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Do Government Subsidies Crowd In or Crowd Out R&D Investment? Evidence from China's Animal Husbandry Companies

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Abstract

Purpose: The purpose of this paper is to empirically investigate the relationship between government subsidies and research and development (R&D) investment of animal husbandry companies in China. The moderating effects of firm size, debt ratio, and firm profitability on this relationship are also examined. **Research design, data and methodology:** The analysis is based on 14 animal husbandry companies listed on the Shanghai and Shenzhen stock exchanges over the period of 2012-2016. Data are obtained from the China Stock Market & Accounting Research (CSMAR) database and the RESSET database, and multiple regression analysis is utilized with the aid of Stata. **Results:** The empirical results show that government subsidies can promote R&D investment of animal husbandry companies in China. In addition, firm size, debt ratio, and firm profitability have positive moderating effects on the relationship between government subsidies and R&D investment. **Conclusions:** Based on the results, the paper concludes that government subsidies play an important role in the process of R&D of China's animal husbandry companies. This paper recommends that managers of animal husbandry companies should enhance the utilization efficiency of government subsidies and put great emphasis on R&D investment. The policymakers should implement more incentives to encourage animal husbandry companies to invest more in R&D.

Keywords: Government Subsidies, R&D Investment, Animal Husbandry Companies

JEL Classification Code: O30, O32, O38

1. Introduction

Research and development (R&D) is a key engineer for a company's sustainable development and wealth creation (Singh, Kiran, & Goyal, 2015). It can also reduce the cost in the production of agribusiness (Hu, Yuan, & Shieh, 2017; Nuintin & Calegario, 2014). Enterprises are the main participants of R&D activities (Lin & Luan, 2020). High capital investment, the continuity of innovation process, the uncertainty of innovation, and the irregularity of innovation cycle suggest the high risks of corporate R&D activities, which will affect the firm's profitability and innovation behaviors. From the perspective of neoclassical economics, market failure caused by the externality and high risks of R&D activities requires government intervention. Government subsidies are viewed as an important government policy tool to improve corporate investment in R&D as well as global competitiveness of firms. Aghion, Cai, Dewatripont, Du, Harrison and Legros (2015) concluded that innovative enterprises tend to reduce their willingness to carry out R&D activities without industrial policies such as subsidies. Government subsidies are necessary for funding firms to boost private R&D investment (Lazzarini, 2015).

China, the world's second largest economy, is attracting increasing global attention (Jiang, Zhang, Bu, & Liu, 2018). Animal husbandry industry plays an important role in the construction of China's modern agriculture. Figure 1 shows that China's animal husbandry accounts for about

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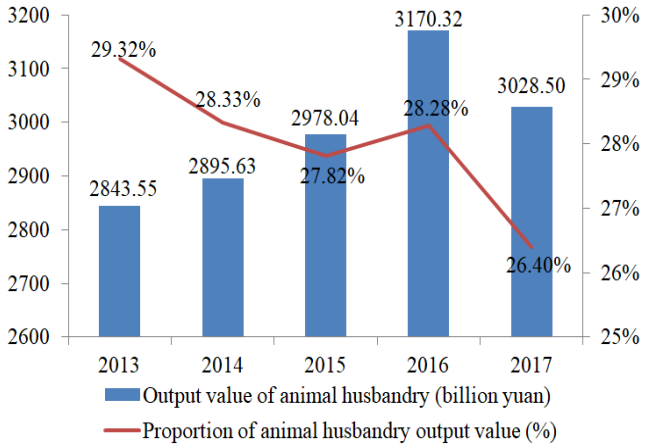
28% of total agricultural output value, which means that there is a large amount of room to grow. The sustainable development of animal husbandry companies is of great significance to achieve the strategy of rural revitalization (Feng, 2010; Sun & Kong, 2019). Marketing and service are the major determinants of business success of these companies (Preisinger, 2004). Their operating performance will also affect China's national economy (Zhao, Guo, & Yin, 2017). Compared with other industries, animal husbandry industry is easily affected by some uncontrollable factors (e.g. climate, epidemic disease, and consumption demand), which results in low profitability of animal husbandry companies (Almada, de Souza, & Laia, 2016). At present, the Chinese government has released various preferential policies to boost animal husbandry industry. However, as compared to developed countries, the level of policy support for this industry is still lower. Weible, Christoph-Schulz, Salamon and Zander (2016) analyzed firm scale and market share of animal husbandry enterprises and suggested that governmental policy tools can ensure their sustainable development during the economic recession.



