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Innovation Vouchers and the Sustainable Growth of High-Tech SMEs: Evidence from China

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Abstract: Innovation has become an essential source of sustainable growth for most firms, especially small- and medium-sized enterprises (SMEs). Governments around the world widely implement innovation vouchers to promote innovation in SMEs. This study empirically explores the effects of innovation vouchers in stimulating patentable innovation and ultimately enhancing firms' financial performance. Using a panel of 1274 listed SMEs from the Small and Medium Enterprise Board (SMEB) and the Growth Enterprise Board (GEB), we find that innovation vouchers lead firms to utilize knowledge-intensive services and significantly increase their financial performance. We further document that patentable innovations mediate the relationship between innovation vouchers and firms' financial performance. We report that the effects of innovation vouchers on financial performance are more prominent for SMEs with limited external informational resources. We believe that our study yields novel evidence and sheds further light on the important policy implications of innovation vouchers to facilitate the sustainable growth of SMEs.

Keywords: innovation vouchers; sustainable growth; small and medium-sized enterprises; innovation

1. Introduction

Recently, governments have implemented innovation vouchers to fund short-term collaborative projects to solve innovation problems for small and medium-sized enterprises (SMEs). This policy has become an increasingly popular way to boost innovation in many European countries, including Germany, Ireland, Great Britain, and the Netherlands [1,2]. For example, in 2015, 5000 SMEs in Ireland benefited from innovation vouchers, and 92,000 Italian SMEs received innovation vouchers to develop their technologies with research organizations [3]. According to official government documents, innovation vouchers are defined as credit notes, allowing high-tech SMEs to purchase innovation consultant services and collaboration services with universities or research institutions that provide knowledge-intensive services. Innovation vouchers have some advantages that can help SMEs. First, innovation vouchers could offer resources to SMEs and aim to incentivize collaboration with a research organization to address an innovation problem [2]. In addition, an innovation voucher is one kind of credit note for a research–industry collaboration. More specifically, innovation vouchers reduce the cost of external collaborations and encourage collaborations with research organizations for R&D activities. For example, in the UK, innovation voucher programmes provide organizations with a voucher that has a small monetary value (i.e., £5000), which is then exchanged with a university or private sector company in return for short-term collaborative assistance (i.e., six months) with their innovation project. Thus, innovation vouchers increase SMEs' opportunities to gain knowledge and innovation assistance from research organizations.

Although vouchers have emerged as a popular type of policy for start-ups and small businesses, the empirical evidence is still very fragmented. Chapmana and Hewitt-

Dundas [4] found that innovation vouchers influence R&D investment and managers' attitudes. Sala et al. [1] argued that innovation vouchers are effective for obtaining new knowledge. Kleine et al. [5] believe that innovation vouchers could positively increase short- and medium-term product and service development. Researchers have tested the direct effect of innovation vouchers on R&D activities, but have not examined the indirect effect of innovation vouchers on financial performance through innovation.

Based on these, the paper conducts a comprehensive investigation of innovation vouchers in emerging countries, and tries to answer the following questions: (1) Could innovation vouchers encourage high-tech SMEs to increase innovation? (2) How can innovation vouchers increase financial performance? (3) Do innovation vouchers help high-tech SMEs achieve a higher level of innovation output and contribute to financial performance?

Using a large and unique dataset of 1724 high-tech SMEs listed on the Small and Medium-Sized Enterprise Board (SMEB) and the Growth Enterprise Board (GEB), the paper uses OLS regression to test the relationship between innovation vouchers and financial performance. We use propensity score nearest neighbour matching method to reduce self-selection problems. The results of our empirical analysis are as follows. First, there is a strong positive association between innovation vouchers and innovation. Second, innovation vouchers can significantly increase SMEs' financial performance. Third, innovation plays the mediating role between innovation vouchers and financial performance. Fourth, social networks moderate the relationship between innovation vouchers and financial performance. Indeed, innovation vouchers can help SMEs with few external networks to increase their financial performance.

The contributions of this paper are as follows: First, scholars still debate how innovation policy should be implemented and evaluated. Indeed, the literature still lacks systematic and robust assessments of innovation vouchers' effects on innovation and financial performance. Previous research has shown a positive relationship between innovation vouchers and R&D activities. Chapman and Hewitt-Dundas [4] argue that innovation vouchers could increase risk-taking and encourage more R&D programmes. However, the effect of innovation vouchers on financial performance is still unclear. In the paper, we prefer to provide the first comprehensive analysis of the impacts of innovation vouchers on the improvement of innovation and financial performance. Second, this paper provides micro-empirical evidence for the wide application of the innovation voucher policy and a policy inspiration for the further promotion of the development of SMEs, especially those that operate in high-tech industries.

The remainder of this paper proceeds as follows. Section 2 provides a comprehensive review of the literature about theory and innovation vouchers. Section 3 describes our sample and measurement choices. Section 4 presents our results and a robustness check. Section 5 provides concluding remarks.

2. Background and Literature Review

2.1. Institutional Background: Innovation Voucher Programmes

Resource constraints, such as internal financial constraints and knowledge deficits, may impede innovation and growth in high-tech SMEs [6]. As a result of this negative impact, governments introduce innovation vouchers to help SMEs gain knowledge-intensive services and encourage innovation activities in enterprises. An innovation voucher is a credit note that allows innovative SMEs or entrepreneurs to work with knowledge providers, such as universities and research intuitions, on innovative projects. Innovation vouchers can provide SMEs with opportunities to obtain new and persuasive evaluative information to improve investment decisions.

