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The Effectiveness of Government Subsidies on Manufacturing Innovation: Evidence from the New Energy Vehicle Industry in China

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Abstract: Manufacturing innovation is of strategic importance to China in its effort to reshape future technology. This study explores the impact of government subsidies on the research and development (R&D) intensity of China's new energy vehicle (NEV) enterprises. The dynamic relationship between government subsidies and R&D intensity is tested with a panel regression model and a threshold regression model. We find that government subsidies have a significantly positive impact on R&D intensity when considering the sample group as a whole, but market profit does not contribute to R&D intensity. As for the sub-sample, government subsidies have a significantly positive impact on R&D intensity in assembly enterprises but are insignificant in supporting enterprises. Two threshold values are also identified with the logarithm of government subsidy. We find that government subsidies have a significant crowding in effect on the R&D intensity of NEV enterprises. With the increasing of government subsidy, the crowding in effect weakens gradually. The policy implication is that the structure of government subsidies should be optimized. More demand-oriented policy instruments should be adopted to cultivate the market. The government subsidies should be reduced gradually until full withdrawal.

Keywords: manufacturing innovation; R&D investment; government subsidies; new energy vehicle enterprises

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1. Introduction

China, as a rising power, is attracting increasing global attention [1,2]. Along with the rapid development of manufacturing, China also faces serious environmental pollution. As an energy-efficient technology, new energy vehicles (NEVs) are of strategic importance to China in its effort to cope with the deterioration in environmental quality and also to reshape future technology. NEV technology, as with other new technologies, is also facing hurdles such as high research and development (R&D) risks, high initial production costs and market uncertainty [3,4].

More than a decade ago, R&D subsidies began to be provided to start NEV technologies in China. The "National High Technology Research and Development Program" (the so-called 863 Program) in 2001 identified NEVs as a priority and began to finance projects in this area. Within two years, about 2 billion Yuan were provided to support research on core technologies, key components, and system integration in three "vertical" and three "horizontal" NEV programs [5] (three "verticals" refer to hybrid electric vehicles, battery electric vehicles and fuel cell electric vehicles; three "horizons" refer to battery, electronic motor and electronic control). Over the next 10 years, most of the leading Chinese auto companies entered the NEV industry and received R&D subsidies from the program.

In addition to R&D support, many government subsidies were offered with the aims of cutting production costs and speeding up the popularization of NEVs. In the "Automotive Industry Readjustment and Revitalization Plan" of 2009, and the "12th Five-Year Development Plan for the Auto Industry (2011–2015)", Chinese central government subsidies were offered in order to increase NEV production capacity. Enterprises producing key parts of NEV would be subsidized by central government via "The Guideline Catalog for Industrial Restructuring" issued by the State Council in 2011. To accelerate the diffusion of NEVs, a large-scale demonstration project for NEVs called "1000 Vehicles in 10 Cities" was implemented in 2009. In the mid of 2010, the government announced subsidies for the private consumer market in a "Notice on Subsidies for Private Purchases of New Energy Vehicles". With all these efforts, China has possessed the largest production capacity and sale volume of NEVs in the world since 2015.

Despite the booming sales of NEVs, the actual efficiency of government subsidies has garnered some controversy. Government subsidies are turning into "Tang's monk meat", as some NEV enterprises defrauded the government with forged production figures (on 20 December 2016, four new energy vehicle companies in China were penalized by the Ministry of Industry and Information for cheating on government subsidies). There is anxiety about whether government subsidies are deviating from their original intention, which is aimed at promoting core technology competencies. To address this question, this study examines the impact of government subsidies on the R&D activities of NEV enterprises, as well as the contribution ratio of government subsidies to total income and the threshold values of subsidies on R&D intensity. A panel regression model is first used to test the relationship between government subsidies and R&D intensity. Following that, a growth accounting method is used to calculate the ratio of contributions of government subsidies to total income. Lastly, a threshold regression model is used to find the threshold values.