Source: China's National Bureau of Statistics

Figure 1: The development of animal husbandry industry in China during 2013-2017

This paper attempts to address the following two questions. For China's animal husbandry companies, are government subsidies effective in promoting corporate R&D investment? Do firm size, debt ratio, and firm profitability moderate the relationship between government subsidies and R&D investment?

This paper contributes to the existing literature in three aspects. First, few studies have been conducted to investigate the impact of government subsidies on R&D investment in animal husbandry sector in developing countries such as China, and this paper attempts to fill this research gap. Second, this study examines the moderating effects of firm size, debt ratio, and firm profitability on this relationship that are neglected in previous literature. Finally, this study will provide insights for corporate managers as well as government policymakers to make and design optimal R&D strategies.

This paper is organized as follows. Section 2 presents the literature review and develops relevant hypotheses. Research methodology is described in Section 3, and empirical results are reported in Section 4. Finally, the conclusion and implications as well as limitations are discussed in Section 5.

2. Literature Review and Hypotheses Development

A large body of literature has examined the impact of government subsidies on corporate R&D investment, but offers mixed results. On the one hand, government subsidies can solve the problem of insufficient R&D input. They can integrate R&D resources and reduce R&D risks (Lee & Cin, 2010). On the other hand, government subsidies have the signaling effect, which improves the external financing ability of firms (Meuleman & De Maeseneire, 2012; Wu, 2017). Based on the signaling effect, if the government issues a series of subsidy policies to support a certain industry, receiving these subsidies has crowding-in effects on corporate endogenous financing, debt financing, and equity financing. Finally, government subsidies can compensate for indirect loss due to knowledge spillover during innovative activities (Gil-Moltó, Poyago-Theotoky, & Zikos, 2011).

Lee and Cin (2010), analyzing small and medium-sized enterprises (SMEs) in Korea, argued that there is no solid evidence for crowding-out effect of government subsidies on corporate R&D investment. Basit, Kuhn and Ahmed (2018) found that government subsidy has a significant positive effect on organizational innovation in the German service sector. The findings of Guo (2018) showed that R&D subsidies significantly promote innovation inputs of Chinese listed firms. Jiang et al. (2018) suggested that government subsidies are conducive to R&D intensity of China's new energy vehicle enterprises. Taking Chinese manufacturing companies as the sample, Jin, Shang and Xu (2018) found that R&D investment is positively associated with government subsidies. Ma, Zhang and Chai (2019) concluded that the government should subsidize both the retailer and the manufacturer to improve the level of green innovation. Sung (2019), using data from the Korean renewable energy technology firms, confirmed that there is a positive relationship between R&D subsidy and firms' innovation.

However, Wang and Liu (2009) found that public R&D subsidies serve as substitutes for private R&D expenditure in Taiwan. Yu, Guo, Le-Nguyen, Barnes and Zhang (2016) observed that government subsidies crowd out enterprises' R&D in China's renewable energy sector. Lin and Luan (2020) found a U-shaped relationship between government subsidies and innovation efficiency of Chinese wind power industry. Therefore, we come to the following hypothesis:

H1: Government subsidies have a positive impact on the company's R&D investment.

Schumpeter's hypotheses stated that large-scale enterprises have more innovation opportunities than small-scale enterprises because of resource endowments (Schumpeter, 1942). Some supporting research (e.g. Choi & Lee, 2018; Majumdar, 2011) suggested corporate private R&D investment changes in the same direction with a firm's size. However, some scholars (e.g. Tsai & Wang, 2005; Zhu, 2006) found a non-linear relationship between firm size and R&D investment because small enterprises are more flexible and can quickly respond to the dynamic environment. Thus, small enterprises may have more behavioral advantages in technological innovation.

If small enterprises want to survive and develop in the fierce competition, technology plays a vital role in product design. Small enterprises can make up for resource disadvantages through government subsidies, which can enable them to have a more positive attitude toward R&D input. The motivations of innovation might be weakened in large enterprises with sufficient funds and competitive advantages. González and Pazó (2008), Lach (2002), and Zhu and Li (2014) argued that the incentive effects of government subsidies are more suitable for small businesses. Therefore, we come to the following hypothesis:

H2: Firm size has a moderating effect on the relationship between government subsidies and R&D investment.

