as the sum of the squares of the market share of each firm in the market. *HHI sq* is the square of the HHI index. *SOE* is a dummy variable which equals one if the government is the largest shareholder, or a nominal agent controlled by the government is the largest shareholder. Robust standard errors are in parentheses. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	1st Stage	2nd Stage					
	EIP (amount)	Total patent appl	Invention patent appl	Utility model patent appl	Total patent stock	Invention patent stock	Utility model patent stock
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry location	0.960***						
	(0.0254)						
Fitted EIP		0.0417***	0.0324***	0.0247***	0.0455***	0.0233***	0.0384***
		(0.00967)	(0.00791)	(0.00802)	(0.0119)	(0.00853)	(0.0108)
L.R&D		0.0104**	0.00111	0.00980**	0.0200***	0.00485	0.0192***
		(0.00525)	(0.00429)	(0.00435)	(0.00644)	(0.00463)	(0.00589)
EIP(amount)*L.R&D		-0.00108	-0.000458	-0.00110	-0.00127	0.000387	-0.00194
		(0.00166)	(0.00136)	(0.00138)	(0.00204)	(0.00147)	(0.00186)
L.Managerial ownership	0.669***	0.336***	0.228***	0.243***	0.380***	0.139***	0.370***
	(0.145)	(0.0493)	(0.0403)	(0.0409)	(0.0604)	(0.0435)	(0.0553)
L.Overseas	0.407***	0.482***	0.370***	0.345***	0.676***	0.441***	0.598***
	(0.150)	(0.0508)	(0.0415)	(0.0421)	(0.0623)	(0.0448)	(0.0570)

L.Size	0.175***	0.247***	0.206***	0.195***	0.282***	0.195***	0.250***
	(0.0350)	(0.0121)	(0.00988)	(0.0100)	(0.0148)	(0.0107)	(0.0136)
Coastal	0.00520	-0.171***	-0.118***	-0.165***	-0.174***	-0.0955***	-0.191***
	(0.116)	(0.0387)	(0.0317)	(0.0321)	(0.0475)	(0.0341)	(0.0434)
L.R&D expense	54.45***	4.747	8.880*	0.395	12.58*	19.94***	4.596
	(16.66)	(5.626)	(4.602)	(4.666)	(6.901)	(4.964)	(6.311)
L.HHI	3.571*	-5.490***	-4.542***	-3.219***	-6.891***	-5.062***	-5.244***
	(1.843)	(0.618)	(0.505)	(0.512)	(0.758)	(0.545)	(0.693)
L.HHI sq	-5.913	15.35***	12.79***	9.688***	18.51***	13.60***	14.30***
	(4.244)	(1.422)	(1.163)	(1.180)	(1.744)	(1.255)	(1.596)
SOE	-0.248*	-0.114**	-0.0775**	-0.108***	-0.246***	-0.175***	-0.187***
	(0.128)	(0.0447)	(0.0366)	(0.0371)	(0.0548)	(0.0394)	(0.0501)
Constant	-4.097***	-4.711***	-3.970***	-3.768***	-5.193***	-3.669***	-4.677***
	(0.760)	(0.261)	(0.213)	(0.216)	(0.320)	(0.230)	(0.292)
Observations	3,601	3,601	3,601	3,601	3,601	3,601	3,601
R-squared	0.327	0.184	0.180	0.159	0.182	0.162	0.169
Year effect	No	Yes	Yes	Yes	Yes	Yes	Yes
F test	194.2	47.68	46.21	39.70	46.92	40.65	42.88
Adjusted R-squared	0.326	0.181	0.176	0.155	0.178	0.158	0.165

Table 11. Two-stage least squares (2SLS) estimation in PSM sample: The interaction effect of *R&D* and *SOE*

In this table, we report the 2SLS regression results of the PSM sample for a test on the interaction effect of R&D subsidy with SOE status. *EIP* is the natural logarithm of one plus the amount of employee incentive plan in Chinese Yuan. *Industry location*, which is measured as the average value of the EIP for all firms within the same year, industry, and location, serves as an instrumental variable for *EIP*. *R&D* is the natural logarithm of one plus the amount of R&D subsidy from government in Chinese Yuan. *Invention patent appl* is the natural logarithm of one plus the number of invention patent application. *Utility model patent appl* is the natural logarithm of one plus the number of utility model patent application. *Total patent appl* is the natural logarithm of one plus the number of total patent application in both invention and utility model categories. *Invention patent stock* is the natural logarithm of one plus the number of invention patent stock. *Utility model patent stock* is the natural logarithm of the one plus the number of utility model patent stock. *Total patent stock* is the natural logarithm of one plus the number of total patent stock in both invention and utility model categories. *Managerial ownership* is the ratio of the number of shares owned by managers as a proportion of total shares outstanding. *Overseas* is a dummy variable which equals one if the firm has overseas sales. *Size* is the natural logarithm of the firm's total assets. *Coastal* is a dummy variable that equals 1 if the headquarters of a listed firm is located in coastal provinces. *R&D expense* is the ratio of the capitalized R&D expenditure to total assets. *HHI* is the Herfindahl-Hirschman Index calculated as the sum of the squares of the market share of each firm in the market. *HHI sq* is the square of the HHI index. *SOE* is a dummy variable which equals one if the government is the largest shareholder, or a nominal agent controlled by the government is the largest shareholder. Robust standard errors are in parentheses. The symbols ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