The other parts of this paper are organized as follows: Section 2 provides an overview of past studies about the evaluation of NEV policies, as well as literature on the impact of government subsidies on the R&D invested by firms. Section 3 introduces research methods and data resources. The results of our study are presented in Section 4, followed by conclusions and policy implications in Section 5.

2. Literature Review

The Chinese government has issued a lot of policies to promote NEVs. There has been a great deal of research on the policy evaluation of China's NEV industry. The special funds for subsidizing the public sector's purchases of NEVs and the subsidies for the private consumer market in China's NEVs policies were analyzed [5]. Subsidies in the long term may foster "reliance disease" among NEV players, such as slack in R&D breakthroughs, low standard expansion, and an increasing risk of over-capacity for the whole automotive industry [5]. For the lack of a mature market mechanism, the generous subsidies provided by the government at various levels carry a risk of fraud [6]. China's policy mix was found to have transitioned from a government-selection to a market-selection concept and from a producer-orientated to a consumer-orientated system [7]. By using a four-paradigm model to analyze the consumers' evaluation of NEVs policies in terms of perception of importance and satisfaction, the consumers' perception of importance of subsidization is found to be high, while the perception of their satisfaction of subsidization is found to be low [8]. Purchasing subsidies can contribute to closing the gap of life cycle cost between the NEVs and traditional fuel vehicles, which will induce the purchasing of NEVs and accelerate the diffusion of NEVs [9].

Several studies have tested the influencing factors on the adoption of NEVs. The Energy Policy Act of 2005 in the United States was found to increase the sales of NEVs, and this incentive is effective when the amount provided is sufficiently large [10]. Using the structural equation model, the policy privilege, financial benefit, infrastructure readiness and environmental concern are found to promote the purchase of an NEV for residents conspicuously, and the cruising range of the NEV does not significantly affect the consumers' purchasing intentions toward the NEV [11–14], while subsidies for energy-efficient appliances have not changed people's purchasing intentions or the behavior of 436 urban residents from 22 provinces in China [15]. The strong desire of urban residents to buy NEVs has not effectively turned into real purchases because of the lack of supporting facilities [16].

By developing a stochastic dynamic real options model, subsidies and taxes in solar photovoltaics (PVs) are found to become increasingly ineffective with higher rates of technological change [17]. Cohen et al. quantified how demand uncertainty impacts various players in green technology, and the subsidy mechanism is found to be sufficient to coordinate the government and the supplier [18]. A congestion tax exemption was also able to increase the share of exempt energy efficient vehicles (EEVs) in Stockholm [19]. Diamond found a strong relationship between gasoline prices and NEV purchases but a much weaker relationship between incentive policies and NEV purchases [20].

R&D investments are crucial for enterprises to develop core technologies. The relationship of government subsidies and R&D investment were tested in some research. An S-shaped relationship and an inverted-U correlation for public subsidies and the R&D investments of Chinese manufacturing enterprises are found [21]. The government R&D subsidy is found to stimulate rather than crowd out private R&D activities of small biotechnology venture firms [22]. Using difference-in-difference (DID) and the two-stage least squares (2SLS) procedure, no robust evidence of crowding-out effects was found in Korean manufacturing firms [23]. An addition effect or a substitution effect has not been found when investigating the relationship between public subsidies and private R&D expenditure in French firms [24]. Public subsidies have not been found to crowd out R&D expenditures in Spanish manufacturing enterprises [25]. Dimos and Pugh investigated subsidies and R&D expenditure, and their meta-regression analysis (MRA) rejected the crowding out of private R&D investment by public subsidies [26]. However, R&D subsidies given to listed Chinese firms are found to have an immediate crowding-out effect on R&D investment but were neutral in later periods [27].

