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External Finance or Government Subsidy? Evaluating the Impact of Multiple-Funds on High-Tech SMEs' Innovation in Shandong Province, China

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ABSTRACT

This paper addresses the challenge of evaluating the influence of external finance and government subsidies on innovation in high-tech SMEs, within a financial policy-driven context in China. Using a firm-level panel dataset from 2011 to 2020, we aim to shed light on this issue. Our results show that both types of funding positively impact high-tech SMEs' innovation, and government subsidies can strengthen the positive impact of external finance on high-tech firms' innovation. We also find that private firms' innovation benefits more from external financing than state-owned firms. Furthermore, an additional analysis of in-depth interviews with policy-makers, about the impact of fiscal policy in Shandong province in China, enhance the validity and generalizability of our findings. Our study reveals that government subsidies play an active monitoring role by providing insurance to firm managers against innovation failures and providing new insights to both policy-makers and firm managers.

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Introduction

During the early stages of China's economic transformation, high-tech enterprises play a significant role in shaping innovation patterns within Chinese industries and sectors [1]. However, some problems arise. Specifically, uncertainty and R&D spillovers pose significant challenges for R&D activities in high-end enterprises, leading to a suboptimal equilibrium level of private R&D investments to the socially optimal [2]. Although government subsidies deliver a way to facilitate firm innovation, the application quota and government budget are limited. In addition, external financing is inclined to be difficult for the reason of information asymmetry [3,4]. Furthermore, for high-tech Small and Medium Enterprises (SMEs) with low R&D funds but high innovation demands, the entry of external financing may significantly boost their R&D activities while evidences show that these financing are more likely to follow to high-tech SMEs. Under this circumstance, an important role is realized by both formal and informal investors, and thus some external financings are considered to be vital and can solve these problems to some extent [5-7]. Hence, whether external finance or government subsidies, or both for SMEs can really affect high-tech corporate R&D activities is worth studying.

Various studies have been conducted over the last decades, and trying to answer the question of the relationship between external

finance and government subsidies on the firm's innovation in a financial policy-driven context [8,9]. Existing literature have already struggled to explore the impacts of external finance and government subsidies over the world, and their conclusion is inconsistent [10]. For instance, noted that external finance led to an increase in high-tech SME's innovation input and output, while argued there was no significant evidence to support the impact of external finance on SMEs' innovation [11]. Empirical literature showed that government subsidies produced mixed findings [12]. For example, used a Germany case to identify that government subsidies could not produce the full crowding-out effect; however, reported crowding-out effects for firms that received subsidies [13]. Through a case study of China, argued that government subsidies play a significant role in a firm's success, but it produces mixed effect both crowding-in and crowding-out. Researchers call for more papers to further examine the impact of external financing and government subsidies on firm's innovation [14,15].

Recently, many studies discussed the relationship between government policy and the business community [16,17]. Political connection is one of the crucial means for the close connection between the government and firms (i.e., state-owned firms) and is widespread around the globe such as in China. For example, state-owned enterprises normally refer to the state that has strong control over firms' economic activities by means of being shareholders of some firms. However, the existing literature present that the state-owned firms are more likely to receive government subsidies and

external finance due to their political connection [18]. Compared to state-owned enterprises, the innovation of private firms is in an entirely different strategy such as they maximize economic wealth rather than only government goals [19]. Some researchers discussed those private enterprises tend to increase R&D investment more than state-owned enterprises, and private enterprises invest more in R&D in financially successful periods may easily stand out [20]. However, few papers consider the impact of multiple funds on different firms' ownership simultaneously.

Previous studies often treat external financing as a dummy variable due to a lack of specific financing amounts, resulting in incomplete information capture. In our research, we construct external financing as a continuous variable, utilizing exact figures for calculation and aiming to obtain more information for analysis.

The objective of this study is to empirically investigate the impact of multiple funds on innovations. It aims to answer two questions. First, how external financing and government subsidies influence a firm's innovation. Second, what is the impact of multiple funds on different firms' ownership in China. The findings aim to contribute to the existing literature in several ways. Firstly, we shed light on the impact of multiple rounds of funds on high-tech enterprises in China, providing a new perspective on the joint effect of government subsidies and external finance on the firm's innovation. Considering multiple funds' effectiveness, existing studies state that government subsidies and external finance instantaneously crowd-out firms' own R&D investment but are neutral in later periods. For instance, one RMD reduced firms' own R&D investments by half an RMB in 2006, which means that government subsidies fail to correct business R&D towards the social optimum but instead cause partial crowding-out. However, our results reveal the neutral effect of government subsidies on high-tech firms, and government subsidies will strengthen the impact of external finance on firms – certification effect. Secondly, we concentrate on subsidized industries such as information technology, high-end control machinery, automotive, aerospace and aviation equipment, new materials, biomedicine, and medical equipment, which can conduce us explore the impact of multiple funds on different industries and gain a deeper understanding of the innovation chain. Thirdly, there is limited literature focusing on the micro-enterprise level due to data availability, with most attention given to macro-level situations such as regions or countries. Our paper addresses this gap by examining the effects of external finance and government subsidies on high-tech SMEs in Shandong province, based on a unique database covering the period of 2011-2020. Furthermore, we enhance the generalizability of our findings through in-depth interviews with policy-makers, making contributions not only to theoretical practice but also to government policymaking.