	1st Stage	2nd Stage					
	EIP (amount)	Total patent appl	Invention patent appl	Utility model patent appl	Total patent stock	Invention patent stock	Utility model patent stock
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry location	0.960***						
	(0.0254)						
Fitted EIP		0.0396***	0.0316***	0.0227***	0.0430***	0.0243***	0.0346***
		(0.00903)	(0.00739)	(0.00749)	(0.0111)	(0.00797)	(0.0101)
L.R&D		0.00707	-0.000809	0.00638	0.0167***	0.00440	0.0148**
		(0.00521)	(0.00426)	(0.00432)	(0.00639)	(0.00460)	(0.00584)
L.Managerial ownership	0.669***	0.335***	0.228***	0.242***	0.379***	0.139***	0.369***
	(0.145)	(0.0493)	(0.0403)	(0.0409)	(0.0604)	(0.0435)	(0.0553)
L.Overseas	0.408***	0.483***	0.370***	0.345***	0.677***	0.440***	0.599***
	(0.150)	(0.0508)	(0.0415)	(0.0421)	(0.0623)	(0.0448)	(0.0569)

L.Size	0.175***	0.248***	0.206***	0.196***	0.283***	0.195***	0.251***
	(0.0350)	(0.0121)	(0.00986)	(0.01000)	(0.0148)	(0.0106)	(0.0135)
Coastal	0.00593	-0.171***	-0.118***	-0.165***	-0.174***	-0.0955***	-0.191***
	(0.116)	(0.0387)	(0.0317)	(0.0321)	(0.0475)	(0.0341)	(0.0434)
L.R&D expense	54.48***	4.851	8.917*	0.502	12.71*	19.87***	4.805
	(16.67)	(5.621)	(4.598)	(4.663)	(6.895)	(4.961)	(6.306)
L.HHI	3.589*	-5.482***	-4.537***	-3.210***	-6.885***	-5.057***	-5.237***
	(1.843)	(0.618)	(0.505)	(0.512)	(0.758)	(0.545)	(0.693)
L.HHI sq	-5.942	15.33***	12.77***	9.662***	18.49***	13.58***	14.28***
	(4.245)	(1.423)	(1.164)	(1.180)	(1.745)	(1.255)	(1.596)
SOE	-0.227*	-0.125***	-0.0850**	-0.118***	-0.254***	-0.182***	-0.197***
	(0.132)	(0.0466)	(0.0381)	(0.0386)	(0.0572)	(0.0411)	(0.0523)
L.R&D*SOE	-0.0195	0.00847	0.00606	0.00824	0.00711	0.00503	0.00751
	(0.0280)	(0.0106)	(0.00868)	(0.00880)	(0.0130)	(0.00937)	(0.0119)
Constant	-4.112***	-4.720***	-3.974***	-3.777***	-5.203***	-3.665***	-4.694***
	(0.760)	(0.260)	(0.213)	(0.216)	(0.319)	(0.230)	(0.292)
Observations	3,601	3,601	3,601	3,601	3,601	3,601	3,601
R-squared	0.327	0.185	0.180	0.159	0.182	0.162	0.169
Year effect	No	Yes	Yes	Yes	Yes	Yes	Yes
F test	174.8	47.69	46.23	39.71	46.91	40.67	42.83
Adjusted R-squared	0.326	0.181	0.176	0.155	0.178	0.158	0.165