The Netherlands' government first launched innovation vouchers in 1998; the vouchers were assigned to local small firms to purchase industry–university collaboration [1]. Then, this policy was emulated throughout many European countries—such as the United Kingdom, Ireland and Finland—to stimulate innovation ability. Furthermore, the policy was adopted outside Europe; many states in the USA introduced innovation voucher poli-

cies to provide funding for small businesses to collaborate with research centres to conduct research and development. In 2009, the Canadian government applied an innovation voucher policy was to help small and medium-sized companies access direct assistance from universities to develop new products or technologies.

In 2015, the Chinese government issued a regulation that introduced innovation vouchers as a new kind of innovation policy to help SMEs gain access to knowledge-intensive services from universities and research institutions. The main reason that the government implemented this policy was to boost innovation in SMEs, especially those that are disadvantaged in terms of their knowledge stock and other resources. After 2015, innovation vouchers became a widespread policy for local governments to promote innovation, and an increasing number of high-tech SMEs benefited from this policy. In 2016, Zhejiang province, one of the most economically developed provinces in Eastern China, provided 8630 SMEs with innovation vouchers; the subsidy amount is expected to reach 102 million RMB (around $14.7 million). As a result, R&D expenditure in high-tech SMEs increased by 305 million RMB (around $43.6 million).

This policy serves only limited companies which must meet the following requirements: (1) they must be classified as a high-tech SME, (2) they must be registered in the local county, and (3) they must be a standardized management system and have no bad credit record. Typically, innovation vouchers are credit notes that allow high-tech SMEs to purchase knowledge-intensive services—such as consultancy services, intellectual property (IP) protection services, and innovation process improvements—from universities or research institutions. Using innovation vouchers to purchase such services, these enterprises can obtain discounts ranging from 10,000 to 1 million RMB (Science and Technology Committee of Shanghai, 2018), accounting for 5% to 25% of R&D spending. Enterprises can choose the type of service according to their needs. For service providers, universities or research institutions should transfer technological achievements to enterprises, which will enhance the efficiency of the market allocation of innovation resources and encourage enterprises to invest in innovation.

2.2. Review of the Academic Literature on Innovation Vouchers

Previous studies held that innovation vouchers could contribute to knowledge. Matulova [7] found that innovation vouchers could encourage SMEs to purchase knowledge-intensive services from universities or research organizations. Under knowledge-intensive services, SMEs could cooperate with these organizations on R&D projects and share information. Thus, SMEs could gain access to professional information and knowledge. Sala [1] demonstrated that innovation vouchers can provide high-tech SMEs with opportunities to collaborate with research organizations. These enterprises can be encouraged to increase their R&D investment to achieve better innovation performance. Then, the increase of knowledge flow and stock benefits an enterprise with a remarkable ability to enhance innovation activities and financial performance [8–10]. Albort-Morant [11] stated that obtaining knowledge from a research organization could increase knowledge and contribute to innovation.

Existing research provides abundant evidence that knowledge is an essential resource for enhancing enterprise innovation and financial performance [12]. Ben et al. [13] found that obtaining external knowledge is positively related to innovation and financial performance. De Silva [14] highlighted that knowledge sharing with collaborators could increase firms' value through innovation. Papazoglou and Spanos [15] researched the length of time that it takes for knowledge convert to gains, and they found that knowledge could positively influence financial performance after patents were applied for one year. Therefore, in light of the existing studies, we intend to explore whether the innovation vouchers could increase knowledge in SMEs and then improve innovation performance and financial performance.

In addition to that, the innovation voucher policy can help enterprises reduce their R&D costs during innovation activities. The innovation voucher programme is one type of

discount voucher with monetary value, often ranging from 10,000 RMB to 500,000 RMB (approximately $1400–71,000). By using these vouchers, high-tech SMEs may collaborate on innovation with research organizations such as universities at a lower cost [4]. For example, suppose an innovation voucher is worth $9000, and collaborative assistance in an important innovation project provided by a university costs $18,000. In that case, a high-tech SME pays only $9000 to the service provider, and therefore the collaboration cost is lower. This means that innovation vouchers can be an alternative funding source for high-tech SMEs' R&D investment, especially when these enterprises face financial constraints [6]. As a result of this reduction in R&D costs, managers may have more incentive to pursue innovation activities [16]. Thus, innovation vouchers play a "financing assistance role" that can increase innovation performance. Then, with the increase of innovation, the financial arrangement is improved. We propose that innovation vouchers could increase financial performance in high-tech SMEs.

Despite the effect of innovation vouchers on innovation performance, we attempt to investigate further whether innovation vouchers can positively influence financial performance, and whether innovation vouchers improve financial performance through innovation.

2.3. Open Innovation Dynamics and Innovation Vouchers

According to Chesbrough and Bogers [17] and Bogers et al. [18], open innovation is defined as a kind of innovation process in which knowledge flows across the organization's boundries, and external knowledge is used. In addition, Skordoulis et al. [19] define open innovation as the innovation that uses knowledge from both internal and external sources to increase innovation ability and raise the economic value. Firms could benefit from open innovation. First, the adoption of open innovation could increase the access to external cooperation and advance knowledge absorption [20]. Pichlak et al. [21] found that firms with an open innovation strategy could acquire more knowledge from external partners and create new knowledge and new technological solutions. Second, open innovation could provide opportunities for employees to obtain value creation knowledge [22]. Third, open connections between innovation and the market could further increase technology, innovation and economic development. Compared to big companies, SMEs with open innovation are more likely to develop technologies and improve radical innovation [21]. In addition, open innovation could innovate firms' business models to use the emerging opportunities [23,24]. Although firms could employ an open innovation strategy to increase economic advantages, firms should change their open innovation strategy based on the market situation [20]. The social innovation economy could conquer the limitation of capitalism and encourage SMEs to create new technology, products, and social value [25]. Under open innovation dynamics, Tayal et al. [26] built a measurement for overall equipment effectiveness to indicate production losses, performance, and productivity in manufacturing industries.