The remainder of this paper is structured as follows: Section 2 provides a brief overview of the literature, while section 3 presents the mechanisms and hypotheses developed to examine the impact of multiple funds on high-tech SMEs in China. Section 4 describes the data, empirical model, and the resulting empirical findings. In Section 5, we conduct further analysis, and the final section concludes with some remarks and policy recommendations.

Theoretical Background

Government Subsidy and External Finance in China

Government subsidies can enhance firms' innovation performance in several ways. First, prior literature suggested that government subsidies generate a "certification effect". This means that subsidized firms can signal to the market that they have strong

business operations and quality. Proposed that subsidies can promote innovation in the Chinese context. However, argued that excessive subsidies may hinder innovation, prompting firms to seek funds from external financial markets. Moreover, previous studies investigated the moderating effects of property rights and regional development levels on government subsidies, with results indicating that non-state-owned firms benefit more from such subsidies. Second, government subsidies can create an ideal environment for promoting innovation and economic growth [21]. Subsidies can deliver a strong signal from the government, providing guidance and increasing firms' incentive for innovation. Lokshin and Mohnen (2013) explored the effects of the Dutch R&D tax incentive scheme and found that it effectively lowered R&D costs, leading to increased R&D investment by firms.

Previous researches examined the influence of external finance on innovation activities of high-tech SMEs [22-24]. For instance, revealed that higher leverage ratios in the previous fiscal year decrease R&D investments for US firms and promote their innovation outputs [25,26]. Also found evidence of the impact of external finance on innovation activities of German firms. Similarly, reported that the effects of external financing on R&D activities of US firms differed between mature and young firms, suggesting that external financial institutions should pay more attention to the innovation and investment of high-tech SMEs [27,28]. Moreover, highlighted the divergent effects of external finance on innovation activities of Korean firms, where bank loans negatively impacted innovation while financial institutions had a positive effect [29]. Provided evidence of the positive impact of external finance on innovation activities of Chinese high-tech SMEs, and they suggested that tech-industry policy and financial policy are two significant policy instruments. However, there are limited studies on policy instruments that drive the development of external financial institutions and promote external financing for high-tech SMEs in emerging economies, especially in international circles.

Political Connection

Literature has closely discussed the relationship between government policy and the business community [30]. Political connection is one of the crucial means for the close connection between the government and firms and is widespread around the globe such as in the United States. By exploring the situation in different countries, many scholars deduced that firms can obtain competitive advantages from a close relationship with the government including tax incentives, financial support and subsidies [31]. State-owned enterprises normally refer to the state that has strong control over firms' economic activities by means of being shareholders of some firms. The existing literature presents that due to this political connection, the state-owned firm is more likely to receive government subsidies. For example, the government protects some strategically significant businesses and only makes state-owned firms available through regulations [32-34]. Furthermore, due to state-owned enterprises' close linkage to the political promotion of officials, it is more vulnerable to government attention. Importantly, subsidized firms in China with state-owned enterprises are often influenced by political considerations rather than their pursuit of economic goals. Moreover, the enterprise with a higher state-ownership percentage has a stronger connection with the government, and their governmental priorities will also be more pronounced [35,36].

Compared to state-owned enterprises, the innovation of private firms is in an entirely different strategy such as they maximize economic wealth rather than only government goals. Existing

literature discussed those private enterprises tend to increase R&D investment more than state-owned enterprises, and private enterprises invest more in R&D in financially successful periods may easily stand out. Most importantly, as President Xi mentioned in the symposium on private enterprises, the private economy has the characteristics of “five-six-seven-eight-nine”, that is, the contributions from private enterprises are more than 50% of tax revenue, more than 60% of GDP growth, more than 70% of technological innovation achievements, more than 80% of the urban labor employment, and more than 90% of the number enterprises. Thereby, the private economy has contributed enormously to China. Furthermore, due to the officials of state-owned enterprises are controlled by the government, it is hard to implement R&D investment because of the sophisticated government review process. In this case, private enterprises have more flexibility in the institutional review and make it easier to invest in R&D when they are discovered a new economic growth point.

Hypotheses Development

It is well known that firm innovation and technological change are the core drivers of productivity growth, and technological innovation and firm upgrading are main aspects of catching up for most developing countries. President Xi at the 2018 Private-Enterprises-Symposium mentioned, “High-tech SMEs are considered the largest contributors to innovation and technology generation, transfer and diffusion” and “Encourage private capital to invest in high-tech SMEs”. A key source of firm innovation and technological change in the initial stages of economic transition in developing countries the external financing and policy support. China delivers a significant case study that various low and middle-income counties attempt to emulate. Since Twelfth Five-Year Plan, firms have relied increasingly on industrial policy and external financing to encourage indigenous innovation and technological upgrading. In turn, the Chinese government at both the central and local levels expects firms' innovation and upgrade to spur regional development and catch-up. Government policies are being used to help and facilitate the restructuring of the economy transforms into an innovation perspective society in China [37].