Appendix A. Variable Definition

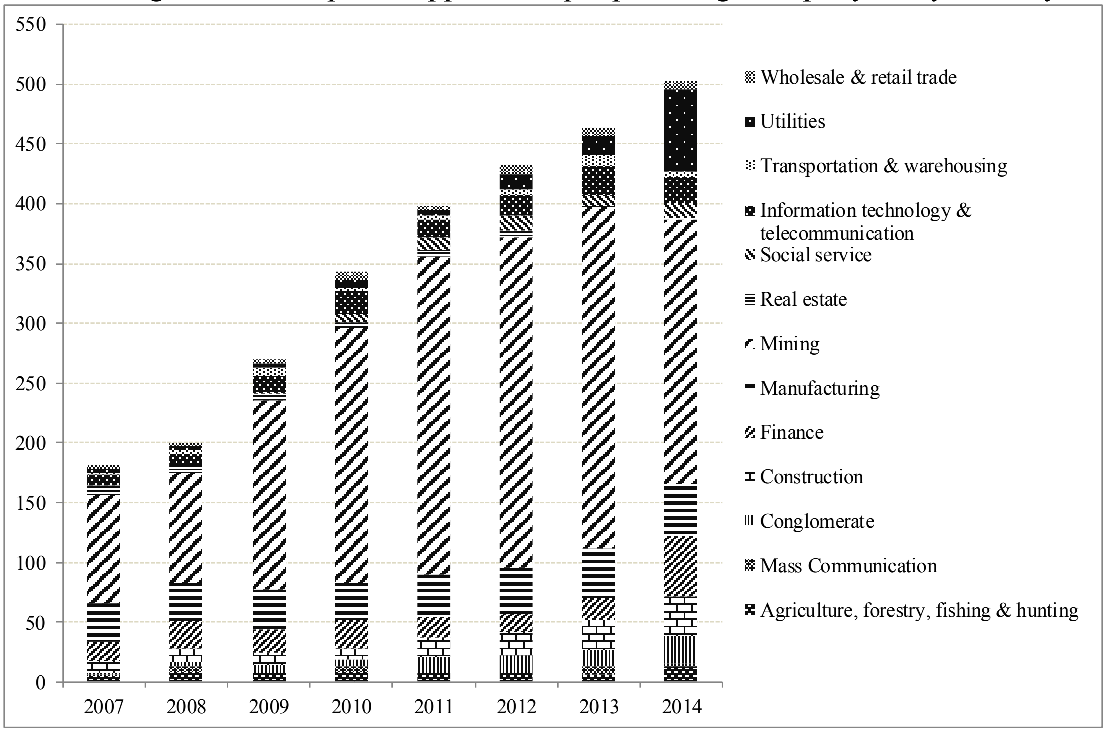
Variable Name	Description
Innovation Variables	
Total patent appl	ln(1+total number of patent application in both invention and utility model model category) for firm *i* in year *t*
Invention patent appl	ln(1+number of invention patent application) for firm *i* in year *t*
Utility model patent appl	ln(1+number of utility model patent application) for firm *i* in year *t*
Total patent stock	ln(1+total number of patent stock in both invention and utility model category) for firm *i* in year *t*
Invention patent stock	ln(1+number of invention patent stock) for firm *i* in year *t*
Utility model patent stock	ln(1+number of utility model patent stock) for firm *i* in year *t*
# patent	"#" sign represents the actual number of patents for firm *i* in year *t*
Innovation	Innovation refers to the six measures of innovation including # *Total patent appl, # Invention patent appl, # Utility model patent appl, # Total patent stock, # Invention patent stock,* and # *Utility model patent stock*
Subsidy Variables	
R&D	ln(1+amount of R&D subsidy from government) for firm *i* in year *t*
R&D subsidy (CNY)	Amount of R&D subsidy from government in Chinese Yuan for firm *i* in year *t*
# R&D subsidy deal	Total number of R&D subsidy deals received by listed firms in year *t*
Incentive Plan Variables	
EIP (%) (Employee Incentive Plan)	Ratio of number of incentive shares to total shares outstanding for firm *i* in year t. There are three incentive rights used in the employee incentive plan: stock options, restricted stock, and stock appreciation rights.
EIP	ln(1+amount of employee incentive plan in Chinese Yuan) for firm *i* in year *t*
EIP (CNY)	The amount of employee incentive plan in Chinese Yuan for firm *i* in year *t*. It is calculated as the following formula: Number of stock options * exercise price for stock options+ number of restricted stock shares* grant price for restricted stocks + number of appreciation rights* benchmark price for appreciation rights.
# EIP	The actual number of deals for EIPs
Stock options	A stock option is a privilege, sold by one party to another that gives the buyer the right, but not the obligation, to buy or sell a stock at an agreed-upon price within a certain period of time.
Restricted stocks	Refer to stock of a company that is not fully transferable (from the stock-issuing company to the person receiving the stock award) until certain conditions (restrictions) have been met. Upon satisfaction of those