Recently, many researchers have paid attention to the role of policy in motivating open innovation. When the policy gives SMEs more funding or capital to boost their innovation, they are more likely to seek open innovation [27]. Chesbrough et al. [28] highlighted open innovation with Chinese characteristics, and they believed that country-level policy in China plays a vital role in open innovation.

There is still a lack of studies analyzing the role of innovation policy for open innovation, and how innovation policy influences external knowledge flows. Thus, in the paper, we try to extend the above literature to indicate the importance of innovation policy for open innovation. The paper argues that innovation vouchers, as a type of innovation policy, could help high-tech companies access open innovation and acquire knowledge from universities.

3. Method

3.1. Sample

We obtained data on Chinese listed high-tech SMEs from the Small and Medium-Sized Enterprise Board (SMEB) and the Growth Enterprise Board (GEB) between 2011 and 2018 as the initial sample. For each sample firm, we obtained financial information from the China Stock Market and Accounting Research (CSMAR) database and the Chinese Research Data Services Platform (CNRDS), which are two major databases of listed companies in China. We manually collected information on innovation vouchers from the government's official website. Additionally, firm innovation data were collected from the National Intellectual Property Administration of the People's Republic of China and the CNRDS. In order to ensure consistency with prior studies in the field, we excluded firms in banking, financing and insurance, as well as ST observations (firms with a designated special treatment due to irregularities in their financial statements and negative profits for two or three consecutive years). Our final sample consisted of 7711 firm-year observations from 1274 high-tech SMEs over the entire sample period. All of the firms in our sample are officially registered as high-tech SMEs and innovative SMEs, according to data from the CSMAR database. In order to eliminate the influence of outliers, all of the continuous variables were Winsorized at the upper and lower 1% levels.

3.2. Measures

The first dependent variable is financial performance, measured as the return on assets (ROA) and the return on equity (ROE) [29].

The second dependent variable is innovation. Following the existing literature [30,31], we measured innovation using the natural logarithm of the number of patents applied. Furthermore, to ensure the robustness of our findings, we used patents granted as another indicator of innovation, because not all patent applications were eventually approved [32,33]. Although some studies argue that patents could result in biases in judging the innovative performance, the use of patent data to measure the level of innovation is widespread in the literature, and best captures corporation innovation at the firm level.

Consistent with the existing literature [4], we measured innovation vouchers as a binary variable that took the value of 1 if a high-tech SME received an innovation voucher, and 0 otherwise.

We also included several control variables that may affect firms' innovation behaviours and economic performance [34–36]. Firm age (Age) is the log number of years the firm has been listed on the SMEB or GEB. Size is the log of total assets at the end of the year [36]. Leverage (Lev) is the sum of the book value of short-term and long-term debt divided by the sum of total assets [36]. Cash holdings (Cash) is the balance of cash divided by total assets. Salaries (Salary) are the natural logarithm of the total number of decision-makers' salaries. Large shareholders (Holder) are the percentage of shares that the largest shareholders own [35]. In order to control the intensity of the R&D activities, we took R&D (R&D personnel) as the ratio of innovation employees to the total number of employees [37]. Institutional investors (Institutions) are the percentage of shares owned by institutional investors [38]. Duality (Duality) is a dummy variable that equals one if the board chair serves as the CEO at the end of the year [39]. State ownership (SOE) is a dummy variable that equals one if the firm is a state-owned enterprise at the end of the year [34]. In order to reduce the influence of outliers, we winsorized all of the continuous variables at the 1st and 99th percentiles.

3.3. Econometric Model

The Primary Regression Models are shown in Equations (1) and (2). Equation (1) tests the effect of innovation vouchers on innovation. The dependent variable is *Innovation* $_{i,t}$. The independent variable in this equation is vouchers, which indicates whether an SME received innovation vouchers from the local government. The control variables include the firm age (Age), total assets (Asset), leverage (Lev), cash holdings (Cash), salaries (Salary),

R&D (R&D person), the size of the board (Board), duality (Duality), state ownership (SOE) and government subsidies (Subsidies). Equation (2) tests the impact of innovation vouchers on financial performance. ROA measures the financial performance. The independent variable in this equation is innovation vouchers.

$$
\begin{aligned}
Innovation_{i,t} = \quad & \beta_0 + \beta_1 Voucher_{i,t-1} + \beta_2 Controls_{i,t-1} \\
& + \sum Year\ Indicator + \sum Industry\ Indicator + \varepsilon_{i,t-1}
\end{aligned}
\tag{1}
$$

$$
ROA_{i,t} = \beta_0 + \beta_1 Voucher_{i,t-1} + \beta_2 Controls_{i,t-1} + \sum Year\ Indicator + \sum Industry\ Indicator + \varepsilon_{i,t-1}
\tag{2}
$$

$$
ROE_{i,t} = \beta_0 + \beta_1 Voucher_{i,t-1} + \beta_2 Controls_{i,t-1} + \sum Year\ Indicator + \sum Industry\ Indicator + \varepsilon_{i,t-1}
\tag{3}
$$

3.4. Sample Descriptive Statistics

Table 1 reports the summary statistics of the key variables used in our analysis. Each firm in our sample generally generates 36 patents per year, which means that these high-tech SMEs have a greater ability to create patents than those in other industries. The standard deviation of the number of patents is 50.53, indicating that the number of patents varied widely in different firms.