Some realities needed to be considered. In our research, we particularly focus on the government tech-industry policy and the financial policy (i.e., “*Medium-to- Long-term Plan for Science and Technology Development*” and “*Policies supporting the high-quality development of the real economy in Shandong province*”), because external institutions may follow the contents of policies underlying the perspective of Chinese institution (shown in **Appendix B and C**). According to prior studies and the reality, government policies and subsidies also impact the high-tech SME innovation. It is generally acknowledged that the growth potential for a country depends largely on its business R&D ability to develop original knowledge and products. China is now facing the challenge of transition from non-sustainable growth to sustainable one from social, economic and environmental perspectives in the way of reforming science and technology system. The realistic need for development determines that the government support for high-tech SMEs is necessary [38]. Given the above, the purpose of government policies and subsidies are to deliver more R&D funds to target high-tech SMEs with innovative potential to motive and facilitate their R&D activities, and the R&D output can be enhanced. Therefore, we hypothesize that **Hypothesis 1:**

H1(a): Government subsidies have a positively significant effect on the innovation of high-tech SMEs.

H1(b): Government subsidies strengthen the impact of external financings on the high-tech SME's innovation.

External finance be viewed as a solution to the funding gap can partly mitigate the problem of financing innovation [39,40]. This research analyses this kind of external financing from three dimensions including external financing institutions mechanism, government supportive policies, and the advantages of the selected firms themselves. First of all, external financings are considered to address the problems of asymmetric information well [41]. External financial institutions mainly concentrate on the return and potential risks of the project, and definitely, they can evaluate them quickly and correctly due to these institutions are allowed to separately allocate cash flow rights and other control rights. And then, external institutions often try to detect and select the ones with continuous innovation ability and large market share before investment. It is because those institutions invest in the purpose of gaining benefits. Lastly, external institutions may be more cautious about the select of targeted firms because they not only seek direct financial return on investment but also seek indirect strategic benefits as well such as innovation and promising technologies development. Thus, firms receiving external financings often have some competitive advantages over others. Following that, the **Hypothesis 2** is proposed in ideally and theoretically:

H2: External finance can significantly and positively affect the innovation.

Political connection is one of the crucial means for the close connection between the government and firms and is widespread around the globe such as in the United States. By exploring the situation in different countries, many scholars deduced that firms can obtain competitive advantages from a close relationship with the government including tax incentives, financial support , and subsidies. State-owned enterprises normally refer to the state that has strong control over firms' economic activities by means of being shareholders of some firms. The existing literature presents that due to this political connection, the state-owned firm is more likely to receive government subsidies and external financings. However, compared to the state-owned enterprises, the innovation of private firms is in an entirely different strategy such as they maximize economic wealth rather than only government goals. Existing literature discussed that private enterprises tend to increase R&D investment more than state-owned enterprises and private enterprises invest more in R&D in financially successful periods may easily stand out. Most importantly, As President Xi mentioned in the *symposium on private enterprises*, the private economy has the characteristics of “five-six-seven-eight-nine”, that is, the contributions from private enterprises are more than 50% of tax revenue, more than 60% of GDP growth, more than 70% of technological innovation achievements, more than 80% of the urban labor employment, and more than 90% of the number enterprises. Thereby, the private economy has contributed enormously in China. Furthermore, due to the officials of state-owned enterprises are controlled by the government, it is hard to implement R&D investment because of the sophisticated government review process. In this case, private enterprises have more flexibility in the institutional review and make it easier to invest in R&D when they are discovered a new economic growth point. Therefore, we hypothesize **Hypothesis 3:**

H3: External finance has a positive effect on the high-tech non-state-owned firms.

Methodology

Data Collection and Variables

This research investigates the relationship between external financing, R&D innovation activities, and the economic value from Scientific and Technology (S&T) innovation by focusing on Shandong province's high-tech SMEs. High-tech SMEs in China has been defined that produces high-tech products with modern cutting-edge technology

as well as it is characterized by intensive knowledge with low-energy consumption [42]. The panel data used in this research are come from three official sources, it includes **CNIPA** (*China National Intellectual Property Administration*), *China statistics yearbook on high-tech industry (2011-2021)* and *Shandong province department of statistics (2011-2021)*. Moreover, to make our results more generalizable, we conducted in-depth interviews with several provincial officials. Our interviews were designed from a policy-maker perspective, thereby enabling a greater understanding of the nature and complexity of research phenomenon and the meaning behind the policy in Shandong province.

Dependent Variable

To evaluate the firm's innovation, previous studies usually choose patent applications or patent grants as a proxy, and we use the later one rather than the former. First of all, patent grants are better to evaluate innovative ideas while patent applications demonstrate the motivation of the high-tech SME's innovation. In this sense, the number of patent grants is a better proxy of the high-tech SME's innovation, which is more suitable to be applied to investigate the impact of external financings and government subsidies on the firm's innovation. What's more, it is undeniable that invention patent and utility patent are the core indicator to measure a firm's innovation in the Chinese background. Thus, our research employs total number of invention patents and utility patents (Patent) for each firm as the dependent variable.