Due to the paucity of samples and data, few studies have been conducted to reveal how government subsidies influence R&D investment in China's NEV enterprises. In the innovation process, the markets are important for firms' R&D incentives [28,29]. Few studies have considered these two factors in a whole framework. This study will take the government subsidies and market profit as endogenous variables in the regression model. By collecting data from designated websites of China Securities Regulatory Commission and the Economic and Financial database of China Center for Economic Research, the influences of government subsidies on R&D intensity of NEV enterprises will be tested. The findings will help identify the actual efficiency of government subsidies in China.

3. Research Method

3.1. Research Design

The government subsidies of NEV enterprises in China can be divided into industrial subsidies and consumption subsidies. The former aim to stimulate the R&D investments of NEV enterprises to produce more patents, new products and key parts of NEVs; these subsidies are usually provided according to certain high-tech standards. Consumption subsidies aim to accelerate the adoption of NEVs. One such example is the demonstration project which began in 2009 to accelerate the diffusion of new technologies; it can be characterized as a demand-pull innovation incentive [30,31]. Since NEV enterprises are considered as high-tech enterprises, they also receive tax credits every year from the government besides government subsidies. A number of scholars have used government subsidies and tax credits as core explanatory variables [32,33].

With a surfeit of R&D investments encouraging innovation, enterprises have aimed to acquire a monopoly position and thus obtain super profits in the market. In return, the market may provide favorable conditions for sustainable R&D activities [29,34]. In such a case, the rate of profit can be used to denote the market conditions. As in most emerging industries, enterprises usually invest a great deal in R&D but actually make very little profit initially. Increases in total income therefore constitute the practical foundation of R&D investments. Here, the total income of enterprises will be selected as an explanatory variable.

In order to explore how the government subsidies influence the R&D investments of NEV enterprises, an annual panel dataset over the period from 2010 to 2015 is employed. A panel data regression is conducted to examine the relation of government subsidies and the R&D intensity of NEV enterprises. Furthermore, by calculating the contribution ratio of government subsidies to the total income of NEV enterprises via a growth accounting method, we can find to what extent the government subsidies have gone into the total income. The relation of government subsidies and R&D intensity may change in different intervals. Therefore, a threshold model is selected to find the different effects of government subsidy on R&D intensity of NEV enterprises.

3.2. Panel Regression Model

Our basic regression model is

$$\begin{aligned} \mathrm{R\&D}_{i,t} = {} & \alpha_1 \mathrm{Sub}_{i,t} + \alpha_2 \mathrm{Tax}_{i,t} + \alpha_3 \mathrm{Income}_{i,t} + \alpha_4 \mathrm{Profit}_{i,t} + \alpha_5 \mathrm{Scale}_{i,t} + \alpha_6 \mathrm{Debt}_{i,t} \\ & + \alpha_7 \mathrm{Reg}_{i,t} + u_i + \varepsilon_{i,t} \end{aligned} \tag{1}$$

In the demonstration project, the government subsidy catalogue can serve as a signal for both consumers and private investors [35,36]. NEV enterprises will not only receive subsidies but will also be influenced by signal effects. With a virtual variable, Signal, the signal model can be tested in Equation (2).

$$\begin{aligned} \mathrm{R\&D}_{i,t} = {} & \beta_1 \mathrm{Signal}_{i,t} + \alpha_1 \mathrm{Sub}_{i,t} + \alpha_2 \mathrm{Tax}_{i,t} + \alpha_3 \mathrm{Income}_{i,t} + \alpha_4 \mathrm{Profit}_{i,t} + \alpha_5 \mathrm{Scale}_{i,t} \\ & + \alpha_6 \mathrm{Debt}_{i,t} + \alpha_7 \mathrm{Reg}_{i,t} + u_i + \varepsilon_{i,t} \end{aligned} \tag{2}$$

3.2.1. Dependent Variable

"R&D" refers to R&D intensity. The higher the R&D intensity, the more efforts are attached to innovation by NEV enterprises.