Table 1. Descriptive statistics: the number of observations, and all of the variables' mean, median and standard error (2015–2018).

Variables	Control	Mean1	Treatment	Mean2	MeanDiff
Apply	3859	2.934	569	3.141	−0.206 ***
ROA	3859	0.385	569	0.442	−0.057 **
Age	3859	2.765	569	2.813	−0.048 ***
Asset	3859	7.944	569	7.988	−0.044
Lev	3859	0.357	569	0.344	0.013
Salary	3859	14.322	569	14.435	−0.113 ***
Subsidies	3859	0.006	569	0.007	0
Holder	3859	7.73	569	10.136	−2.406 ***
Duality	3859	1.606	569	1.634	−0.029
Cash	3859	0.176	569	0.168	0.008
Board	3859	8.188	569	8.035	0.153 **
R&D person	3859	0.183	569	0.215	−0.033 ***
SOE	3859	0.877	569	0.931	−0.055 ***

Note: ** and *** represent significance at the 5% and 1% levels, respectively.

Table 2 presents the descriptive statistics of the differences between firms with innovation vouchers (treated firms) and firms without innovation vouchers (control firms). There are some significant differences between the treated and control groups. For example, treated firms have higher R&D expenditure and apply for more patents. Additionally, the firms in the treated group are older and have more cash in hand. However, they receive the same amount of subsidies on average.

The multicollinearity analysis revealed that the variance inflation factors (VIFs) for all of the variables ranged from 1 to 1.41, and were below the accepted level of 10, indicating that multicollinearity had no effect in this study.

Table 2. Descriptive statistics for the treated (second and third columns) and control firms (fifth and sixth columns). The number of the treatment groups is 572 and the number of control groups is 7139 (2011–2018).

Variables	Treatment	Mean	Control	Mean	Mean Diff.
Apply	572	3.14	7139	2.898	0.243 ***
ROA	572	0.042	7139	0.042	0
Age	572	2.813	7139	2.629	0.184 ***
Asset	572	7.988	7139	7.712	0.276 ***
Lev	572	0.344	7139	0.331	0.012
Salary	572	14.434	7139	14.182	0.252 ***
Subsidies	572	0.007	7139	0.007	0
Holder	572	10.085	7139	4.341	5.744 ***
Duality	572	1.633	7139	1.604	0.029
Cash	572	0.168	7139	0.219	0.051 ***
Board	572	8.033	7139	8.292	0.259 ***
R&D person	572	0.214	7139	0.101	0.113 ***
SOE	572	0.932	7139	0.876	0.056 ***

Note: *** represent significance at the 1% levels.

4. Results

4.1. Main Results

In order to examine the hypothesized relationships, the study conducted ordinary least squares (OLS) regressions together with a bootstrap procedure using Stata 16. The independent variable is a dummy variable indicating whether the firm received innovation vouchers. The dependent variables are innovation and financial performance. In addition, the control variables include Age, Size, Lev, Cash, Salary, Holder, R&D person, Institutions, and SOE. Table 3 presents the results of our baseline regressions. In column 1, we use the patents applied as the measure for innovation, and the results indicate that innovation vouchers have a significantly positive effect on innovation (at the 1% level). Some studies suggest that patents granted could be a reliable measurement for innovation performance, and thus the paper also measures the dependent variable as the number of patents granted. Column 2 shows that the innovation vouchers' effects on patents granted ($\beta = 0.181$, $p < 0.001$) were significantly positive. Columns 3 and 4 use the ROA and ROE as the indicators for financial performance. As shown in column 3, innovation vouchers are significantly related to ROA and ROE. That is, innovation vouchers have significant positive effects on innovation and financial performance.

4.2. Mediating Test

According to Baron and Kenny [40] and Muller et al. [41], we tested the mediation effect of innovation between innovation vouchers and financial performance. The mediator is innovation, which is measured as the patents applied and granted by the company. In columns 1 and 2 from Table 4, the effect of innovation vouchers on the dependent variable (financial performance) and mediator (innovation performance) are significant ($p < 0.01$). In column 3, innovation vouchers still have a significantly positive effect on financial performance, and both the statistical significance and coefficient drop substantially (0.118–0.110). We also conducted a Sobel test to measure the mediation effect, which revealed a significant mediation effect decline (8.09%). Some studies suggest that the patents granted by authorities are a reliable way to measure innovation performance, so we used the patents granted to test the mediation effect. In columns 4 and 5, innovation vouchers were significantly related to patents granted (innovation performance), and the financial and total effect declined. In addition, the Sobel test indicated that innovation performance still exists a significant mediation role between the innovation vouchers and financial performance.

Table 3. The regression results of innovation vouchers, innovation and financial performance.