As compared to companies with less debt, companies with higher debt ratio may face serious financing difficulties and risks of capital shortage. Sufficient R&D funds are the key factor for the success of R&D projects (Xu & Sim, 2018). Therefore, companies with insufficient internal R&D funds usually have weaker willingness to engage in R&D activities (Czarnitzki, Hottenrott, & Thorwarth, 2011). Government subsidies, an important external source of funds, can alleviate the risks of the interruption of R&D activities, which reduces the negative impact of R&D investment (Zhu & Li, 2014; Zuniga-Vicente, Alonso-Borrego, Forcadell, & Galan, 2014). For companies with lower debt ratio, the role of government subsidies is relatively less important. Therefore, we come to the following hypothesis:

H3: Debt ratio has a moderating effect on the relationship between government subsidies and R&D investment.

According to the resource-based view, internal funds are the main source of corporate R&D activities under imperfect capital market. The shortage of internal funds will hinder innovative activities, and R&D inputs in previous years will be viewed as the sunk cost. Well-developed enterprises urgently need to increase their R&D intensity in order to achieve the goal of sustainable development. Government subsidies can create a favorable policy environment and alleviate the negative impact of funding constraints on R&D investment (Hyytinen & Toivanen, 2005; Zuniga-Vicente, et al., 2014). R&D intensity in enterprises with limited funds is lower than that in enterprises with abundant funds (Czarnitzki, Hottenrott, & Thorwarth, 2011). Therefore, we come to the following hypothesis:

H4: Firm profitability has a moderating effect on the relationship between government subsidies and R&D investment.

3. Data and Methodology

3.1. Sample Selection

The study is based on 14 animal husbandry companies listed on the Shanghai and Shenzhen stock exchanges. The samples are taken for five years (2012-2016). All data are collected from the China Stock Market & Accounting Research (CSMAR) database and the RESSET database, and multiple regressions are then carried out by using Stata 14.

3.2. Variables

(1) Dependent variable. Guided by some literature (Czarnitzki, Ebersberger, & Fier, 2007; Guo, 2018; Jiang et al., 2018; Jin, Shang, & Xu, 2018; Wu, 2017; Xu, Liu, & Chen, 2019; Xu & Sim, 2018; Zhu & Li, 2014), R&D intensity (RD) is used to measure corporate R&D investment.

(2) Independent variable. Guided by the studies (Guo, 2018; Jin, Shang, & Xu, 2018; Wu, 2017), subsidy intensity (SUB) is used to measure government subsidies receipts. In addition, Guo (2018), Jiang et al. (2018), Jin, Shang and Xu (2018), and Wu (2017) confirmed that

government subsidies have a lagged effect on R&D investment. Therefore, this study uses 1-year lagged subsidy intensity to examine the influence of government subsidies on R&D investment of animal husbandry companies.

(3) Moderator variables. Firm size (SIZE), debt ratio (LEV), and firm profitability (PROFIT) are used as moderators.

(4) Control variables. Consistent with previous literature (Bai, Song, Jiao, & Yang, 2019; Guo, 2018; Jiang et al., 2018; Lin & Luan, 2020; Peng & Lan, 2018; Sung, 2019; Xu & Sim, 2018; Yu et al., 2016; Zhu, Zhu, Xu, & Xue, 2019), return on assets (ROA), cash position (CASH), ownership concentration (OWN), and firm age (AGE) are chosen as control variables. In addition, a year dummy (YEAR) is also included to control for changes in the economic environment.

Table 1 shows the definition of the variables used in this study.

Table 1: Variable Definition

Variable	Definition	Measurement
RD	R&D intensity	R&D expenditure/Total sales
SUB	Subsidy intensity	Government subsidies/Total assets
SIZE	Firm size	Natural logarithm of total assets
LEV	Debt ratio	Total liabilities/Total assets
PROFIT	Firm profitability	Dummy variable that takes 1 if the company makes a profit, 0 otherwise
ROA	Return on assets	Net income/Average total assets
CASH	Cash position	Cash flow from operating activities/Net income
OWN	Ownership concentration	The largest shareholder's shareholding ratio
AGE	Firm age	Years since the setup of companies
YEAR	Year dummy	Dummy variable that takes 1 for the test year, 0 otherwise