Independent Variable

Government subsidies and external finance help create an idea situation for promoting innovation and economic growth. To find the amount of government subsidies, we first collect the data from the government official, and second collected the footnotes of a sample firm's annual financial statements. On the other hand, we collect the external financing data from the external financial institutions including banks, private investment, equity investment, financial market investment, and government-led venture capitals, with a focus on funds from institutions and private investors as they are most likely to support a firm's innovation activities. We then calculated the total value of government subsidies and external financing allocated to R&D and innovation for each company on an annual basis. Thus, our independent variables are $Subsidy_{it}$ and EI_{it} .

$$EI_{it} = Private\ Investment_{it} + Financial\ Market\ Investment_{it} + Equity\ Investment_{it}$$

Control Variable

When evaluating the impact of external financings on the high-tech SME innovation, several control variables associated with this

relationship should be added. Due to the tech-industry policies are play a significant role in the Chinese market, the contents of the policy also should be considered. From the perspective of received financings high-tech SMEs, we find that due to the external financial institutions' budget being very strict, therefore the firm's project proposals or presentations are critical. On the one hand, all applications or presentations must meet the direction encouraged by both the central government and the provincial government, and these ideas can be specified in the "12th Five-Year Plan", "13th Five-Year Plan", and "State Council of the People's Republic of China". On the other hand, in order to improve the success rate of gaining the external financings, the firm's project plans or presentations must clearly indicate the proportion of funds used for R&D activities, approximately numbers of patent outputs, and tax. Therefore, our research considers this issue from different perspectives including firm age, technology capability, economic development, and tax.

Firm age (FA) is defined as the number of years from its foundation to the focal year. Some studies view that the firm age as a significant factor impacting the innovation. Younger firms tend to have a higher possibility of innovation but riskier while older firms show a lower innovative possibility but more mature. Technology capability (TC) presents a firm's level of innovation, and it is calculated through total intangible assets divided total assets. Economic development (LEV) refers to innovation level in the specific region, which is calculated through the level of innovation of a region divided by the level of innovation of a state. Tax shows the high-tech SME's ability of performance and asset.

Furthermore, both the firm fixed effects and time fixed effects were included in the regression model, which account for unobservable firm-invariant and time-invariant characteristics that may affect the firm's innovation, respectively.

Descriptive Statistics

Table 1 presents the descriptive statistics of variables and correlation matrix coefficient, through coefficients, mean, standard deviation, some information could be delivered. We can observe that the dependent variable $Patent_{it}$ is correlated and significant with external financings and government subsidies. The average number of patent applications is 2.95 and the standard deviation is 1.27 after taking the logarithm. Moreover, while correlation between Tax and patent, external financings, and government subsidies implies the possibility of multicollinearity, the variance inflation factor ($VIF=1.22$) indicates multicollinearity is not a concern, and all data are normalized. Our data also is tested by Hausman specification thus we will use fix-effect model to do our empirical regression, and our Hausman Test is reported in **Appendix A**.

Table 1: The Descriptive Statistics and Correlation Matrix Coefficient

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Innovation (Patent)	1						
2. External financing (EI)	0.197***	1					
3. Government subsidies (Subsidy)	0.143***	0.382***	1				
4. Economic development (LEV)	0.194***	-0.264***	-0.349***	1			
5. Firm Age (FA)	0.140***	0.344***	0.257***	-0.192***	1		
6. Technology capability (TC)	0.039**	0.042**	0.068***	0.110***	0.068***	1	
7. Tax (Tax)	0.351***	0.315***	0.302***	-0.177***	0.321***	0.078***	1
Mean	2.95	0.363	2.67	0.552	16.33	0.061	2.757
Std.Dev	1.27	0.044	0.129	0.31	8.32	0.05	0.108

Note: (1) t-value in parentheses; (2) ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Panel Regression Model

To examine whether external financings influence the innovation capabilities of high-tech SMEs in Shandong province, fixed-effect panel data estimates are implemented through the following regression model:

$$Patent_{it} = \beta_1 * EI_{it} + \beta_2 * Subsidy_{it} + \beta_3 * EI_{it} * Subsidy_{it} + \beta_4 * FA_{it} + \beta_5 * TC_{it} + \beta_6 * LEV_{it} + \beta_7 * Tax_{it} + \lambda_i + v_t + \varepsilon_{it}$$

where $Patent_{it}$ represents the total patents (invention and utility) output of firm i in year t . EI_{it} refers to external financings of firm i in year t , and β_1 represents coefficient of external financings on firm's innovation. $Subsidy_{it}$ refers to the government subsidies received by firm i in year t , and β_2 represents the coefficient of firms' government subsidies on firm's innovation. β_3 represents the coefficient of interaction term between the external financing and the government subsidy, which captures the moderating effect of government subsidy. FA_{it} , TC_{it} , LEV_{it} , and Tax_{it} are control variables. λ_i represents the firm fixed effect that does not change by firms, and v_t represents the time fixed effect that does not change over time, and ε_{it} refers to random errors.

Analysis and Result

We examine whether external financings can have an impact on high-tech SMEs innovation process in output in the subsequent analysis. Firstly, the influences of external financings and government subsidies on innovation is compared. And then, the following comparison about the difference of impact between private firm and state-owned firm in China is carried out.