	(1)	(2)	(3)	(4)
	Innovation1	**Innovation2**	**ROA**	**ROE**
Vouchers	0.227 ***	0.181 ***	0.118 ***	3.017 **
	(0.059)	(0.063)	(0.043)	(1.522)
Age	−0.057	−0.081 **	0.020	0.252
	(0.039)	(0.040)	(0.025)	(0.995)
Asset	0.486 ***	0.447 ***	−0.000	−0.424
	(0.022)	(0.024)	(0.017)	(0.560)
Lev	0.052	0.228 **	−0.962 ***	−13.531 ***
	(0.095)	(0.099)	(0.091)	(3.833)
Salary	0.192 ***	0.145 ***	0.180 ***	3.423 ***
	(0.027)	(0.027)	(0.020)	(0.500)
Subsidies	18.855 ***	16.516 ***	7.340 ***	136.427 ***
	(2.138)	(2.279)	(1.448)	(28.520)
Holder	0.032	0.091	0.562 ***	12.242 ***
	(0.101)	(0.106)	(0.065)	(2.672)
Duality	−0.101 ***	−0.061 **	0.044 **	0.307
	(0.027)	(0.029)	(0.021)	(0.643)
Cash	0.019 **	0.010	0.017 **	0.142
	(0.010)	(0.010)	(0.008)	(0.176)
Board	0.567 ***	0.476 ***	−0.392 **	−2.216
	(0.160)	(0.162)	(0.172)	(3.565)
R&D person	0.089 **	0.102 **	0.053 **	−0.010
	(0.042)	(0.044)	(0.023)	(0.785)
SOE	0.088 **	0.102 **	0.049 **	−0.003
	(0.042)	(0.044)	(0.023)	(0.076)
Year	Control	Control	Control	
Industry	Control	Control	Control	
_cons	−4.163 ***	−4.086 ***	−2.361 ***	−47.767 ***
	(0.429)	(0.426)	(0.269)	(9.421)
N	6222.000	6222.000	6222.000	6222.000
ar2	0.262	0.194	0.116	0.029

Standard errors in parentheses, ** $p < 0.05$, *** $p < 0.01$.

4.3. Moderators

Based on the above results, we extend the research and propose that the effects of innovation vouchers shape the external knowledge resources, especially the number of external resources for obtaining outside information. We anticipate that innovation vouchers can be alternative information resources for SMEs to increase firm value when firms have few external information resources. This is because if firms have limited external information resources, they will have a greater need to obtain knowledge and be more willing to use innovation vouchers because knowledge-intensive services may significantly benefit them [42]. In contrast, firms that have more comprehensive external information resources already have efficient knowledge stock, and knowledge from a university may not be useful to them [43]. Accordingly, innovation vouchers can increase firms' financial performance more efficiently when CEOs do not have diverse social networks.

In this study, we used CEOs' social network diversity to indicate firms' external resources. CEOs' social networks provide firms with opportunities to access different types of knowledge and information, which will shape investment decisions [44]. Typically, a wide range of social ties can promote new knowledge transfer, while limited network diversity diminishes the obtained information [45]. Commonly, CEOs' outside directorships are the measure for social networks. In this study, the mean number of CEOs' outside directorships was 2.7. We defined CEOs with more than three outside directorships as having diverse social networks, and CEOs with fewer than three as having small social networks.

Table 4. The results of the mediating relationship.

	(1) ROA	(2) Innovation1	(3) ROA	(5) Innovation2	(6) ROA
Vouchers	0.118 ***	0.243 ***	0.110 **	0.182 ***	0.104 **
	(0.043)	(0.064)	(0.043)	(0.063)	(0.42)
Innovation1			0.035 ***		
			(0.008)		
Innovation2					0.033 ***
					(0.012)
Age	0.020	−0.057	0.022	−0.081 **	0.021
	(0.025)	(0.039)	(0.026)	(0.040)	(0.025)
Asset	−0.000	0.486 ***	−0.013	0.448 ***	−0.012
	(0.017)	(0.022)	(0.019)	(0.024)	(0.018)
Lev	−0.962 ***	0.052	−0.962 ***	0.252 **	−0.949 ***
	(0.091)	(0.095)	(0.091)	(0.106)	(0.090)
Salary	0.180 ***	0.192 ***	0.174 ***	0.144 ***	0.172 ***
	(0.020)	(0.027)	(0.020)	(0.027)	(0.020)
Subsidies	7.340 ***	18.855 ***	6.828 ***	16.451 ***	6.861 ***
	(1.448)	(2.138)	(1.464)	(2.282)	(1.446)
Holder	0.562 ***	0.032	0.562 ***	0.087	0.563 ***
	(0.065)	(0.101)	(0.065)	(0.106)	(0.065)
Duality	0.044 **	−0.101 ***	0.047 **	−0.061 **	0.049 **
	(0.021)	(0.027)	(0.021)	(0.029)	(0.021)
Cash	0.017 **	0.019 **	0.016 **	0.069	0.016 **
	(0.008)	(0.010)	(0.008)	(0.112)	(0.008)
Board	−0.392 **	0.567 ***	−0.408 **	0.010	−0.409 **
	(0.172)	(0.160)	(0.171)	(0.010)	(0.171)
R&D person	0.053 **	0.089 **	0.050 **	0.471 ***	0.053 **
	(0.023)	(0.042)	(0.023)	(0.163)	(0.023)
SOE	0.049 **	0.088 **	0.045 **	0.102 **	−0.016
	(0.023)	(0.042)	(0.023)	(0.044)	(0.080)
Year	Control	Control	Control	Control	Control
Industry	Control	Control	Control	Control	Control
Sobel			$P < 0.05$		$P < 0.05$
Indirect			0.0085		0.014
Direct			0.110		0.104
Total			0.118		0.118
Mediated			7.19%		11.94%
_cons	−2.361 ***	−4.175 ***	−2.202 ***	−4.175 ***	−4.168 ***
	(0.269)	(0.430)	(0.279)	(0.430)	(1.009)
N	6222.000	6222.000	6222.000	6222.000	6222.000
ar2	0.116	0.262	0.119	0.262	0.032

Standard errors in parentheses ** $p < 0.05$, *** $p < 0.01$.

Table 5 reports the results for the moderate effect based on social networks. Columns 1 and 2 indicate that innovation vouchers have a significant impact on financial performance if SMEs have limited social networks and few information resources. From the sample of firms with more social networks, innovation vouchers were not positively associated with financial performance. Column 3 shows that social networks moderate the relationship between innovation vouchers and financial performance. From the above results, for firms with few external resources, innovation vouchers helped the SMEs to increase their financial performance.

