BACKGROUND PAPER

The Effects of the Innofund Program on Technology-Based SMEs' Performance: Evidence from Zhongguancun National Innovation Demonstration Zone (ZNID)

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THE EFFECTS OF THE INNOFUND PROGRAM ON TECHNOLOGY-BASED SMALL AND MEDIUM-SIZED ENTERPRISES' PERFORMANCE: EVIDENCE FROM ZHONGGUANCUN NATIONAL INNOVATION DEMONSTRATION ZONE

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Technology-based small and medium-sized enterprises (SMEs) are SMEs concentrating on research and development (R&D) and the production of high-tech products and services, which has grown as a major driver for innovation and economic development of the People's Republic of China (PRC) (Zhu, Wittmann, and Peng 2012). Although there are debates about the effects of innovation subsidy on nurturing innovation and growth of technology-based SMEs, they are still prevalently used by the developed countries (Howell 2017, Boeing 2016, ans Lerner 1999). The underlying mechanisms of supporting fiscal instruments are alleviating the urgent financial constraints (Meuleman and De Maeseneire 2012) and the potential risk of innovation (Arrow 1962 and Manso 2011) for technology-based SMEs. Learning from the experience of the developed countries and governance practice domestically, the PRC has taken efforts to develop its supporting fiscal instruments for technology SMEs (Liu et al. 2011). Among different kinds of fiscal instruments trying to promote technology-based SMEs, one of the most famous instruments initiated by Government of the PRC is the Innovation Fund for Technology-Based SMEs (the Innofund) initiated in 1999. The Innofund is a specialized subsidy for supporting potential future R&D activities of technology-based SMEs. Until now, the knowledge of the Innofund program's effects is still limited, which is caused by the lack of technology-based SMEs' statistical data or relatively rigor policy evaluation methods (Guo, Guo, and Jiang 2018; Wang, Li, and Furman 2017; and Guo, Guo, and Jiang 2016).

Using a comprehensive official survey data from Innofund application and evaluation dataset from 2005 to 2010, combining with the Zhongguancun National Innovation Demonstration Zone (ZNID) annual statistical data from 2005 to 2015, this study provides empirical analyses about the effects of the Innofund on technology-based firms' innovation performance and economic performance respectively and further examines the channels of the Innofund's effects. Particularly the expansion of the Innofund in 2009 provides an appropriate quasi-natural experiment context, which can alleviate the potential endogenous problem in identifying the policy effects. The rest of the research is arranged as follows. The first part introduces the development of Innofund and ZNID. The second part introduces the data and empirical designs of this research. The third part presents the empirical results. The final part discusses the results and provides policy suggestions.

I. BACKGROUND

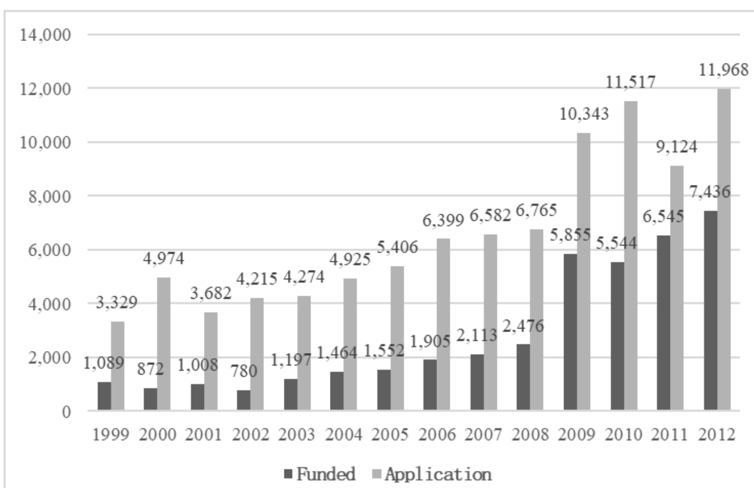
A. The Innofund

Initiated by the PRC's State Council in 1999 as part of the Torch Program, the Innovation Fund for Technology-Based SMEs (the Innofund) is the PRC's first and premier program targeting technology-based SMEs. The Innofund is administrated by the Ministry of Science and Technology (MOST), though it is funded by the Ministry of Finance. The 863 and 973 programs, which target large established (state-owned) enterprises and state research institutions, are older and larger than the Innofund. The Innofund, however, constitutes the largest source of state-supported R&D innovation financing for young, entrepreneurial ventures in the PRC, which is also the main innovation subsidy program for technology-based SMEs in the PRC. By the end of 2012, the Innofund has provided cumulatively CNY30.68 billion grants for the PRC's technology-based SMEs, and a total of 46,261 projects were funded.

To apply the Innofund, firms should meet some requirements: (i) fewer than 500 employees; (ii) at least 50% of the equity shares are owned by one or more people who are current or former citizens; (iii) R&D expenditure must be at least 5% of its annual revenue; (iv) at least 30% of the firm's employees must have a college degree or higher. When applying for an innovation fund project, the firm needs to complete a series of processes, such as application materials online filling and qualification review. As the direct management institution of the Innofund, the Torch Center of the MOST organizes technical and financial experts to review the application materials submitted by the applicants each year, and they will give the technical scores and financial scores of a project respectively. Then the management organization of the Innofund integrates the final financial and technical scores and generates the project's composite or "total" score, which is the basic reference of funding. The Innofund ranks the applicants by total score and funds projects in rank order until its annual budget runs out.