Main results

The regression results of the influence of external financings under different business scales are reported separately in Table 2, and Model (1) includes control variables only. Model (2) reports the coefficient of government subsidies on high-tech SME innovation is significantly positive ($b=0.1379$, $b<0.01$). It means that government subsidies also facilitate the high-tech SME innovation, **which is supported H1(a)**. Similarly, According to Model (2), it can be seen that external finance is positively associated with high-tech SME innovation ($b=0.3764$, $p<0.01$). This result indicate that the outcome-based nature of financial institutions determine that they focus on the high-tech SMEs' output stage, particularly the invention patents and utility patents. **H2 is supported in that way**. Furthermore, we find the coefficient of external finance is larger than that of government subsidies ($0.2831 > 0.1334$, $p<0.01$) shown in Model (4), and this result indicate that the high-tech SME innovation may benefit more from financial institutions than the government subsidy. In turn, the external institutions consider the perspective of market demands. According to prior studies unlike the government subsidy, external finance more likely serves as a catalyst for commercialization. This is because financial institutions are based on the market demand and more conducive to cultivating a pool of entrepreneurial talent in an area. Moreover, government subsidies generally support the front end of the innovation chain, while external financing supports the development of these ideas and fosters high-tech SMEs that can bring these ideas to the market.

Table 2: Main Regressions

Variables	Patent	Patent	Patent	Patent
LEV	-0.0836*** (-4.97)	-0.0904*** (-5.46)	-0.1005*** (-5.82)	-0.1029*** (-6.04)
FA	-0.0700*** (-3.08)	-0.0677*** (-3.03)	-0.0692*** (-3.10)	-0.0678*** (-3.04)
TC	0.1231 (0.25)	0.0327 (0.07)	0.0432 (0.09)	-0.0244 (0.05)
Tax	0.1159*** (5.06)	0.1394*** (6.15)	0.1024*** (4.43)	0.1285*** (5.61)
Subsidy		0.1379*** (9.96)		0.1334*** (9.59)
EI			0.3764*** (4.05)	0.2831*** (3.07)
Firm-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Constant	1.8142*** (4.19)	-0.4737 (-0.98)	0.7807 (1.56)	-1.1761** (-2.20)
Observations	3,355	3,355	3,355	3,355
R-squared	0.2967	0.3190	0.3005	0.3211

Note: (1) t-value in parentheses; (2) ***, **, and * indicate significance at the 1%, 5%, and 10% level; (3) All models are fixed-effect regression with panel data, including a set of high-tech SMEs and year (2011-2020).

Moderating Effect

To test the moderating effects of government subsidies regarding the relationship between the external financings and the high-tech SME innovation, we follow the procedure in to add the interaction term, which is $EI_Subsidy_{it}$, and shown in Model (5) and Model (6) of **Table 3**. The significantly positive coefficient of $EI_Subsidy_{it}$ ($b=0.5350$, $p<0.01$) indicates that government subsidies strengthen the impact of external financings on the high-tech SME's innovation. Thus, **H1(b) is supported**. Government subsidies may fill the gap while the high-tech SME has financed from external.

What's more, we examine and compare the difference of impact between state-owned firm and non-state-owned firms through dummy variable Type (1 refers to state-owned firm; 0 refers to private firm) shown in Model (7) and Model (8). The coefficient of EI_Type_{it} shows that there is a negative significantly ($b=-0.1805$, $p<0.01$) on the high-tech SME innovation. It means that private firm may have a better innovation than the state-owned firm after receiving external financings. Studies also provide evidence on that the private enterprises usually develop results-oriented therefore, **H3 is supported**.

Table 3: Grouped Regression

Variables	Patent	Patent	State-owned vs Private (7)	State-owned vs Private (8)
EI	-0.2825*** (-2.59)	-0.1203*** (-2.26)	0.1713*** (7.22)	0.1861*** (8.13)
EI Subsidy	0.1835*** (9.24)	0.5350*** (3.55)		
EI Type			-0.1673*** (-5.15)	-0.1805*** (-5.87)
Type			0.0652*** (4.55)	0.0667*** (5.29)
LEV		-0.0989*** (-5.80)		-0.0950** (-2.23)
FA		-0.0679*** (-3.05)		-0.0696*** (-7.89)
TC		0.1042 (0.21)		0.1745 (0.13)
Tax		0.1341*** (5.58)		0.1386*** (2.90)
Firm-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Constant	0.4066 (1.23)	-8.7278 (-2.51)	-3.9349*** (-3.99)	-5.0569*** (-4.22)
Observations	3,355	3,355	3,355	3,355
R-squared	0.3057	0.3239	0.2989	0.3155

Note: (1) t-value in parentheses; (2) ***, **, and * indicate significance at the 1%, 5%, and 10% level. (3) All models are fixed-effect regression with panel data, including a set of high-tech SMEs and year (2011-2020).