In order to increase reliability, we divided the sample into CEOs who have no outside directorships and CEO who have outside directorships. The results show that the effect of innovation vouchers is significant when CEOs have no directorships.

Table 5. The results of innovation vouchers, social networks and financial performance.

	(1) Less Networks	(2) More Networks	(3) Moderators	(4) None	(5) Social Networks
Vouchers	0.188 ***	−0.057	0.079	0.167 **	−0.020
	(0.052)	(0.069)	(0.067)	(0.075)	(0.059)
networks			0.037 *		
			(0.022)		
Vouchers * Networks			0.276 ***		
			(0.083)		
Age	0.006	0.024	0.018	0.073	−0.004
	(0.037)	(0.041)	(0.027)	(0.051)	(0.037)
Asset	−0.016	0.025	−0.003	−0.008	0.020
	(0.019)	(0.024)	(0.015)	(0.027)	(0.021)
Lev	−0.984 ***	−0.910 ***	−0.960 ***	−0.767 ***	−0.734 ***
	(0.084)	(0.100)	(0.064)	(0.126)	(0.096)
Salary	0.200 ***	0.135 ***	0.177 ***	0.194 ***	0.121 ***
	(0.023)	(0.029)	(0.018)	(0.031)	(0.025)
Subsidies	7.158 ***	7.690 ***	7.360 ***	8.242 ***	6.402 ***
	(1.596)	(2.141)	(1.274)	(2.081)	(1.884)
Holder	0.626 ***	0.425 ***	0.554 ***	0.753 ***	0.383 ***
	(0.090)	(0.110)	(0.070)	(0.127)	(0.096)
Duality	0.060 **	0.030	0.049 **	0.081 **	0.041
	(0.026)	(0.030)	(0.019)	(0.036)	(0.026)
Cash	0.014	0.024 **	0.018 ***	0.586 ***	0.544 ***
	(0.009)	(0.011)	(0.007)	(0.138)	(0.100)
Board	−0.324 **	−0.553 ***	−0.386 ***	0.015	0.022 **
	(0.137)	(0.181)	(0.108)	(0.012)	(0.010)
R&D person	0.064 *	0.021	0.054 *	−0.386 **	−0.485 ***
	(0.039)	(0.048)	(0.030)	(0.183)	(0.158)
Year	Control	Control	Control	Control	Control
Industry	Control	Control	Control	Control	Control
SOE	−2.440 ***	−2.125 ***	−2.255 ***	0.078	0.009
	(0.357)	(0.515)	(0.283)	(0.052)	(0.043)
N	3787.000	2435.000	6222.000	2446.000	3776.000
ar2	0.116	0.110	0.110	0.126	0.111

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4. Robustness Check

4.4.1. Fixed Effect

The advantage of the model with fixed effects is that it allows for individual unobserved heterogeneity with respect to the intercepts. We also used fixed effects to reduce endogenous problems and confirm the overall findings. The results rejected the Hausman null hypothesis. Thus, the paper adopted the fixed effects model. The results in Table 6 support our main findings.

4.4.2. PSM

In order to reduce endogenous problems, we chose propensity score matching (PSM) to evaluate innovation vouchers' effects on high-tech SMEs' innovation and financial performance. The reason why we chose the PSM econometric model is shown below.

Government support usually comes in two forms. One is where enterprises self-select into the support, and the other is for decision-makers to choose the recipients. Innovation vouchers belong to firms' self-selection programmes: enterprises choose to join the programme, and the government randomly grants the innovation vouchers. Self-selection means that companies that apply may have different characteristics from those that do not apply, and these differences may affect financial performance; thus, the selection bias needs to be reduced. In the reduction of the selection bias, matching estimators are widely used to evaluate the effectiveness of government support. We chose nearest-

neighbour propensity score matching (PSM) to estimate the treatment effect because PSM has been shown to generate estimates consistent with actual experimental conditions, and it does not require a functional form or error term distribution assumptions.

Table 6. Regressions of innovation vouchers on innovation and financial performance: fixed effects.

	(1) Innovation1	(2) Innovation2	(4) ROA	(5) ROE
Vouchers	0.111 **	0.095 **	0.099 **	0.191 ***
	(0.049)	(0.047)	(0.046)	(0.060)
Age	−0.533 ***	−0.190	0.126	0.049
	(0.164)	(0.165)	(0.154)	(0.644)
Asset	0.447 ***	0.404 ***	−0.272 ***	−0.495 ***
	(0.035)	(0.035)	(0.033)	(0.136)
Lev	−0.002	0.288 **	−0.188 *	0.201
	(0.120)	(0.120)	(0.113)	(0.472)
Salary	−0.015	0.001	0.188 ***	0.564 ***
	(0.039)	(0.039)	(0.036)	(0.152)
Subsidies	4.430 **	5.232 ***	−0.184	0.945
	(1.885)	(1.890)	(1.768)	(7.389)
Holder	0.595 ***	0.426 *	0.488 **	0.478
	(0.225)	(0.226)	(0.211)	(0.883)
Duality	−0.078 **	−0.005	0.016	0.015
	(0.033)	(0.033)	(0.031)	(0.129)
Cash	0.035 **	0.045 ***	−0.021 *	−0.021
	(0.013)	(0.014)	(0.013)	(0.053)
Board	−0.152	0.067	−0.350 **	−0.992 *
	(0.147)	(0.148)	(0.138)	(0.577)
R&D person	0.670	−0.822	−0.391	−3.746
	(0.677)	(0.679)	(0.635)	(2.653)
Year	Control	Control	Control	Control
Firm	Control	Control	Control	Control
N	6222.000	6222.000	6222.000	6222.000
ar2	0.247	0.167	0.083	0.017