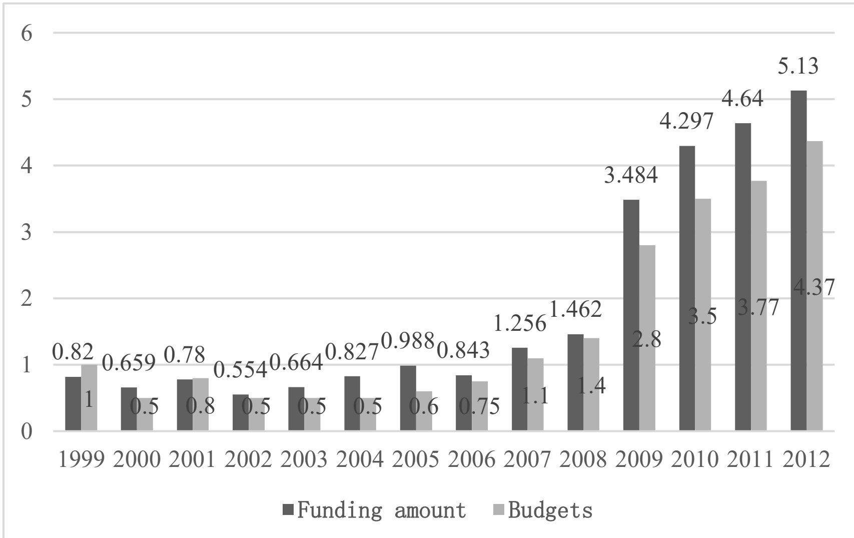
Figure 1 presents the number of applications and the number of funded projects from 1999 to 2012. Figure 2 presents the budgets and actual funding amount (CNY billion) of the Innofund from 1999 to 2012. Because of the global financial crisis in 2008, the Government of the PRC strengthened its support on technology-based SMEs. In 2009, the Innofund decreased the supporting threshold, which allowed more firms to be involved in this program. According to Figure 1 and Figure 2, there is an obvious "jump" from 2008 to 2009, where the funded projects and funding amount increases dramatically. The Innofund granted 2,476 projects in 2008 and 5,855 in 2009, which increased by 136.47%; the Innofund's actual funding amount in 2008 was CNY1.462 billion, and in 2009 it rose to CNY3.484 billion, which increased of 138.30%. This "jump" is called "the expansion of the Innofund", which creates an effective context for the quasi-natural experiment.

Figure 1: Funded Number and Application Number of the Innofund (1999–2012)



Sources: Annual reports of the Innofund.

Figure 2: Actual Funding Amount (CNY billion) and Application Amount (CNY billion) of the Innofund (1999–2012)

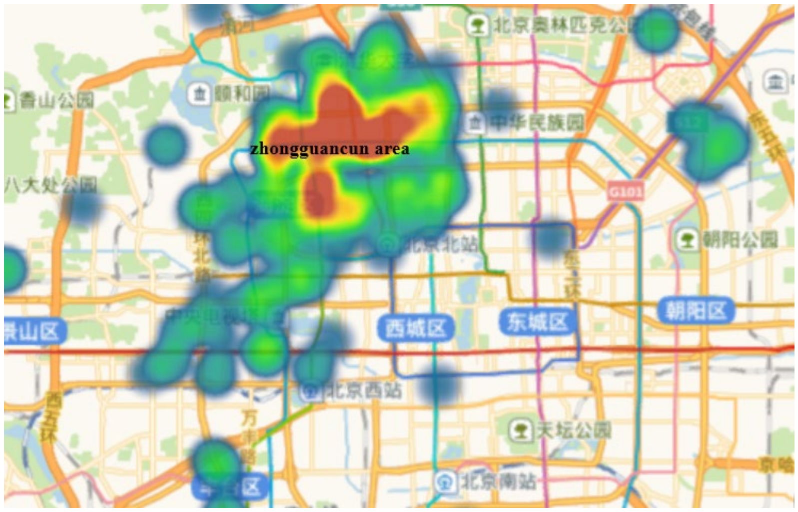


Sources: Annual reports of the Innofund.

B. The Development of ZNID

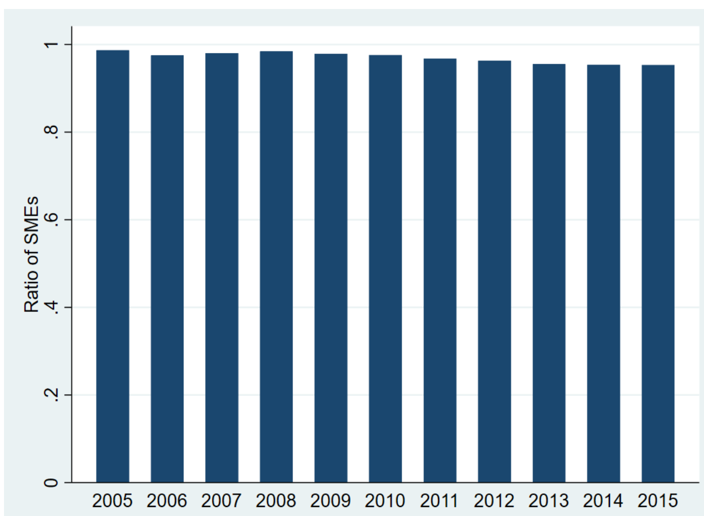
The Zhongguancun National Demonstration Zone dates back to the "Zhongguancun Electronics Street" in the early 1980s. In May 1988, the State Council of the PRC approved the establishment of the Beijing New Technology Industrial Development Trial Zone (predecessor of the Zhongguancun Science and Technology Park), and Zhongguancun became the first high-tech park in the PRC. In August 1999, the Beijing New Technology Industrial Development Trial Zone was renamed as Zhongguancun Science and Technology Park. On 13 March 2009, the State Council approved the construction of the Zhongguancun National Innovation Demonstration Zone (ZNID), which confirmed the goal of ZNID is to build a S&T center with global influence. Later the Development Plan Outline for Zhongguancun National Innovation Demonstration Zone (2011–2020), was launched by the State Council on 26 January 2011, which gives more detailed guidelines for developing international science and technology (S&T) center. Initially, Zhongguancun Science and Technology Park was located in Haidian District, Beijing. Although the Haidian Zone at Zhongguancun area (Figure 3) is still the core of ZNID. However, the ZNID has expanded as “One park with six-teen sub-parks” pattern covering every district of Beijing. According to the statistical data conducted by Zhongguancun Listed Companies Association, by the end of 30 June 2018, there are above 200 listed companies in ZNID, which created great economic values and job positions. Moreover, most firms operated in ZNID are SMEs. As presented in Figure 4, companies less than 500 employees constitute over 90% in ZNID every year. On the whole, ZNID provides sufficient observations and appropriate context to investigate the policy effects.