3.2.2. Independent Variable

"Sub" refers to subsidies. The NEV enterprises mainly receive industrial subsidies and consumption subsidies, both of which can promote innovation. We adopt the total amount of subsidies received by NEV enterprises from the government as the total amount of government subsidies and examine the impact of government subsidies on the R&D intensity of NEV enterprises.

Tax: The government usually uses tax credits to spur innovation of high-tech enterprises. In the article, we use "Tax" to denote tax credits to examine the impact of tax credits on the R&D intensity of NEV enterprises.

Profit: In the innovation chain of enterprise, market condition is an important factor that affects innovation. We use "Profit" to denote the enterprise profit and test the influence of market conditions on the R&D intensity of NEV enterprises.

Income: In the early development stage of NEV enterprises, total business income is an important foundation to support enterprise innovation. The impact of total business income on the R&D intensity of NEV enterprises is tested here.

Scale: In the previous research, enterprise scale is an important factor that influences the R&D investment of enterprises. Here, we use the NEV enterprise's fixed capital to reflect enterprise scale.

Debt: Debt ratio is an important factor affecting enterprise financing. "Debt" is used to reflect the ratio of corporate debt to fixed capital.

Reg: Environmental regulation intensity is an important environmental variable affecting the innovation of NEV enterprises. The ratio of waste investment to GDP is used to reflect the intensity of environmental regulation.

Signal: If the vehicle of NEV enterprises entered the subsidy catalogue, Signal = 1. If the vehicle did not enter the subsidy catalogue, Signal = 0.

A list of these variables are shown in Table 1.

I denotes the individual and t denotes the year. The absolute values are deflated to 1978 values (China's reform policy began in 1978; it has been common practice among researchers to deflate the price to the year of 1978) and the logarithm is taken to eliminate multiple co-linearity. The co-efficient can be explained as elasticity.

Table 1. Definition of Variables.

Variables	Definition
R&D	The ratio of R&D expenditure to total income (%)
Sub	The total subsidies that new electric vehicle (NEV) enterprises received (10,000 Yuan)
Tax	The total tax credit that NEV enterprises received (10,000 Yuan)
Income	The total business income of NEV enterprises (10,000 Yuan)
Profit	The total profit of NEV enterprises (10,000 Yuan)
Scale	The total fixed capital of NEV enterprises (10,000 Yuan)
Debt	The ratio of debt to total fixed capital of NEV enterprises (%)
Reg	The ratio of waste investment to GDP (%)
Signal	If the car entered the subsidy catalogue, Signal = 1. If the car did not enter the subsidy catalogue, Signal = 0.

Forty-one listed new energy vehicle enterprises from 2010 to 2015 were selected as research samples, including 18 assembly enterprises and 23 supporting enterprises. The data of R&D, Sub and Tax were collected from the annual report of listed companies from designated websites of China Securities Regulatory Commission. The data of Income, Profit, Scale, Debt, Reg and Signal were collected from the Economic and Financial database of the China Center for Economic Research.

3.3. Growth Accounting Method

From an input–output point of view, every NEV enterprise can be considered as a microcosmic economic entity. R&D investments, government subsidies and fixed capital are direct input factors; the total income is a direct output. The contribution proportion of government subsidy to total income can be calculated in Equation (3):

$$\frac{\Delta \text{Income}}{\text{Income}} = \theta_1 \frac{\Delta \text{R\&D}}{\text{R\&D}} + \theta_2 \frac{\Delta \text{Sub}}{\text{Sub}} + \theta_3 \frac{\Delta \text{Scale}}{\text{Scale}} \tag{3}$$

θ_1 denotes the contribution proportion of R&D investments to the growth rates of total income of NEV enterprises. θ_2 denotes the contribution proportion of government subsidies to the growth rates of total income of NEV enterprises, which can help to depict the efficacy of government subsidies. θ_3 denotes the contribution proportion of fixed capital to the growth rates of total income of NEV enterprises.