Additional Analysis

The Chinese case presents a unique and unprecedented opportunity to study state-driven innovation, as few countries have intervened in their innovation systems as systematically and invasively as China has. China has designated industries such as information technology, new materials, medical equipment and electronic automation as high-tech firms. Through the implementation of policies like the “China 2025 Plan” and the “Medium- to Long-term Plan for Science and Technology Development”, we aim to analyze and evaluate the evolution of innovation across different industries, as shown in Table 4. Our results indicate that both government subsidies and external financing have a positive impact on the information technology ($b=0.1845$, $p<0.01$; $b=0.0747$, $p<0.01$) and new materials industries ($b=0.0855$, $p<0.01$; $b=0.0879$, $p<0.05$). Government subsidies also have a positive impact on the medical equipment industry ($b=0.0881$, $p<0.05$) and the electronic automation industry ($b=0.1582$, $p<0.01$). However, since external financing tends to focus on short-term ROI and firm growth potential its impact on some industries, such as medical equipment and electronic automation, is not significant [43]. Furthermore, due to a lack of information and confidentiality regarding R&D in the aerospace industry, the impact of both government subsidies and external financing on the industry is not significant.

Table 4: Additional Regressions Based on the Industry

Industries					
Variables	(9) Information Technology	(10) New Martials	(11) Medical Equipment	(12) Aerospace	(13) Electronic Automation
Subsidy	0.1845*** (6.89)	0.0855*** (2.87)	0.0881** (2.39)	0.0400 (1.04)	0.1582*** (5.77)
EI	0.0747*** (2.96)	0.0879** (3.83)	-0.0532* (-1.78)	-0.1031** (-2.42)	-0.4200 (-1.36)
Control Variables	Yes	Yes	Yes	Yes	Yes
Firm-FE	Yes	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes	Yes
Constant	-2.0618 (-0.31)	-5.2206 (-0.80)	7.0812*** (0.88)	-10.378 (-0.88)	4.4582*** (4.51)
Observations	781	902	484	319	869
R-squared	0.4564	0.3556	0.4196	0.2950	0.3339

Note: (1) t-value in parentheses; (2) ***, **, and * indicate significance at the 1%, 5%, and 10% level. (3) All models are fixed-effect regression with panel data, including a set of high-tech SMEs and year (2011-2020).

Robust Analysis

In the above parts, we document the influence of the external financing on high-tech SMEs' innovation. In this section, some robust checks are displayed to confirm the evidence that our results are not driven by unobserved heterogeneity.

We use an alternative dependent variable, namely *Patent2_{it}*, which is total number of patent grants from the high-tech SMEs. The results in Table 5 are consistent with those presented in previous sections. More precisely, both external financings ($b=0.1328$, $p<0.01$) and government subsidies ($b=0.0725$, $p<0.01$) have a positive significantly impact on the high-tech SMEs innovation in Shandong province. Furthermore, it can be noted that the coefficient of external financings in Model (15) is higher than those government subsidies presented in Model (16), it thus indicates the higher effectiveness of external financings on high-tech SMEs. In addition, Model (17) shows a significantly positive coefficient of *EI_Subsidy_{it}* ($b=0.2646$, $p<0.01$), which means government subsidies moderated the impact of external financings as well as the high-tech SME's innovation. Therefore, we test the robustness of these findings and all results remain broadly consistent with previous analysis.

Table 5: Robust Regressions

Variables	(14) Patent2	(15) Patent2	(16) Patent2	(17) Patent2
LEV	-0.3692*** (-3.71)	-0.4370*** (-4.25)	-0.4142*** (-4.23)	-0.4823*** (-4.25)
FA	-0.0367*** (-2.90)	-0.0367*** (-2.90)	-0.0353*** (-2.83)	-0.0353*** (-2.83)
TC	0.2127 (0.73)	0.1872 (0.65)	0.1678 (0.59)	0.2158 (0.75)
Tax	0.0621** (4.67)	0.0576*** (4.30)	0.0746*** (5.66)	0.0740*** (5.56)
EI		0.1328** (2.46)		-0.6522*** (-2.66)
Subsidy			0.0725*** (9.15)	-0.1130** (-1.87)
Subsidy EI				0.2646*** (3.07)
Firm-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Constant	0.5585** (2.26)	0.1938 (0.67)	-0.6434** (-2.33)	0.0944 (0.22)
Observations	3,256	3,256	3,256	3,256
R-squared	0.2552	0.2567	0.2758	0.2788

Note: (1) t-value in parentheses; (2) ***, **, and * indicate significance at the 1%, 5%, and 10% level. (3) All models are fixed-effect regression with panel data, including a set of high-tech SMEs and year (2011-2020).

Discussions and Implications

We investigate the impact of receiving government subsidies and external finance on high-tech SMEs' incremental innovation in this study. To better illustrate the empirical findings and unfold the underlying reasons for the differentiated effects between tech-industry policies and external financings programs, we carried out follow-up research with experts from Shandong Province. Indeed, we interviewed several provincial governmental officials in order to corroborate the empirical analysis.

Our interviews are designed from a policy-making perspective, we mainly focus on the process of policy formulation to understand the meaning behind the policy. First of all, we find that the formulation of financial policies is mainly based on the solve high-tech SMEs financing problems faced by the industry clusters in the province, and central and provincial policies play different roles. As one of representer noted, *"The implementation purpose of financial policy is to solve the financing problem of high-tech enterprises. Central policy sets the big picture while provincial policy focuses on implementations and results."* This point of view shows that the government wants to use the least amount resource to driven external institutions development and further enhance the overall level of innovation in high-tech SMEs.