Figure 3: Location of Haidian Zone (Zhongguancun Area)



Source: Google map.

Figure 4: Ratio of Small and Medium-Sized Enterprises, by Year



Sources: Zhongguancun National Innovation Demonstration Zone annual statistical data.

II. DATA AND RESEARCH DESIGN

A. Data

The 2005–2010 Innofund application and evaluation of ZNID is from the Torch Center of the MOST, which is the direct administration department of the Innofund. This dataset contains firms' basic information, application information, evaluation scores, and funding information. To acquire the later performance

data of technology-based firms, 2005–2015, ZNID annual statistical data is collected from the Management Committee of Zhongguancun, which contains the data of 41908 firms and 182,158 observations initially. As shown in Figure 4, among the firms, most of which are SMEs. The Management Committee of Zhongguancun conducts an annual statistical survey officially each year, which includes various firm information, for instance, basic info, employees, financial indicators, and innovation indicators. Besides, we collect the number of software copyrights from a specialized firm information website in the PRC (Qichacha.com). After matching different datasets, the final sample has 559 technology-based SMEs and 3,459 firm-year observations.

B. Variables

The paper mainly examines the impact of the Innofund on the innovation performance and economic performance of technology-based SMEs. Therefore, we use multi-indicators to measure the quantity and quality of dependent variables. The paper uses four indicators to measure the innovation performance of SMEs. Concerning innovation performance measurements, the first is to use the naturally logarithmized number of patent applications (*Patent_app*) in the previous research (Tian and Wang 2014). Second, we introduced the patenting efficiency (*Inno_p*) (Desyllas and Hughes 2010), which is measured as the natural logarithm of the number of patent applications divided by the naturally logarithmized R&D expenses (in yuan). In the PRC, the patents include invention patents, utility patents, and design patents, while invention patents are with high quality and difficulty (Fu 2015). The naturally logarithmized number of invention patent applications (*Ipatent_app*) and invention patenting efficiency (*Iinno_p*) (calculated as the number of invention patent applications divided by the naturally logarithmized R&D expenses) are introduced to measure the quality of innovation outputs.

To comprehensively measure the economic performance of technology-based SMEs, we also use four indicators. The first is the naturally logarithmized profit (*Profit*) of the company (in yuan), which is also the economic performance indicator commonly used in past research (Guan and Yam 2015). Second, return on total assets (*ROA*) is introduced, which is calculated by the ratio of total profits to total assets, reflecting the profitability of the company. Also, this paper introduces the natural logarithm of the company's sales revenue (*Sales*) and the natural logarithm of the operating income (*O_income*).

To exclude the influence of other factors other than the support of the Innofund, we selected some control variables closely related to the performance of technology-based SMEs. Firm size (*Firmsize*) uses the natural logarithm of total assets (in yuan) as a proxy variable to control the capital and resources owned by the firms. The age of the firm (*Firmage*) controls the resources and operating experience of the firm as its age increases. The ifmpact of the company's S&T human capital (*ST_employees*) is measured as the ratio of the number of S&T employees to the total number of employees. The R&D intensity (*RD_intensity*), reflecting the degree of emphasis on R&D and the level of R&D, is measured as the ratio of R&D expense to the firm's total assets. State-owned company (*State*) is measured as a dummy variable, where 1 represents state-owned holding companies, 0 represents non-state-owned holding companies. Listed *(Listed*) is also a dummy variable, where 1 represents a listed firm, 0 represents a non-listed firm. The debt ratio (*Debt_ratio*) is calculated by the ratio of the total debt of the firm to the total assets, reflecting the solvency of the firm. The degree of competition in the technical field (HHI) is calculated by the Herfindahl index of sales in

various technical fields using the full-sample of ZNID annual statistical data. The index ranges from 0 to 1. The greater the value, the less the competition. The year that the firm applied for the Innofund (*App_year*) is also controlled. Finally, the fixed effects of eight technical field (*Techfield*) of the firm are controlled, which covers "advanced manufacturing technology", "new materials ", "new energy", "environmental protection", "modern agriculture", "bioengineering and new medicine", "electronics and information", and "aAerospace technology". However, above 60% of firms are from the "electronics and information" technical field. By performing a variance inflation factor test (VIF) on the independent variables and control variables, all VIFs and average VIF are less than 10, indicating that there is no significant multicollinearity between these variables.