Source: Author's illustration

3.3. Models

Model (1) is used to examine the impact of government subsidies on R&D investment of animal husbandry companies.

$$RD_{i,t} = \beta_0 + \beta_1 SUB_{i,t-1} + \beta_2 ROA_{i,t} + \beta_3 CASH_{i,t} + \beta_4 OWN_{i,t} + \beta_5 AGE_{i,t} + YEAR + \varepsilon_{i,t} \quad (1)$$

Model (2) is applied to test the moderating effect of firm size.

$$RD_{i,t} = \beta_0 + \beta_1 SUB_{i,t-1} + \beta_2 SIZE_{i,t} + \beta_3 SUB_{i,t-1} \times SIZE_{i,t} + \beta_4 ROA_{i,t} + \beta_5 CASH_{i,t} + \beta_6 OWN_{i,t} + \beta_7 AGE_{i,t} + YEAR + \varepsilon_{i,t} \quad (2)$$

Model (3) is employed to test the third hypothesis.

$$RD_{i,t} = \beta_0 + \beta_1 SUB_{i,t-1} + \beta_2 LEV_{i,t} + \beta_3 SUB_{i,t-1} \times LEV_{i,t} + \beta_4 ROA_{i,t} + \beta_5 CASH_{i,t} + \beta_6 OWN_{i,t} + \beta_7 AGE_{i,t} + YEAR + \varepsilon_{i,t} \quad (3)$$

To test H4, Model (4) is used to test the moderating effect of firm profitability.

$$RD_{i,t} = \beta_0 + \beta_1 SUB_{i,t-1} + \beta_2 PROFIT_{i,t} + \beta_3 SUB_{i,t-1} \times PROFIT_{i,t} + \beta_4 ROA_{i,t} + \beta_5 CASH_{i,t} + \beta_6 OWN_{i,t} + \beta_7 AGE_{i,t} + YEAR + \varepsilon_{i,t} \quad (4)$$

where $i = 1, \ldots n$ and $t = 1, \ldots t$ represent firm and year, respectively; β_0, β_1, β_2, β_3, β_4, β_5, β_6, and β_7 stand for the presumed parameter; ε denotes the disturbance.

4. Results

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics of the variables used in this study. The mean value of RD is 0.0079, which indicates that the level of R&D expenditure is still very low in China's animal husbandry sector. Gao and Zhang (2011) stated that the level of innovation capability of China's agricultural high-tech enterprises is barely acceptable. The mean SUB of 0.0089 reveals that animal husbandry companies tend to depend more on government support, consistent with the findings of Peng and Lan (2018). The mean value of ROA shows that animal husbandry companies suffer some operating losses during China's economic transformation. Mijić, Zekić, Jakšić and Vuković (2014) also found that Serbian livestock companies experienced a serious decrease in corporate returns over the period of 2010-2012. Cash position of these companies is kept at high level. In addition, OWN, AGE, SIZE, and LEV post average means of 0.3115, 17.43, 22.3381, and 0.4707, respectively. The mean value of PROFIT is 0.75, which means that 75% of the sample companies experience profitable earnings during the study period.

Table 2: Descriptive Statistics

Variables	N	Mean	Min	Max	Standard Deviation
RD	56	0.0079	0	0.0383	0.0097
SUB	56	0.0089	0.0002	0.0570	0.0124
ROA	56	-0.0008	-1.8591	0.3300	0.2763
CASH	56	4.2044	-3.1686	60.3721	10.0148
OWN	56	0.3115	0.0408	0.4787	0.1304
AGE	56	17.43	12	25	3.500
SIZE	56	22.3381	20.3536	24.7113	1.1353
LEV	56	0.4707	0.1732	0.8789	0.1794
PROFIT	56	0.75	0	1	0.437