3.4. Threshold Regression Model

The effectiveness of government subsidies may be different in different intervals. The threshold regression model will be used to divide the samples into different groups, and the relationships in different intervals will be tested. Then, more detailed information can be found as follows:

$$\text{R\&D}_{i,t} = \grave{\imath}_i + a_1 \text{Sub}_{i,t}\, I(\text{Sub} \le r_1) + a_2 \text{Sub}_{i,t}(\text{Sub} \ge r_1) + \hat{a}_2 X_{it} + \tilde{a}_t \tag{4}$$

Equation (4) is a single threshold model, is the threshold value of government subsidies, X_{it} is the control variable. A multi-threshold model can be extended from Equation (4). Following Hansen [37], a bootstrap will be used here to test the threshold values one by one; until *n* + 1, when the threshold value is not significant. After that, the threshold values and different intervals can be identified. According to the threshold values, the threshold panel data model can be estimated.

4. Results

4.1. Descriptive Statistical Analysis

The mean, standard deviation, minimum and maximum of variables are given in Table 2. The pairwise correlation coefficients are given in Table 3. Three variables have high correlations; the correlation coefficients of the other variables are below 0.3. Variance inflation factors (VIF) are used to test multiple co-linearity. The VIF values distribute around 1, which is far below the traditional threshold value of 5. The results show that this sample will not be influenced by multiple co-linearity.

Table 2. Descriptive Statistics.

Variables	Mean	Std. Dev.	Min	Max
R&D	0.040	0.030	0	0.187
Sub	8.077	1.754	0	12.600
Tax	13.088	8.170	−9.21	21.046
Income	13.133	2.208	0	18.021
Profit	0.0777	0.0771	−0.5107	0.4225
Debt	0.500	1.963	0	0.930
Scale	13.286	2.176	0	17.751
Reg	11.491	2.526	9.082	15.492

Table 3. Pairwise correlations coefficients.

Variables	R&D	Sub	Tax	Income	Profit	Debt	Scale	Reg
R&D	1.000							
Sub	0.040	1.000						
Tax	0.151	0.093	1.000					
Income	−0.146	0.780	0.070	1.000				
Profit	0.083	−0.176	−0.052	−0.224	1.000			
Debt	−0.327	0.345	0.013	0.508	−0.518	1.000		
Scale	−0.093	0.634	0.131	0.710	−0.141	0.369	1.000	
Reg	0.097	0.151	−0.035	0.101	−0.094	0.082	0.134	1.000

4.2. Regression Analysis

Data of the 41 NEV enterprises were tested by using panel data regressions. The results are shown in Table 4. The Hausman's p value indicates the fixed effect is suitable for the basic model, while the random effect is fit for the signal model.

Table 4. Estimation results of whole samples.

	Basic Model	Signal Model
Sub	0.003 ** (2.17)	0.003 * (1.91)
Tax	−0.000 (−0.85)	0.000 (0.05)
Signal	——	0.009 *** (2.62)
Income	0.005 *** (3.85)	0.002 * (1.74)
Profit	−0.057 *** (−2.88)	−0.045 ** (−2.28)
Debt	−0.008 (−0.52)	−0.037 *** (−2.62)
Scale	0.003 *** (2.85)	0.002 (1.49)
Reg	0.000 (0.18)	−0.000 (−0.10)
Cons	−0.083 *** (−4.29)	−0.012 (−0.63)
R^2	0.392	0.377
N	249	249
F(Wald) value	8.24	42.34
Hausman	Prob > chi2(7) = 0.000	Prob > chi2(8) = 0.123

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In the basic model and the signal model, the coefficients of Sub are both significant with a value of 0.003, which indicates that every 1% increase in government subsidies will result in a 0.003% increase in R&D intensity. In practice, a government subsidy is usually given according to certain strategic objectives or high-tech standards and then assessed by new patents or new products. Enterprises receiving government subsidies need to put a lot of investment into R&D to satisfy their objectives or assessment. Government subsidy usually has a positive relationship with R&D investment. Similarly, Signal has a significantly positive influence on R&D because if their vehicles enter the subsidy catalogue, NEV enterprises will be greatly stimulated to increase their investment in R&D.