C. Research Design

Table 1 lists the composite scores distribution of the application projects and the distribution of funded projects for the ZNID Innofund applicants from 2005 to 2010. Among them, most projects with scores of more than 75 points can be supported from 2005 to 2007. In 2008, the demarcation score was 70 points. In 2009 and 2010, the demarcation scores dropped further to 65 points. Thus, the funding of the Innofund program embodies obvious fuzzy discontinuity characteristics, and scores above can be fuzzy demarcation scores for funding. Drawing on that the experts' evaluation standards kept constant during this period (presented in http://innofund.chinatorch.gov.cn/2/jjwja/list.shtml), we can assume that companies with similar scores have similar "levels", but because of accidental factors (such as "expansion of the Innofund"), some firms are supported by the Innofund, while others are not supported. As Figure 5 indicated, a significantly "jump" of the probability of funding exists around the demarcation scores. Figure 6 presents the McCrary density test, which shows that around the demarcation scores, there is no significant density difference. These results demonstrated that firms do not operate the fuzzy demarcation scores (McCrary 2008). The bolded interval in Table 1 is five absolute scores above and below the threshold score. Given the similarity between firms between the upper five scores interval and lower five scores interval, the bolded part of 6 years can be used as a fuzzy regression discontinuity sample.

Besides, in the first section, we have presented "the expansion of the Innofund", while Table 1 further shows that the demarcation scores decrease. Thus, similar firms that cannot get the Innofund grants in 2008 can get grants in 2009 since the evaluation standard decreased, which provides an effective context for quasi-natural experimental analysis. The quasi-natural experiment is an effective policy evaluation method, which is characterized by a clear exogenous event dividing subjects into the treated group and untreated group. Compared with regression discontinuity, the quasi-natural experiment can make inference about the causality question precisely (Abadie and Cattaneo 2018). In this study, we use the bolded part data of the 2008 and 2009 in Table 1 as a

Table 1: Evaluation Scores, Application Number, and Funded Number of the Innofund (2005–2010)

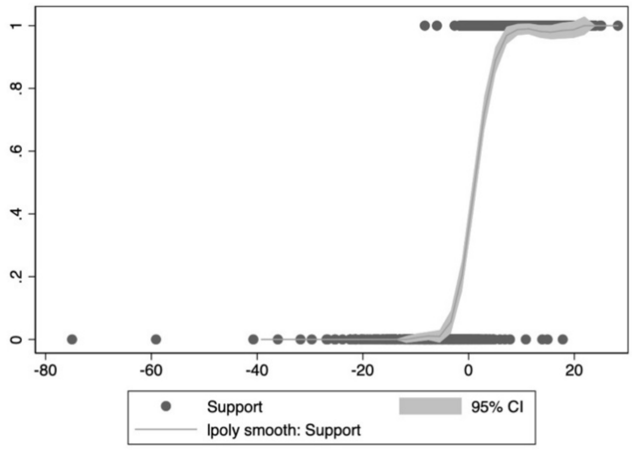
2005				2006				2007			
Scores	**Apply**	**Funded**	**%**	**Scores**	**Apply**	**Funded**	**%**	**Scores**	**Apply**	**Funded**	**%**
[0–55)	16	0	0%	[0-55)	7	0	0%	[0-55)	6	0	0%
[55–60)	13	1	7.69%	[55-60)	14	0	0%	[55-60)	10	0	0%
[60–65)	25	0	0%	[60-65)	29	0	0%	[60-65)	32	0	0%
[65–70)	58	1	1.69%	[65-70)	34	1	2.86%	[65-70)	44	5	10.20%
[70–75)	**35**	**10**	**28.57%**	**[70-75)**	**24**	**1**	**4.17%**	**[70-75)**	**27**	**0**	**0%**
[75–80)	**53**	**47**	**88.68%**	**[75-80)**	**31**	**26**	**83.87%**	**[75-80)**	**23**	**19**	**82.61%**
[80–85)	28	28	100.00%	[80-85)	41	40	97.56%	[80-85)	38	33	86.84%
[85–90)	3	2	66.67%	[85-90)	13	13	100%	[85-90)	1	1	100%
[90–95)	0	0	0%	[90-95)	1	1	100%	[90-95)	2	2	100%
Total	**231**	**89**	**38.53%**	**Total**	**194**	**82**	**42.27%**	**Total**	**183**	**60**	**32.79%**
2008				**2009**				**2010**			
Scores	**Apply**	**Funded**	**%**	**Scores**	**Apply**	**Funded**	**%**	**Scores**	**Apply**	**Funded**	**%**
[0–55)	1	0	0%	[0-55)	3	0	0%	[0-55)	1	0	0%
[55–60)	6	0	0%	[55-60)	7	0	0%	[55-60)	4	0	0%
[60–65)	21	0	0%	**[60-65)**	**28**	**1**	**3.45%**	**[60-65)**	**35**	**0**	**0%**
[65–70)	**33**	**2**	**5.71%**	**[65-70)**	**30**	**19**	**63.33%**	**[65-70)**	**32**	**19**	**59.38%**
[70–75)	**23**	**18**	**78.26%**	[70-75)	37	34	91.89%	[70-75)	27	27	100.00%
[75–80)	31	30	96.77%	[75-80)	47	46	97.87%	[75-80)	38	38	100.00%
[80–85)	26	25	96.15%	[80-85)	47	44	93.62%	[80-85)	33	33	100.00%
[85–90)	12	12	100%	[85-90)	6	6	100.00%	[85-90)	16	16	100.00%
[90–95)	2	2	100%	[90-95)	1	1	100.00%	[90-95)	1	1	100.00%
Total	**155**	**89**	**57.42%**	**Total**	**206**	**151**	**73.30%**	**Total**	**187**	**134**	**71.66%**

Source: Authors' calculations.

quasi-natural experiment sample.