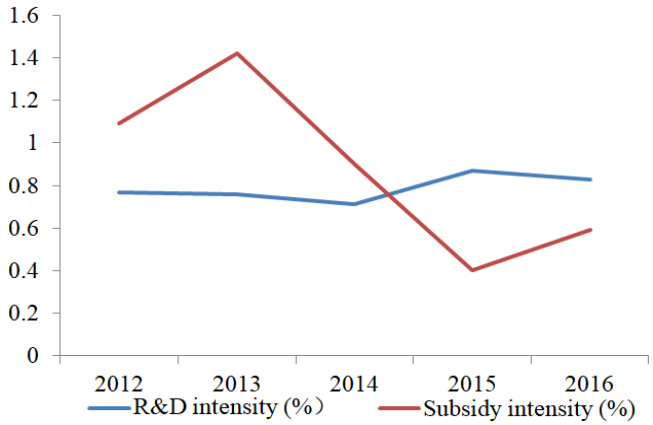
Source: Author's calculation

Table 3 shows the evolution of RD and SUB indicators. During 2012-2016, RD indicator is relatively stable, while SUB indicator shows a downward trend (See Figure 2). During China's economic transformation, companies were required to put more emphasis on innovation to improve their competitiveness.

Table 3: Year-wise Means for RD and SUB

Year	RD	SUB
2012	0.0077	0.0109
2013	0.0076	0.0142
2014	0.0071	0.0090
2015	0.0087	0.0040
2016	0.0083	0.0059

Source: Author's calculation



Source: The results of Table 3

Figure 2: R&D intensity and subsidy intensity during 2012-2016

4.2. Correlation Analysis

The correlation analysis is shown in Table 4. Referring to Table 4, SUB is positively correlated with RD ($p < 0.01$). CASH, OWN, and LEV demonstrate a significant and positive association with RD ($p < 0.05$). ROA, AGE, SIZE, and PROFIT correlate negatively with RD. To test for multi-collinearity, an analysis of the variance inflation factor (VIF) is conducted. Individual VIF values greater than 10 indicate a multi-collinearity problem (Neter, Wasserman & Kutner, 1989). In Table 4, all VIF values are calculated and found to be less than 3, which indicates that multi-collinearity is not a serious issue in this study.

Table 4: Correlation Matrix

Variable	RD	SUB	ROA	CASH	OWN	AGE	SIZE	LEV	PROFIT	VIF
RD	1									
SUB	0.410***	1								1.258
ROA	-0.189*	-0.097	1							1.831
CASH	0.276**	0.057	0.031	1						1.098
OWN	0.360***	0.197*	0.046	-0.016	1					1.465
AGE	-0.347***	-0.144	0.210*	-0.184*	-0.455***	1				1.674
SIZE	-0.212*	-0.284**	0.268**	-0.163	-0.335***	0..381***	1			1.858
LEV	0.356***	0.219*	-0.480***	-0.010	0.099	-0.311***	0.114	1		2.024
PROFIT	-0.306**	-0.316***	0.490***	0.087	-0.151	0.143	0.242**	-0.448***	1	1.645

*, ** and *** indicates significance at the 10%, 5% and 1% level, respectively.
Source: Author's calculation

4.3. Regression Results

Table 5 and 6 show the results of regression analysis. Our first research hypothesis measures whether or not government subsidies stimulate corporate investment in R&D. When control variables are included in Model (1), the adjusted R^2 increases to 29 percent. SUB is positive and significant with RD at the 5% significance level ($\beta = 0.247$,

t = 2.69). This implies that receiving government subsidies makes animal husbandry companies engage in more innovative activities. This result substantiates the findings of Guo (2018), Jiang et al. (2018), Jin, Shang and Xu (2018), Ma, Zhang and Chai (2019), and Wu (2017), supporting H1. However, Peng and Lan (2018) found that subsidies policies have no significant impact on the performance of Chinese animal husbandry companies. This might be caused by the fact that insufficient funds received cannot meet the requirement of high-cost operating pattern. In addition, Deng, Lu, Hong, Chen and Yang (2019) suggested that government R&D subsidies are negatively related to innovation in China's eastern region, but positively associated with innovation in central region.

Regarding control variables, a company's cash position (CASH) and ownership concentration (OWN) positively affect R&D investment, consistent with Lin and Luan (2020). Sufficient internal funds provide a financial guarantee for the continuity of R&D activities. Managers would be expelled by the board of directors if their R&D strategies failed. High ownership concentration enables managers to focus on the long-term interests of the firm, which is beneficial to technological innovation.