	conditions, the stock is no longer restricted, and becomes transferable to the person holding the award. Restricted stock is often used as a form of employee compensation, in which case it typically becomes transferrable ("vests") upon the satisfaction of certain conditions, such as continued employment for a period of time or the achievement of particular product-development milestones, earnings per share goals or other financial targets.
Stock appreciation rights	A stock appreciation right (SAR) is a bonus given to employees that is equal to the appreciation of company stock over an established time period. Similar to employee stock options, SARs are beneficial to the employee when company stock prices rise; the difference with SARs is that employees do not have to pay the exercise price but receive the sum of the increase in stock or cash. The primary benefit that comes with SARs is the fact that the employee can receive proceeds from stock price increases without being required to buy anything.
Other Variables	
Managerial ownership	Shares owned by managers as a proportion of total shares outstanding for firm *i* in year *t*.
Overseas	A dummy variable that equals 1 if the firm has overseas sales for firm *i* in year *t*, and 0 otherwise.
Size	ln(total asset)
Coastal	A dummy variable that equals 1 if the headquarters of a listed company is located in coastal provinces for firm *i*, and 0 otherwise.
R&D expense	Capitalized R&D expenditure as a proportion of total asset for firm *i* in year *t*
HHI	Herfindahl-Hirschman Index is calculated as the sum of the squares of the market share of each firm *i* in the market per year.
HHI sq	Square of HHI index.
Industry location	Industry-location average of EIP. It is an instrument variable for EIP.
SOE	A dummy variable that equals 1 if the government is the largest shareholder, or a nominal agent controlled by the government is the largest shareholder, and 0 otherwise.
Employment	The number of employees in an enterprise divided by its assets, then scaled by 106 for firm *i* in year *t*.
Rel Rank	The highest ranked government position the board members have served in the past. The ranks of positions are 1-below county level. 2-county or town level. 3-city council level. 4-provincial level. 5-central government level.
Post	A dummy variable that equals 1 after a firm receives a latest R&D government subsidy, and 0 otherwise.

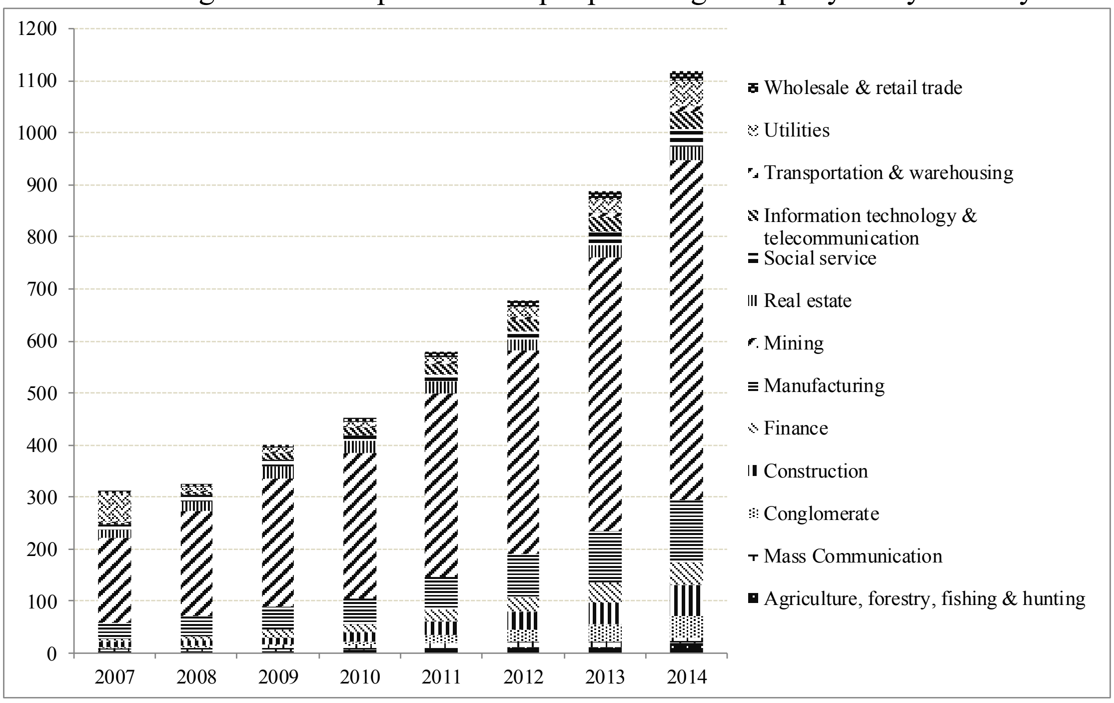
Appendix B. Average number of patents per patenting firm per year by industry

In this figure, *Panel A* and *B* report the trends of the average patent application and stock per patenting firm per year by industry for a sample of 2,632 Chinese listed firms between 2007 and 2014. *Patenting firm* is the firm that holds at least a patent application or a registered patent in a particular year over the sample period of 2007-2014. *Total patent application* is the sum of invention and utility model patent applications. *Total patent stock* is the sum of invention and utility model patent stock.

Panel A: Average number of patent application per patenting firm per year by industry



Panel B: Average number of patent stock per patenting firm per year by industry



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