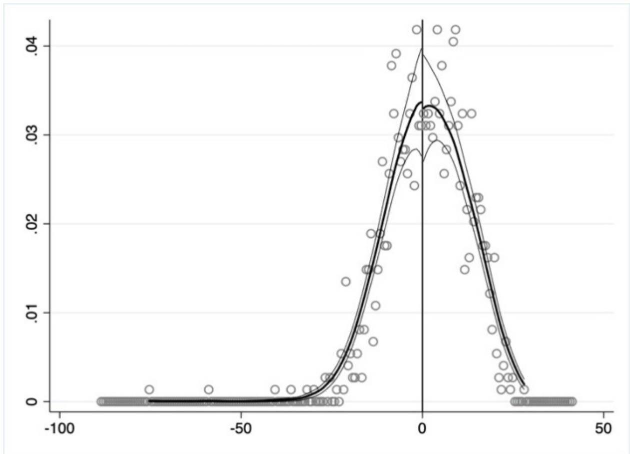
Table 2 reports the t-tests of control variables for the full sample, the fuzzy regression discontinuity sample, and the quasi-natural experiment sample. The results indicate that the quasi-natural experiment sample is free of potential selection problem since all control variables of the funded and unfunded firms are insignificantly different (p>.10). Therefore, in later empirical research, the quasi-natural experiment sample is adopted.

Figure 5: Probability of Funding and Scores



Source: Authors' calculations.

Figure 6: McCrary Test for Density Continuity



Source: Authors' calculations.

Table 2: T-tests of Control Variables for Three Samples

Variables	Full sample		Fuzzy RDD		QNE	
	C-T	t	C-T	t	C-T	t
Firmsize	-0.229**	-2.002	0.043	0.225	-0.376	-0.871
Frimage	-0.872***	-2.887	0.641	1.377	-1.545	-1.229
ST_employees	0.002	0.056	-0.031	-0.626	0.118	0.944
Rd_intensity	0.018	0.645	-0.011	-0.280	0.098	1.101
State	-0.049**	-2.366	-0.081**	-2.526	-0.083	-0.956
*Listed_*	-0.004	-0.458	-0.026	-1.585	.	.
Debt_ratio	-0.006	-0.168	0.078	1.209	0.133	1.101

Note. "C" means the unfunded firms while "T" means the funded firms. ***, **, and * are significant at 1%, 5%, and 10% significance level, respectively.

Source: Authors' calculations.

D. Regression Models

As shown in Formula (1) and Formula (2), the coefficient of treatment δ needs to be estimated in order to identify the effects of obtaining the Innofund grants. The *i* denotes the firm, while the *t* denotes the year. Dependent variables are the performances of the firm after applying for the Innofund (year> application year)($Performance_{i,after}$). The time-invariant fixed effect is denoted as μ_{ind}. The fixed effect of application year is denoted as μ_t while the random error is denoted as ε_{it}. However, the fuzzy discontinuous nature of funding still exists, that is, the firms above the threshold scores only have a large probability of obtaining support from the innovation fund, so it is necessary to continue the robustness test through the Formula (2). In this model, we first calculate the probability of deviation of threshold scores on funding. Then, we introduce the estimated probability into Formula (2) to estimate its coefficients.

$$Performance_{i,after} = \alpha_0 + \beta controls_{it} + \delta treatment + \mu_{ind} + \mu_t + \varepsilon_{it} \quad \text{Formula (1)}$$

$$Performance_{i,after} = \alpha_0 + \beta controls_{it} + \delta' \Pr(treatment = 1 \mid \eta) + \mu_{ind} + \mu_t + \varepsilon_{it} \quad \text{Formula (2)}$$

Table 3: Innovation Performance of Technology-Based Small and Medium-Sized Enterprises and the Innofund Support

Variables	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**
	Patent_app	***Inno_p***	***Ipatent_app***	***Iinno_p***	***Patent_app***	***Inno_p***	***Ipatent_app***	***Iinno_p***
Treatment	0.264*	0.021**	0.118	0.011				
	(0.136)	(0.009)	(0.113)	(0.007)				
Pr(Treatment=1)					0.346**	0.027**	0.203	0.017**
					(0.173)	(0.011)	(0.138)	(0.008)
Firmsize	0.221***	0.015***	0.167***	0.011***	0.205***	0.013***	0.158***	0.010***
	(0.064)	(0.004)	(0.050)	(0.003)	(0.060)	(0.004)	(0.046)	(0.003)
Firmage	-0.064**	-0.005**	-0.009	-0.001	-0.059**	-0.004**	-0.007	-0.001
	(0.029)	(0.002)	(0.017)	(0.001)	(0.029)	(0.002)	(0.017)	(0.001)
ST_employees_ratio	0.137	0.015	0.159	0.018*	0.162	0.016	0.168	0.018**
	(0.231)	(0.015)	(0.139)	(0.009)	(0.235)	(0.015)	(0.142)	(0.009)
Rd_intensity	0.418	0.025	0.425	0.027	0.268	0.013	0.369	0.021
	(0.500)	(0.034)	(0.351)	(0.023)	(0.416)	(0.028)	(0.291)	(0.018)
State_ownership	-0.241	-0.013	-0.329***	-0.019***	-0.236	-0.012	-0.333***	-0.019***
	(0.147)	(0.010)	(0.114)	(0.007)	(0.145)	(0.010)	(0.108)	(0.007)
Debt_ratio	-0.367	-0.015	-0.430**	-0.022*	-0.410	-0.019	-0.450**	-0.023**
	(0.288)	(0.019)	(0.189)	(0.012)	(0.286)	(0.019)	(0.185)	(0.011)
HHI	136.473	1.865	86.110	0.246	119.632	-0.410	88.231	-0.094
	(120.999)	(5.912)	(109.669)	(4.994)	(155.020)	(8.668)	(126.662)	(6.302)
Tech_field fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
_cons	-2.996***	-0.205***	-2.481***	-0.170***	-2.792***	-0.185***	-2.381***	-0.161***
	(1.010)	(0.065)	(0.798)	(0.049)	(0.957)	(0.063)	(0.741)	(0.044)
Number of firms	23	23	23	23	23	23	23	23
Firm-year	141	141	141	141	141	141	141	141