Profit has a significantly negative influence on R&D in both models, while the coefficients of Income are both significantly positive. The results indicate that although many subsidies have been given to promote demand, the market has not yet provided favorable enough conditions for NEV enterprises to conduct R&D activities. A focus on total income is the basis of R&D for NEV enterprises. As in other strategic emerging industries, NEV enterprises make R&D investments aiming for a future leading position in technology and super profits, even though they make very little return in the beginning.

From an industrial chain point of view, NEV enterprises can be divided into assembly enterprises and supporting enterprises. These are different in strategic position. To probe more detailed differences of government subsidy in assembly enterprises and supporting enterprises, a sub-sample test was conducted in Table 5. The results show that the government subsidy in assembly enterprises has stimulated R&D investment, but the coefficient of Sub in supporting enterprises is not significant. Assembly enterprises include all of the leading vehicle manufacturers, have been subsidized by many kinds of high-tech plans over different periods, and all have sound R&D capability. Supporting enterprises, on the other hand, consist mostly of newly entered enterprises, such as producers of charging pillars and batteries who usually receive industrial subsidies only. As for the amount, supporting enterprises received much less than the assembly enterprises in terms of subsidy resources and subsidy intensity.

Table 5. Estimation results of sub-samples.

	Assembly Enterprises	Supporting Enterprises
Sub	0.006 ** (2.53)	−0.001 (−0.64)
Tax	0.001 (1.29)	−0.002 (−1.30)
Income	0.005 ** (2.44)	−0.010 (−1.27)
Profit	−0.003 * (−1.97)	−0.002 ** (−2.43)
Debt	−0.048 * (−1.92)	0.027 (1.49)
Scale	0.004 ** (2.59)	0.013 ** (2.43)
Reg	0.001 (0.77)	0.000 (0.22)
Cons	−0.092 *** (−3.93)	−0.004 (−0.27)
R^2	0.391	0.404
N	113	138
F	7.98	10.47

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.3. Contribution Rate Analysis

The factor contribution rate can help to explore the contribution trend of the government subsidy. According to Equation (3), with a sample of 18 assembling NEV enterprises, the contribution rate of government subsidy to growth rate of total income was calculated. In Figure 1, the contribution rate of government subsidies rose rapidly from 2010 to 2012 but rose stably from 2012 to 2015. As to the amount, the contribution rate was 1.316% in 2010, but reached to 1.55% in 2015. The results indicate that with the expansion of government subsidies, more government subsidies went into total income. While the subsidies promoted the R&D intensity in NEV enterprises, these government subsidies are also contributing to total income of NEV enterprises partly.

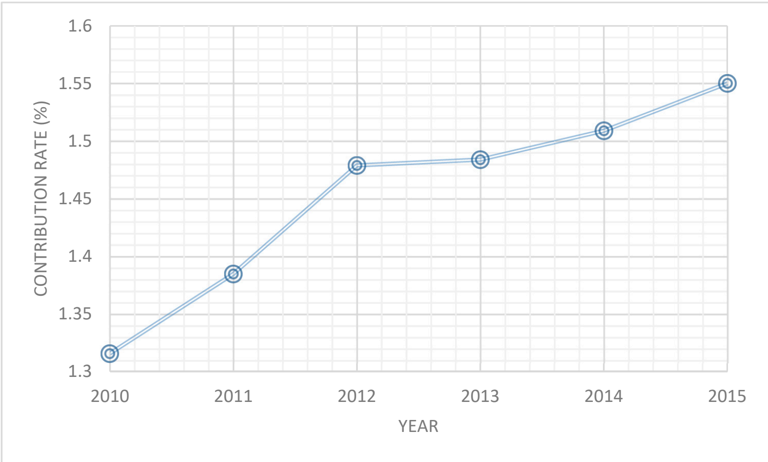

Figure 1. Contribution rate of government subsidies to growth rate of total income (%).