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Based on the propensity score, we ensured that all treatment firms are matched to control firms from the same year, and that there were similar characteristics along all of the covariates used in our main regression. We used nearest-neighbour matching and calliper matching, which are commonly used estimators in innovation literature [31]. In addition, we chose many covariates that simultaneously affect the treatment and outcome in the estimation of propensity scores (Age, Size, Lev, Cash, Salary, Holder, R&D person, Institutions, SOE). Table 7 presents the bias reduction with matching. After the estimation of the propensity score, a balancing test should be conducted. Before matching (stratification test), the purpose of a balancing test before matching (stratification test) is to check how well the estimated propensity score has succeeded in balancing the covariates. Table 7 shows that the bias is significantly reduced, and that both groups balance in terms of means and variance. After the propensity score is estimated, and if the matching quality is satisfactory, matched pairs of treated and nontreated firms are created based on the estimated propensity score. Finally, the ATT is calculated by taking the mean difference of the outcome variables.

Table 7. Bias reduction with matching.

Variable	Unmatched Matched	Mean Treated	Control	% reduct. % bias	|bias|
Age	U	2.7831	2.7045	26.6	
	M	2.7839	2.7853	–0.5	98.2
Size	U	7.8995	7.809	11.3	
	M	7.9	7.8883	1.5	87
Lev	U	0.33077	0.34037	–5.7	
	M	0.33052	0.33156	–0.6	89.2
Two	U	1.6326	1.6177	3.1	
	M	1.6316	1.6198	2.4	21.2
R&D person	U	20.684	13.935	47.9	
	M	20.578	20.791	–1.5	96.9
Salary	U	14.363	14.229	24	
	M	14.363	14.367	–0.8	96.8
Subsidies	U	0.00593	0.00629	–5.2	
	M	0.00592	0.00574	2.6	49.3
Cash	U	0.1771	0.18657	–7.9	
	M	0.177	0.17727	–0.2	97.1
Board	U	8.047	8.2087	–11.3	
	M	8.0499	8.0492	0	99.6
SOE	U	0.93646	0.87819	20.2	
	M	0.93629	0.95014	–4.8	76.2

Note: After matching, there is no significant difference between the treatment group and the control group.

The results of PSM regressions presented in Table 8 show that the ATT from the nearest neighbour and calliper matching are positive and significant, indicating that companies with innovation vouchers have higher innovation and financial performance.

Table 8. PSM analysis: The relationship between innovation vouchers and innovation.

Variables/Method	Propensity Score Matching					
	Nearest Neighbour (1)		Nearest Neighbour (4)		Calliper Matching (0.001)	
	ROA	Innovation	ROA	Innovation	ROA	Innovation
Vouchers	0.014 ***	0.253 ***	0.013 **	0.248 ***	0.014 **	0.240 ***
	0.005	(0.069)	(0.005)	(0.064)	(0.006)	(0.066)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3959	3959	3959	3959	3959	3959

Note: Using nearest neighbours (1:1), nearest neighbours (1:4), and a calliper with a bootstrap procedure. *** and ** represent significance at the 1% and 5% levels, respectively. The standard error was calculated using bootstrapping with 500 replications. Most importantly, all of the control variables are included.

To increase the robustness of the results, we also used the number of awarded patents (Innovation2) to indicate innovation outcomes. Although patents may not capture all-important product innovations, they still directly show the outputs of R&D programs and reflect the cumulative process of technological change [31,46,47]. We used PSM to test the relationship between innovation vouchers and patents, and reported the PSM regression results in Table 9. This table shows that innovation vouchers have a significantly positive impact on the patents awarded.

Table 9. PSM analysis: The relationship between innovation vouchers and innovation (Patents registered).

Variables	Nearest Neighbour (1)	Nearest Neighbour (4)	Calliper Matching (0.001)
Outcomes	Patent	Patent	Patent
Vouchers	0.203 ***	0.197 **	0.203 ***
	(0.077)	(0.08)	(0.074)
Control	Yes	Yes	Yes
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Observations	3959	3959	3959

Note: Table 6 shows the relationship between innovation vouchers and awarded patents. We used nearest neighbours (1:1), nearest neighbours (1:4), and a calliper with a bootstrap procedure. *** and ** represent significance at the 1% and 5% levels, respectively. The standard error was calculated using bootstrapping with 500 replications. Most importantly, all of the control variables are included.

5. Discussion: Innovation Vouchers and Open Innovation

By analyzing listed firms in China, this paper advances the understanding of the critical role of innovation vouchers and open innovation. Our empirical results showed that innovation vouchers directly stimulate knowledge-sharing and innovation performance. The effect of innovation vouchers on financial performance is mediated by innovation. For the moderation effect, innovation vouchers facilitate financial performance when the CEO has limited access to social capital. This reveals that innovation vouchers work in firms with limited knowledge resources.

Innovation vouchers have not attracted much attention yet, despite being regarded as a valuable tool for improving innovation in SMEs [4,46]. Thus, specifically, this study extended the previous literature focused on government policy by demonstrating the vital impact of innovation vouchers on financial performance [4,47]. This is important because SMEs need financial resources and knowledge resources for innovation and economic development. This study reveals that innovation vouchers could empirically stimulate knowledge-sharing, expand knowledge stock and increase innovation.