Variables	M1	M2	M3	M4	M5	M6	M7	M8
	Patent_app	***Inno_p***	***Ipatent_app***	***Iinno_p***	***Patent_app***	***Inno_p***	***Ipatent_app***	***Iinno_p***
R-square	0.281	0.290	0.289	0.295	0.285	0.293	0.295	0.304
Wald Chi2	348.575***	346.455***	270.154***	190.108***	380.140***	307.366***	331.738***	279.266***

Note. ***, **, and * are significant at 1%, 5%, and 10% significance level, respectively. "Y" means "controlled".

Source: Authors' calculations.

Table 4: Economic Performance of Technology-Based Small and Medium-Sized Enterprisders and the Innofund Support

Variables	M9	M10	M11	M12	M13	M14	M15	M16
	Profit	***ROA***	**Sales**	***O_income***	***Profit***	***ROA***	**Sales**	***O_income***
Treatment	1.171	0.080*	-0.231	0.010				
	(1.780)	(0.042)	(0.407)	(0.518)				
Pr(Treatment=1)					0.524	0.082	-0.189	0.052
					(2.457)	(0.067)	(0.605)	(0.684)
Firmsize	0.794	0.009	0.528**	0.677***	0.803	0.006	0.531**	0.675***
	(0.824)	(0.016)	(0.223)	(0.197)	(0.858)	(0.017)	(0.232)	(0.205)
Firmage	0.054	-0.012	-0.053	-0.071	0.069	-0.011	-0.054	-0.071
	(0.329)	(0.008)	(0.048)	(0.050)	(0.322)	(0.008)	(0.049)	(0.049)
ST_employees_ratio	4.328	0.084**	-0.242	-0.030	4.434	0.084**	-0.248	-0.033
	(2.782)	(0.041)	(0.490)	(0.514)	(2.778)	(0.040)	(0.495)	(0.517)
Rd_intensity	1.302	-0.131**	0.647**	0.859***	0.817	-0.148**	0.701**	0.860***
	(3.080)	(0.061)	(0.297)	(0.317)	(2.863)	(0.058)	(0.328)	(0.325)
State_ownership	7.238***	0.213***	1.342***	1.582***	7.505***	0.225***	1.299***	1.575***

Variables	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**
	Profit	***ROA***	**Sales**	***O_income***	***Profit***	***ROA***	**Sales**	***O_income***
	(2.090)	(0.044)	(0.464)	(0.425)	(2.163)	(0.049)	(0.458)	(0.438)
Debt_ratio	-2.188	0.030	0.086	0.176	-2.364	0.024	0.110	0.177
	(3.216)	(0.085)	(0.397)	(0.502)	(3.188)	(0.084)	(0.404)	(0.474)
HHI	-1777.833**	-59.015*	-667.106***	-57.342	-1857.268**	-60.688*	-662.651***	-57.308
	(708.852)	(32.828)	(180.681)	(479.935)	(793.773)	(36.787)	(192.772)	(474.739)
Tech_field fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
_cons	-15.458	-0.105	0.744	-2.245	-15.209	-0.069	0.657	-2.242
	(12.556)	(0.235)	(3.548)	(3.294)	(12.796)	(0.240)	(3.615)	(3.313)
Number of firms	23	23	23	23	23	23	23	23
Firm-year	141	141	141	141	141	141	141	141
R-square	0.267	0.204	0.460	0.371	0.268	0.184	0.459	0.371
Wald Chi2	486.628***	277.120***	157.400***	75.899***	278.158***	228.573***	95.843***	85.911***

Note. ***, **, and * are significant at 1%, 5%, and 10% significance level, respectively. “Y” means “controlled”.

Source: Authors’ calculations.

III. Results

A. Main Effects

Table 3 is an analysis of the relationship between the innovation performance of technology-based SMEs and the support of Innofund based on the quasi-natural experiment method. The first four models are basic analyses based on Formula (1). From the estimates of *Treatment*, it is known that the Innofund support (i) significantly improves the overall innovation output of technology-based SMEs (b=0.264, p<. 10); (ii) significantly improve the overall innovation efficiency of technology-based SMEs (b=0.021, p<.05); (iii) the impact on the quantity and efficiency of high-quality innovation output is positive, but the effect is not significant (b>0,p>.10); and (iv) the promotion effect and significance of the overall innovation output quantity and efficiency are higher than those of high-quality innovation output and efficiency. Models 6–8 are the results of the robustness test using Formula (2), which is highly consistent with the results of the basic analysis. The difference is that the results show that the support of the Innofund can not promote the number of high-quality innovation outputs, but it may enhance invention patenting efficiency.