Then, policies to encourage investment from external institutions seem to have never stopped from 2011 to present such as *"12th Five-Year Plan"*, *"13th Five-Year Plan"*, *"Medium-to- Long-term Plan for Science and Technology Development"*, *"New & old Kinetic Energy"*, *"Tech-industry Policies on Several Policy Measures to Promote the Steady Growth of Private Investment"*, and *"Regarding the Issuance of Several Policies to Support the high-quality Development of the Real Economy"*. Ten years sounds like a short period of time, but many important theoretical and empirical developments have occurred that put a new spin on external financing impact SMEs' innovation, thus many technological, government subsidies, and societal trend have raised new questions for research in the field of SMEs' innovation. For instance, several scholars consider that external finance (institutions) pay attention based on the result-oriented rather than the process of SMEs' innovation. This is because external capitalists are more focused on the back of the high-tech SMEs' commercialization stage as well as the demands of the market. In the contrast, government subsidies pay more attention to the front end of innovation process of high-tech SMEs and mitigates their tendency to underinvestment in R&D activities by increasing the supply of funds. What's more, policies are designed and formulated to adjusting global developments and address wicked problems faced. One of our interviewers noted, *"We need to consider how enterprises develop in uncertain times, how to deal with emergencies such as COVID-19, and how to ensure the smooth operation of the market. Therefore, more work is needed from different institutional settings."*

Furthermore, we find that the provincial government policy interacts more effectively with external institutions during the implementation phase of policies due to their administrative, economic, and geographic proximity to local financial institutions compared to the central government policies. Close interactions with external financial institutions enable provincial governments to establish the appropriate environment and satisfy high-tech SMEs' demands for incremental innovation. Our representer stated, *"Before we formulate the financial policy, we always arrange seminars with high-level representatives of these external financial institutions to discuss and understand the issues related*

to their project. Then, on the basis of understanding the needs of institutions, governments will issue supportive policies." Thus, provincial government policies and their flexibility can therefore facilitate external financial institutions increase investment and indeed promote high-tech SMEs innovation.

Conclusion

This research gains a better contribution to the literature in several ways. On the one hand, with a sample of Shandong province' high-tech SMEs, the role of government subsidies and external finance impact high-tech SMEs innovation in China is analysed in our research. Our study indicates, as expected, both government subsidies and external finance facilitate high-tech SMEs' innovation in China. As Jaffe and Le (2016) noted, research of this kind needs to confront the issue of selection bias, which arises because such supports are not randomly assigned. Thus, to address selection bias, we grouped our samples into two categories which are private high-tech SMEs and state-owned high-tech SMEs in Shandong province. Our results show that the impacts of external finance on non-state-owned firms are better than state-owned firms. Furthermore, our additional analysis suggest that government subsidies and external finance can impact the high-tech SMEs to a certain area such as information technology and new materials.

In addition, the result that external finance can always be good for high-tech SMEs is verified in this study. As President Xi mentioned in the *symposium on private enterprises*, the private economy has the characteristics of *"five-six-seven-eight-nine"*, thus, there has been increased focus on access to finance to high-tech SMEs. However, prior research provide evidence on that it is much harder for high-tech SMEs to access finance for innovation activities due to the imperfection of capital markets and government policies. Based on this point of view, government and external financial institutions (capitalists) have been long regarded as significant interventions to fill the gap of such high-tech SMEs. Nevertheless, studies have not fully explored the influence of external finance over the entire process of high-tech SMEs' innovation and conducted a comparison in terms of government subsidies. Therefore, this study makes sense for providing some evidence of the real contributions of governments and external institutions (capitalists) on innovative activities of high-tech SMEs. In more detail, according to our interviews, we find that the aim of the government is to promote external institutions to enhance their investment and help high-tech SMEs carry out socially beneficial R&D activities – *Certification Effect*; therefore, the output of innovation can be enhanced since the financing constraints faced by high-tech SMEs are alleviated to a certain extent when external financings support is obtained.

Moreover, the managerial implications of our research are significant for the Chinese government, external financial institutions, and high-tech SMEs. We advocate that the government should have a more complex role in the management of policies. As Kou et al., (2020) and Isiam et al., (2018) noted, government policies should play the signalling effects between external institutions and high-tech SMEs. Our empirical evidence also shows that external finance is more conducive to the innovation outputs of high-end SMEs. It is undeniable that the Chinese government policies faced with several problems such that the different roles of the central policy and the provincial policy. Although we suggested policy-makers should focus on provincial policies first due to the more effectiveness, China can learn from the formulation and implementation policies in some developed economies to more efficiently foster and guide high-tech SMEs'

R&D activities. In particular, these policies should be noted that the R&D innovation activities of high-end SMEs should be more tied up to the market. In addition, government has introduced a series of policies to promote the development of external financial institutions as well as external financing. However, there are still many problems in the current development environment due to the short development time and imperfect legal provisions. Therefore, government should guide the scale of external financings and some other financing markets channels in China underlying the healthy operations, so that more funds can be invested to high-end SMEs and to facilitate their innovation development.