4.4. Results of Threshold Estimation

With bootstrap estimation, threshold value, *p* value and 95% confidence intervals are shown in Table 6. The *p* value indicates that both the single and double threshold effects are significant at the 5% level. The triple threshold effect is not significant. Government subsidy can be divided into 3 ascending internals, including a low subsidy (the logarithm is lower than 7.138), a medium subsidy (the logarithm is between 7.138 and 9.813), a high subsidy (the logarithm is higher than 9.813).

Table 6. Estimation results of threshold value.

	Threshold Value	*p* Value	95% Confidence Interval
First	7.138	0.065	(5.408,12.598)
Second	9.813	0.040	(5.430,11.123)
Third	10.818	0.107	(9.709,9.850)

The threshold effects after the bootstrap estimation are shown in Table 7. The contribution of government subsidy on NEV enterprise R&D intensity is significant at a 1% level. Government subsidies have a significant crowding in effect on the R&D intensity of NEV enterprises. However, with the increases of government subsidy, the crowding in effect weakens gradually. When the logarithm of government subsidy was less than 7.138, the crowding in effect on R&D intensity reached 0.007. When the logarithm of government subsidy exceeded 9.813, the crowding in effect on R&D intensity dropped to 0.004.

Table 7. Estimation results of threshold effect.

Explanatory Value (R&D Intensity)	Threshold Model
Sub-1	0.007 *** (3.88)
Sub-2	0.006 *** (3.88)
Sub-3	0.004 *** (2.61)
Income	0.003 ** (2.34)
Tax	0.001 (1.12)
Scale	0.002 ** (2.03)
Profit	−0.002 * (−1.88)
Debt	0.008(0.47)
Reg	0.001(0.64)
Cons	−0.075 *** (−5.68)
N	246
F value	5.280
Fixed effect test	F = 19.58 prob > F = 0

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Conclusions and Policy Implications

A large volume of government subsidies have been granted to NEV enterprises in China in recent years. Whether these mass subsidies have increased R&D intensity in NEV enterprises is the question we should address. With the panel regression model, we found that government subsidies have indeed promoted R&D intensity significantly in NEV enterprises, whereas market profit has not contributed to R&D intensity. The contribution of government subsidies to R&D intensity is significant in assembly enterprises but not significant in supporting enterprises. With the threshold model, we found that government subsidies have a significant crowding in effect on R&D intensity in NEV enterprises, but the crowding in effect weakens off with the increases of government subsidy. Comparatively, a crowding out effect was found on the R&D investment in renewable enterprises [38].

Our research has looked into the current controversy concerning government subsidies to NEV enterprises. Although the government subsidies promoted the growth of R&D intensity significantly, the contribution of government subsidies to the total incomes of NEV enterprises also grew rapidly, indicating that government subsidies may be redirected to profit targets if not supervised strictly [39]. Without effective supervision, government subsidies to NEVs may be used for multi-sourced and obscure objectives, deviating from the promoting of R&D growth. The offering of subsidies has even induced NEV enterprises to cheat. Not only should the subsidy structure be optimized, but more detailed targets and better supervision should be established as well.

In a complete innovation circle, the market will contribute to R&D activities. Considering the profit is not significant, it appears that market mechanisms are invalid for NEV enterprise innovation in China at the present time. Market forces, such as competence and customer learning, cannot increase the growth of R&D intensity in NEV enterprises. Here, we propose that the market should be utilized as a key resource in the promotion of R&D incentives. More demand-oriented policy instruments should be used to cultivate the immature market [40,41].

Our study has revealed the relationship between government subsidies and R&D intensity of NEV enterprises and has found that, with the increases of government subsidy, the crowding in effect weakens gradually. These results imply that higher subsidy will result in a lower crowd-in effect; that is to say, subsidy should be decreased gradually until full withdrawal.

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