Table 4 provides an examination of the relationship between the economic performance of technology-based SMEs and the support of the Innofund in the context of quasi-natural experiments. Models 9–12 are the results of the basic analysis. From the estimates of *Treatment*, it can be seen that the support of the Innofund has only a significant positive impact on the return on assets (b=0.080, p<.10). The results of the robustness show that the impact of the Innofund support on the indicators of the economic performance of technology-based SMEs is not significant (p>.10), and all the estimation direction is consistent with the models 9–12.

In summary, the results of the quasi-natural experiment method can be inferred: (i) the Innofund support can significantly improve the overall innovation output and patenting efficiency of technology-based SMEs, but has a limited effect on high-quality innovation output and related patenting efficiency. (ii) The Innofund supports limited improvement in the economic performance of technology-based SMEs.

B. The Channels of the Innofund Effects

The previous part has confirmed the effects of the Innofund using a quasi-natural experiment design. However, we still need to know the channels of the Innofund effects. As technology-based SMEs usually face financial constraints for development, the effects of the funding amount are firstly tested. According to the results in Table 5, compared with the effect of obtaining the Innofund support (Dummy), the impact of the Innofund funding amount on the innovation performance and economic performance of the company is relatively small. Among the eight estimation models, the only significant estimate is the estimate of patenting efficiency ($b = 0.001$, $p < .10$) in the basic model M18, but the absolute value of the effect is close to zero. Although the Innofund funding amount has positive impacts on other indicators, the effect is not significant (b>0,p>.10). This result shows that the increase in the amount of funding will not bring more innovation performance and economic performance.

As illustrated in the second part, most firms are from the "electronics and information" technical field. For such companies, their innovation performance, except for patented technology, also

includes the development of software and access to software copyrights. We replace the dependent variable with the natural logarithm of the “software copyrights obtained in the year” (Software_IPR) and limit the sample to the “electronics and information” field. For robustness check, we add the number of software copyrights acquired by the company in the same year to the number of patents applied by the company in the current year and calculate its natural logarithm toget the variable *Patent_Software*. Using Formula (1) and Formula (2) we estimate the treatment effect. The results are shown in Table 6.

The estimated results of software copyrights indicate that the Innofund support hurts the software copyright of the technology-based SMEs in the “electronics and information” field (b<0, p<. 05), and the result is robust (b<0, p<.05). Model 27 and Model 28 indicate that the impact of the Innofund on the total number of software copyrights and patent applications is negative but not significant (b<0, p>.10), while the robustness test is significantly negative. (b<0, p<.05). These results may demonstrate that the Innofund grants promote technology-based SMEs’ patenting through guiding them transferring resources from other technology fields.

However, do these results mean that the Innofund has no impact on technology-based firms’ development? Then we further test whether the patenting effects contribute to firms’ long-term economic performance? In this section, using the quasi-natural experimental sample to consider the 2 years of 2008 and 2009 as the “expansion” year, we calculated the difference between the average value of the overall innovation efficiency and the average value of high-quality innovation efficiency before and after 2008. The values greater than 0 are defined as the overall innovation efficiency improvement group (*Inno_pd*) and the high-quality innovation efficiency improvement group (*Iinno_pd*), respectively. Testing the estimated effect of *Treatment* Inno_pd* and *Treatment* Iinno_pd* helps to see whether the patenting effects contribute to firms’ economic performance.

From the results of the interaction items *Treatment* Inno_pd* and *Treatment* Iinno_pd* in Table 7, it is indicated that (i) The economic performance of technology-based SMEs that have obtained the Innofund and then achieved patenting efficiency improvement (overall and high-quality patenting) will be improved. (ii) The increase in overall patenting efficiency may have a greater impact on the economic performance of the firms, either because the right combination of innovations can produce synergies, or because the cycle of high-quality innovation output into economic performance may be longer. The analysis in this section shows that although the support of innovation funds can not directly promote the growth of the economic performance of technology-based SMEs in the short term, it can improve the long-term economic performance of SMEs by improving the short-term innovation efficiency of SMEs.

Table 5: Performance of Technology-Based Small and Medium-Sized Enterprisess and the Innofund Funding Amounts

Variables	**M17** *Patent_app*	**M18** *Inno_p*	**M19** *Ipatent_app*	**M20** *Iinno_p*	**M21** *Profit*	**M22** *ROA*	**M23** *Sales*	**M24** *O_income*
Ln(Fund_amount)	0.016	0.001*	0.004	0.000	0.056	0.004	-0.027	-0.006
	(0.012)	(0.001)	(0.010)	(0.001)	(0.144)	(0.003)	(0.031)	(0.040)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Tech_field fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
_cons	-3.111***	-0.215***	-2.491***	-0.171***	-15.859	-0.115	0.967	-2.182
	(1.084)	(0.072)	(0.836)	(0.053)	(12.546)	(0.234)	(3.487)	(3.325)
Number of firms	23	23	23	23	23	23	23	23
Firm-year	141	141	141	141	141	141	141	141
R-square	0.273	0.280	0.283	0.286	0.268	0.181	0.464	0.371
Wald Chi2	237.497***	193.852***	206.800***	114.576***	396.040***	272.342***	161.617***	74.234***

Note. ***, **, and * are significant at 1%, 5%, and 10% significance level, respectively. “Y” means “controlled”.

Source: Authors’ calculations.