Several limitations to this study need to be acknowledged although we draw several contributions in the theoretical and practical significance. The first limitation lies in the fact that this research does not compare high-tech SMEs that become successful innovators without having received external financings or government subsidies. Also, we have not considered the behaviours of the senior management team in the scope of influencing corporate decision-making. Some studies show that the senior manager's behaviour impact high-tech SMEs' R&D activities and external financing from society [44]. Therefore, future research may focus on the comparison whether or not received external financing high-tech SMEs and the senior executives' behaviours. The current study is also limited by that we having not addressed which year's innovation policy has the best effect on high-tech SMEs' innovation, although we have listed a series of government policies in Shandong province. Thereby, future research can be tested this issue by using the method of Difference in Differences (DID) in order to measure the change in market volume before and after the policy initiative started. Finally, among private firms, the crucial members and operators come from the non-state-owned enterprises and family businesses, and our empirical results report the willingness to innovate in private firms. Thus, high-tech private enterprises should be highly valued in future research. Therefore, these shortcomings will form the potential directions of our future research in the future [45-48].

Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests.

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Appendixes

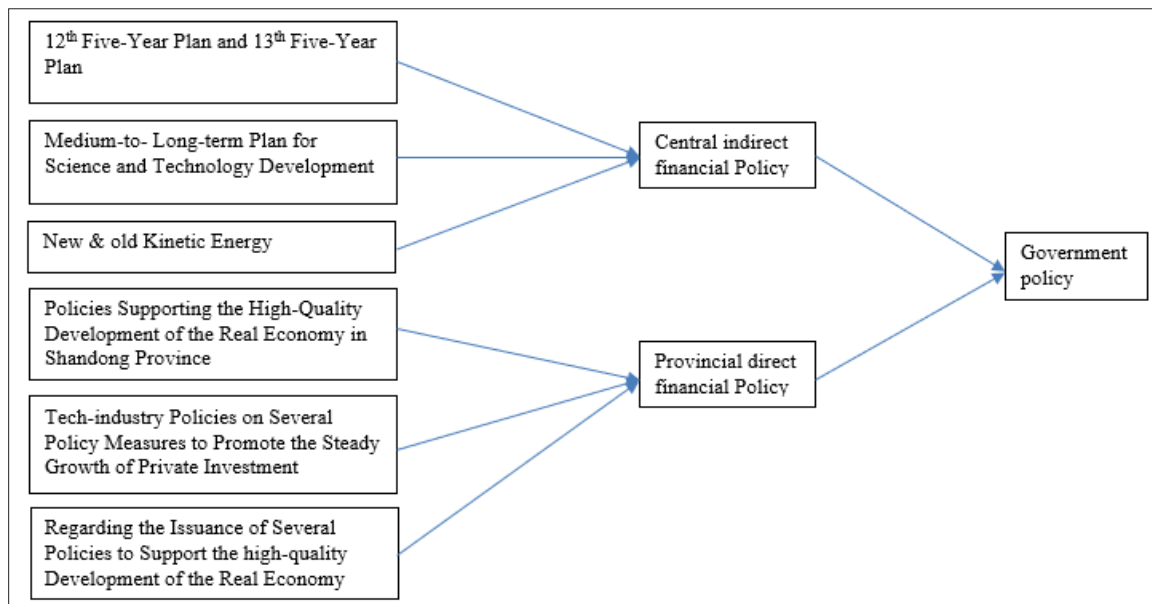
Appendix A

Hausman Test

	Coef.
Chi-square test value	381.031
P-value	0

Appendix B

Government Policies Drive Data Structure



Appendix C

Central government policy	Examples
12th Five-Year Plan	"...Develop the role of private capital and financial institutions in society and encourage investment institutions to invest high-tech SMEs..."
13th Five-Year Plan	"...Private enterprises play an indispensable responsibility and obligation on the road of China's development. More than half of China's tax revenue comes from private enterprises..." "...Promote the healthy development and smooth operation of financial institutions..."
Provincial government policy	
New and old kinetic energy	"...Encourage innovation and guide the healthy and rapid development of private financial institutions (capital). If investment losses are caused by factors such as force majeure, policy changes, or market (operation) risks, decision-making agencies, competent departments, and guiding fund management agencies will not be held accountable..."
Policies Supporting the High-Quality Development of the Real Economy in Shandong Province	"...Implement financial incentives for investment institutions. For those whose investment in SMEs exceeds 70% (inclusive), the fund management institution will be rewarded according to a certain percentage of the actual investment amount, with a maximum reward of 2 million yuan; if the progress of investing in SMEs exceeds 50% (inclusive) and less than 70% (exclusive), the maximum reward is 1 million yuan in proportion to the financial institutions."
Tech-industry Policies on Several Policy Measures to Promote the Steady Growth of Private Investment	"...Establish a multi-channel funding mechanism guided by the government, and encourage the development and establishment of private financial institutions based on financial conditions and structures..."

Regarding the Issuance of Several Policies to Support the high-quality Development of the Real Economy	“...Investment institutions should focus on key areas and related to national (provincial) economic development, such as venture capital investment in emerging industries, transformation and upgrading of traditional industries, development of modern agriculture, development of modern service industries, technological venture capital and transformation of achievements, capital market development, and urbanization. Also, subdividing investment directions, and strengthening professional operations are the aim of the external financial institutions...”
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