Table 5: Regression Results of Model (1)

Variables	Model (1)	Model (1)
Constant	0.005*** (3.44)	0.004 (0.42)
SUB	0.322*** (3.30)	0.247** (2.69)
ROA		-0.006 (-1.32)
CASH		0.0002** (2.13)
OWN		0.020* (1.98)
AGE		-0.0003 (-0.77)
YEAR	Included	Included
R^2	0.168	0.357
Adj. R^2	0.153	0.293
F	10.905***	5.556***

*, ** and *** indicates significance at the 10%, 5% and 1% level, respectively. *t*-values are in parentheses.
Source: Author's calculation

Other hypotheses measure the moderating effects of firm size, debt ratio, and firm profitability. *F*-test values of models (2)-(4) are highly significant at the 1% significance level, indicating that the models are fit and accepted. In Model (2), the coefficient of SUB×SIZE is significantly positive (β = 0.013, t = 3.04), which supports H2. Taking Chinese non-governmental enterprises as the sample, Zhu (2006) found an inverted-U relationship between firm size and R&D intensity. In Model (3), the coefficient of SUB×LEV is positive and significant (β = 0.467, t = 3.33), suggesting that debt ratio plays a significant moderating role in the effect of government subsidies on R&D investment. Thus, H3 is fully supported. The coefficient of SUB×PROFIT (β = 0.276, t = 2.88) means that firm profitability positively moderates the relationship between government subsidies and R&D investment, supporting H4. However, based on the data from China's private enterprises, Zhu and Li (2014) observed that the stimulating effect of government subsidies on private R&D is stronger in smaller and less profitable firms.

Table 6: Regression Results of Models (2)-(4)

Variables	Model (2)	Model (3)	Model (4)
Constant	-0.030 (-1.18)	-0.007 (-0.79)	0.008 (0.88)
SUB	0.156* (1.66)	0.119* (1.34)	0.156* (1.70)
SIZE	0.001 (1.26)		
SUB×SIZE	0.013*** (3.04)		
LEV		0.009 (1.31)	
SUB×LEV		0.467*** (3.33)	
PROFIT			-0.006** (-2.08)
SUB×PROFIT			0.276*** (2.88)
ROA	-0.008* (-1.94)	-0.004 (-0.92)	-0.002 (-0.43)
CASH	0.0002* (1.81)	0.0002** (2.12)	0.0002 (1.57)
OWN	0.023** (2.45)	0.021** (2.35)	0.017* (1.87)
AGE	-0.0002 (-0.52)	0.00003 (0.07)	-0.0002 (-0.67)
Year	Included	Included	Included
R^2	0.470	0.506	0.464
Adj. R^2	0.393	0.434	0.386
F	6.080***	7.032***	5.930***

*, ** and *** indicates significance at the 10%, 5% and 1% level, respectively. *t*-values are in parentheses.
Source: Author's calculation

4.4. Robustness Check

We use the natural logarithm of R&D expenditure and the natural logarithm of 1-year lagged government subsidies received instead of RD and SUB to conduct robustness check. The results are similar to our previous findings, indicating that our conclusion is robust.

5. Conclusions

At the firm level, R&D investment is the engine of the firm's development and growth. Government subsidies play a vital role in enhancing corporate investment in R&D. The goal of the paper is twofold. First, it aims to examine the impact of government subsidies on R&D investment of Chinese animal husbandry companies. Second, it analyzes the moderating effects of firm size, debt ratio and firm profitability on this relationship. The study has analyzed 14 animal husbandry companies operating in China spanning a period of five years (2012-2016). The main conclusions can be summarized in two points. First, government subsidies received by animal husbandry companies stimulate corporate R&D investment. Second, firm size, debt ratio, and firm profitability positively moderate the relationship between government subsidies and R&D investment.

Our findings have some important implications in practice. Animal husbandry companies should establish the concept of innovation and reasonably increase investment in R&D to gain competitive advantage. In addition, these companies should enhance the utilization efficiency of government subsidies. Policymakers should make innovation-induced policies and supervise the actual input of these subsidies. Chinese government should continue to increase R&D subsidies and provide animal husbandry companies with more favorable policies in financing. At the same time, in order to maximize the efficiency of government subsidies, the government needs to take firm size into consideration in the process of fund allocation. Finally, the government should improve the market economy system and intellectual property protection system when implementing these subsidy policies to create a good and fair competitive environment.

This study has some limitations. First, our sample only focuses on one industry with small sample size, and future research should include other industries or develop a cross-country comparison. Second, other factors that may influence this relationship (e.g. political connection) should also be considered. These limitations signal the scope for future research.

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