Table 6: Software Copyrights of Technology-Based Small and Medium-Sized Enterprises and the Innofund Support

Variables	**M25** *Software_IPR*	**M26** *Software_IPR*	**M27** *Patent_Software*	**M28** *Patent_Software*
Treatment	-0.410**		-0.211	
	(0.190)		(0.165)	
Pr(Treatment=1)		-0.589**		-0.392**
		(0.235)		(0.197)
Controls	Y	Y	Y	Y
Tech_field fixed effects	Y	Y	Y	Y
_cons	-3.298**	-3.708**	-6.012***	-6.230***
	(1.406)	(1.487)	(1.499)	(1.547)
Number of firms	18	18	18	18
Firm-year	66	66	66	66
R-square	0.191	0.203	0.242	0.253

Note. ***, **, and * are significant at 1%, 5%, and 10% significance level, respectively. “Y” means “controlled”.

Source: Authors’ calculations.

Table 7: Economic performance of Technology-based SMEs and the Innofund patenting effects

Variables	**M29**	**M30**	**M31**	**M32**	**M33**	**M34**	**M35**	**M36**
	Profit	***ROA***	***Sales***	***O_income***	***Profit***	***ROA***	***Sales***	***O_income***
Treatment	-0.296	0.045***	-0.351**	-0.108	-1.295	0.022	-0.572***	-0.236
	(2.481)	(0.016)	(0.150)	(0.310)	(2.578)	(0.018)	(0.207)	(0.371)
Inno_pd	-2.122	-0.151***	-1.504***	-1.730***				
	(2.808)	(0.030)	(0.236)	(0.284)				
Treatment Inno_pd*	12.006***	0.417***	3.306***	3.478***				
	(3.370)	(0.043)	(0.264)	(0.190)				
Iinno_pd					-1.168	-0.115**	-1.200***	-1.488***
					(3.039)	(0.048)	(0.275)	(0.281)
Treatment Iinno_pd*					9.997***	0.337***	2.828***	2.812***
					(3.848)	(0.079)	(0.461)	(0.447)
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Tech_field fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
_cons	5.386	-0.246	0.553	-1.601	10.869	0.059	3.126*	-0.262
	(17.486)	(0.155)	(1.335)	(1.605)	(17.535)	(0.191)	(1.622)	(2.051)
Number of firms	17	17	17	17	17	17	17	17
Firm-year	109	109	109	109	109	109	109	109
R-square	0.335	0.538	0.733	0.587	0.329	0.510	0.726	0.577

Note. ***, **, and * are significant at 1%, 5%, and 10% significance level, respectively. “Y” means “controlled”.

Source: Authors’ calculations.

IV. DISCUSSION

Using ZNID annual statistical data and the Innofund application and evaluation dataset, this research provides profound empirical examinations of the Innofund's effects on technology-based firms' performance. Under the quasi-natural experiment context, it is found that the Innofund support has significantly positive effects on technology-based firms' innovation performance, and the effect is especially significant for overall patenting instead of high-tech patenting. However, the empirical results show that the Innofund support has no significant direct effects on firms' economic performance. Concerning the channels, it is found that the Innnofund does not improve firms' innovation performance through increasing funding amounts directly but affecting the resource and attention allocation of firms. Although the direct effects of the Innofund are not significant, the indirect effects of short-term patenting on long-term economic performance have been confirmed.

This research can provide several policy suggestions for the catching-up countries in Asia. First, the pre-evaluation and post-evaluation systems of the innovation subsidy need improvements. Like many research on innovation subsidy, this study cannot confirm the direct effects of innovation subsidy (Wallsten 2000). Although the evaluation system based on independent experts seems to be objective and scientific, the Innofund grants still choose some mismatch companies that generate little innovation outputs and economic outputs. Since patents are important indicators in the pre-evaluation and post-evaluation of the Innofund, firms have the incentives to transfer their resources and attention from other technology fields. The future policy should consider the potential guiding effects of the government, and set specific standards for a specific field or different stages of firms. Second, although the inefficiency of innovation subsidy exists, the catching-up countries should not abandon their policy instruments to support technology-based SMEs. As the results reported, the direct effects cannot be confirmed, but the indirect effects of patenting on firms' economic performance have been identified. In developing countries, many firms are operated at a lower value chain with little innovation thinking and habits. Once the government guides their choice about innovation, they may transfer their resources and attention in the short run but build their innovation routines in the long run, which can further contribute to the catching-up of the country.

KEY TAKEAWAYS

1. Supporting the development of small and medium-sized enterprises (SMEs), especially technology-based SMEs, can help innovation of Asian developing economies.

    (i) Technology-based SMEs are SMEs concentrating on research and development and the production of high-tech products and services, which has grown as a major driver for the People's Republic of China's innovation and economic development.

    (ii) The urgent financial constraints and innovation risks are major challenges for technology-based SMEs' survival and innovations.

    (iii) Learning from the experience of the developed countries and governance practice domestically, developing Asian countries can build effective supporting instruments for technology SMEs, like a premier innovation subsidy program—Innofund in the People's Republic of China.

2. The developing Asian countries should notice the potential policy guiding effects of innovation subsidy for technology-based SMEs.

    (i) To acquire the subsidy (money and government's endorsement) from the government, firms have the incentive to behave and operate as the government expects.

    (ii) Patents are key indicators in the pre-evaluation and post-evaluation of the Innofund, which encourages firms to transfer their resources and attention from other technology fields, like software developments.

3. Although the inefficiency of innovation subsidy exists, this type of program may have positive effects on technology-based SMEs in developing Asian economies in the long run.

    (i) In developing Asian countries, many firms are operated at a lower value chain with little innovation thinking and habits.

    (ii) Once the subsidy program guides innovation, firms may transfer their resources and attention in the short run but build their innovation routines in the long run.

    (iii) For instance, the direct effects of Innofud cannot be confirmed, but the indirect effects of patenting on firms' economic performance have been identified.

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