Second, this study also extends the literature on innovation vouchers by being the first to explicitly consider the different effects of innovation vouchers on innovation and financial performance. Previously, researchers have confirmed the positive impact of innovation vouchers on innovation. However, they have neglected the importance of knowledge-intensive services in terms of firm growth. This study extends our understanding by providing novel empirical evidence, showing that innovation vouchers generally increase innovation and financial performance. The results from this paper are consistent with the findings from Sala et al. and Chapman and Hewitt-Dundas [1,4] that innovation vouchers promote the gaining of knowledge from knowledge-intensive services and increase innovation. However, they solely considered the effect of innovation vouchers on innovation and financial performance. We empirically reveal, for the first time, that innovation vouchers could influence financial performance.

Third, the paper discusses the impact of innovation vouchers from an open innovation perspective, and connects innovation vouchers with open innovation literature. Different open innovation strategies have various influences on firms' performance [48]. A sharing platform economy that promotes the sharing of information and resources could be an effective method for open innovation [49]. Governments' policies could facilitate open innovation activities [50]. Governments employ policy tools to reduce market failure and encourage open innovation, and we need more policies to boost SMEs' open innovation [27]. Studies should build a new system for open innovation to promote technology solutions [51]. The paper indicates that innovation vouchers could create reliable contracts between universities and high-tech SMEs, and could increase knowledge flows.

6. Implications

This study has three implications for emerging countries. First, governments, especially local governments, should implement innovation vouchers. China is facing serious economic and environmental pressures, and innovation is undoubtedly a powerful tool to alleviate this pressure. High-tech SMEs cannot improve their financial performance without government support. Among the many types of government support, innovation vouchers could play an essential role in promoting SMEs' development.

In addition, governments should issue more innovation vouchers for firms without social networks. Innovation vouchers could significantly promote financial performance in firms that have limited social networks by supporting them to obtain knowledge. Thus, policymakers should encourage and issue more innovation vouchers for high-tech SMEs with limited social networks.

Third, high-tech SMEs should grasp any opportunity to use innovation vouchers to maximize support from the government and financial institutions. With innovation vouchers, high-tech SMEs can ensure a lower cost of R&D activities with research organizations, and can gain access to knowledge. Thus, when high-tech SMEs encounter financing difficulties, innovation vouchers can be beneficial in pursuing development. Previously, subsidies might not have positively influenced financial performance because of the crowding-out effect [52], but high-tech SMEs should utilize innovation vouchers to promote financial performance.

The outbreak of COVID-19 has brought significant negative externalities to SMEs, and SMEs are more likely to go bankrupt. In this situation, it is crucial for governments to provide support to these SMEs. Innovation vouchers as a support policy could access knowledge-intensive services and obtain solutions from universities about how to run a business during the pandemic.

7. Conclusions

The development of innovation in high-tech SMEs relies on government support; otherwise, limited resources hold these enterprises back. In order to deepen our understanding of whether innovation vouchers—a new type of public support—influence performance, this study used a sample of 1724 high-tech SMEs in China to highlight the influence of innovation vouchers on innovation and financial performance.

Innovation vouchers are becoming an important strategic choice for governments to provide strong incentives for high-tech SMEs to improve their R&D activities and innovation [4,53]. These credit notes allow high-tech SMEs to purchase innovation consultant services and collaboration services from universities or institutions that provide knowledge-intensive services. Therefore, innovation vouchers are essential policy tools for SMEs to reduce their R&D costs and gain knowledge related to innovation. Our empirical results showed that high-tech SMEs can improve their innovation in terms of patents with decreased costs and an increased knowledge stock. The study also points out that innovation vouchers not only increase innovation but can also increase financial performance. Innovation vouchers are becoming an important policy that could improve high-tech SMEs' performance. Furthermore, external networks are vital sources for firms to acquire knowledge, and firms with limited external networks may suffer from knowledge constraints. Innovation vouchers could help firms with little knowledge to improve their innovation and financial performance.

The paper has two main limitations. First, as the innovation voucher program offers high-tech SME discount vouchers, it would be interesting to investigate further how much of a discount or funding they receive. The companies do not publicly show the value of the vouchers they receive. In practice, it is necessary to know how much funding they received from innovation vouchers. Researchers could use these data to test whether the amounts of funding received from innovation vouchers have different impacts. Thus, governments must force companies to announce the values of their vouchers, and we could test the effect of their value. Secondly, we used several covariate variables of the propensity score

at year 't −1' and the dependent variable at year 't'. The relationship between innovation vouchers and financial performance may be further delayed. Finally, quantitative research could not explain the function of innovation vouchers in more detail, and did not show the mechanisms of knowledge acquisitions and transformation. Qualitative research could help us deeply investigate how innovation vouchers influence knowledge transfer, and how knowledge influences innovation and financial performance.

The above limitations offer opportunities for future research. First, researchers could ask firms to indicate the value of their vouchers and how much they invest in the R&D activities in a further study. Thus, we could deeply understand whether the amount of funding received from innovation vouchers could influence innovation and financial performance at a different level. If the amount of funding received from innovation vouchers matters for innovation and financial performance, governments could increase the budget of innovation vouchers. Thus, we need further research to offer interesting insights related to the firm's money for R&D activities and its margin value. Second, researchers could collect long term data to test the long-term impact of innovation vouchers further. For example, further research could test t + 3 years' impact, when the firm receives the innovation vouchers in the year t. Third, it would be interesting to further perform qualitative research on innovation vouchers and investigate these vouchers from the open innovation perspective to explore the ways in which the external sources of knowledge employed within this governmental support programme influenced R&D collaborations, and how innovation vouchers influence knowledge transfer.

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