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Government Subsidies, R&D Investment and Innovation Performance*

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***Abstract*—Taking the listed companies in China in 2012-2016 as a sample, the relationship between government subsidies, R&D investment and corporate innovation performance is discussed in depth. The study found that government subsidies can significantly increase the number of innovation output, innovation complexity and quality of innovation output. R&D expenditure and R&D personnel investment play a part in mediating, indicating that government subsidies can effectively stimulate the innovation vitality of enterprises, increase the investment of enterprises' innovation, and ultimately affect the innovation performance of enterprises in China's capital market.**

Keywords—government subsidies; R&D investment; innovation performance

I. INTRODUCTION

China is in a "three-periods superposition phase" (Lang Lihua, Zhou Mingsheng, 2014) of a positive shifting period, a painful period of structural adjustment, and a digestive period of the previous stimulus policy, "the new economic normal" will further aggravate the downside pressure in current economic operation. Innovation-driven development strategy is an effective measure to solve many contradictions in the current economic situation. Adhering to the transformation of scientific research achievements and the main body of enterprise innovation has become the key to the success of the reform. How to enhance the innovation vitality of enterprises and improve the performance of innovation has become the focus of common concern. Government agencies as the most influential and complex of the external network of enterprises, they are also the most difficult component to predict and their impacts on corporate behavior are significantly uncertain. This paper uses the data of listed companies from 2012 to 2016 to examine and sort out the relationship between government subsidies, R&D investment and innovation performance through empirical tests. The research conclusions are of great significance to rationalizing the allocation of funds and effectively driving the innovation vitality of enterprises.

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II. THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

A. *The Impact of Government Subsidies on the Innovation Performance of Enterprises*

Government subsidies policy is the most direct and extensive means to influence corporate innovation behavior. Link capital constraints (Mao Qilin, Xu Jiayun, 2015) make up for the risk of innovation failure of enterprises, enhance the willingness of enterprises to innovate, and have a positive impact on corporate R&D activities (Nola & Stephen, 2010; Shao Chuanlin, 2015). Some of the government subsidies clarify the use of funds, and require enterprises to report the progress and results of innovation regularly. This supervision mechanism also urges enterprises to use subsidy funds reasonably and accelerate the innovation output of enterprises (Liu Xiaoyuan, Lin Song, 2013).

Some students also believe that government subsidies have not played a positive role in enterprises innovation performance. This may be due to the fact that when the government chooses to fund the target, it is more inclined to choose those companies that are easy to develop. After accepting the government subsidies, the enterprise is more willing to transfer excess funds to other activities, which affects the innovation output. Based on this, the paper proposes the following hypotheses:

Hypothesis 1a: Government subsidies have a positive correlation with enterprise innovation performance

Hypothesis 1b: Government subsidies have a negative correlation with enterprise innovation performance

B. *The Impact of Government Subsidies on R&D Investment of Enterprises*

First of all, because technological innovation has the characteristics of public products, the existence of its spillover effect leads to the lack of innovation investment of enterprises. It needs government support to compensate the externality of enterprises innovation in order to increase the innovation income of enterprises, thus narrowing the gap between corporate private and social benefits. Secondly, some of the government-funded enterprises have the

discretionary power to promote the investment of innovation funds and R&D manpower. In addition, government subsidies have a "signal effect", which means that the enterprise's innovation activities have been recognized by the government. Then they have led to more social capital flows to the enterprise (Wang Minghai, Li Xiaojing, 2017), ensuring the enterprise's R&D funds with better and more obvious private enterprise effects.

Of course, some scholars believe that the government's subsidies policy for enterprises may have the opposite effect, that is, there is a "crowding-out effect" (Wallsten, 2000). First of all, government subsidies may increase the R&D needs of the entire industry, which will lead to an increase in the wages of R&D personnel, higher R&D costs and reduced employment of R&D personnel. Secondly, since the cost of obtaining subsidies from the government is less than the cost of obtaining capital from the market, many enterprises apply for government R&D subsidies to alleviate internal financial pressures. After obtaining government subsidies, enterprises may not only invest in research and development activities, but will transfer funds to other projects and reduce their original R&D expenditures. Based on this, the paper proposes the following hypotheses:

H2a: Government subsidies have a positive correlation with enterprise R&D expenditures investment

H2b: Government subsidies have a negative correlation with enterprise R&D expenditures investment

H2c: Government subsidies have a positive correlation with enterprise R&D personnel investment

H2d: Government subsidies have a negative correlation with enterprise R&D personnel investment

C. *Mediating Effect of R&D Investment*

The investment in R&D expenditures of enterprises and the investment of R&D personnel provide financial and intellectual support for enterprise innovation activities, which is the decisive factor for improving the independent innovation capability of enterprises. Enterprises will invest in R&D funds when they carry out innovation activities, so as to improve the supporting software and hardware facilities required for the activities; at the same time, they will also invest in high-quality R&D personnel to carry out the enterprises' knowledge accumulation and achievement creation.

Government subsidies have stimulated the enterprises' innovative enthusiasm. Through the transmission of internal factors of enterprises R&D investment, it ultimately acts on the innovation performance of enterprises. As part of the source of funding for R&D investment, government subsidies jointly promote the innovation activities of enterprises with independent R&D investment funds. In addition, the increase in government subsidies has enabled enterprises to have more funds to hire more and better R&D personnel, thereby enhancing enterprises innovation performance. It can be seen that government subsidies will realize technological breakthroughs by stimulating enterprises to increase R&D expenditures and personnel investment, thereby promoting the improvement of enterprises innovation performance. Based on this, the paper proposes the following hypotheses:

Hypothesis 3a: R&D expenditures investment has a mediating effect on the relationship between government subsidies and enterprise innovation performance

Hypothesis 3b: R&D personnel investment has a mediating effect between government subsidies and enterprise innovation performance

III. RESEARCH DESIGN

A. *Sample Selection and Data Source*

This paper selects the listed companies in China from 2012 to 2016 as the initial sample, and does the following screening: (1) Excluding samples of abnormal companies such as PT, ST and *ST; (2) Excluding samples of financial and insurance companies; (3) Excluding companies samples with missing data. After the above treatment, 5,000 observable unbalanced panel samples were obtained, including 730 in 2012, 860 in 2013, 990 in 2014, 1,102 in 2015, and 1,318 in 2016. In the study data, the variables are mainly from the GTA (CSMAR) database.

B. *Variable Definition*

1) Explained variable: The innovation performance of an enterprise can be measured from different aspects. Considering the integrity of the indicator system and the availability of data, this paper selects the innovation output quantity index, the complexity of innovation and the quality of innovation output as the measurement indicators of innovation performance to conduct research. (1) The number of innovation outputs (Patent) is measured by the number of patents of each listed company, and it is processed by adding the sum of inventions, utility models, and appearance designs plus one to select the natural logarithm. The more patents an enterprise receives each year, the better the innovation performance of the enterprise will be. (2) Innovation complexity (AtoGInterval) is measured by the length of the time interval from patent application to authorization, and it is processed by adding one to select the natural logarithm. The longer the patent is granted, the more complex the innovation will be. (3) The quality of the innovation output (GtoTInterval) is measured by the time interval between the patent authorization and the termination, and it is processed by adding one to select the natural logarithm. The longer interval between the patent authorization and the termination is, the higher the quality of the innovation output will be.

2) Investigated variable: (1) Government subsidies (LnGov) are measured by the sum of government subsidies funds for the removal of tax preference items, and they are processed by adding one to select the natural logarithm. 2) Tax incentives (LnTax) are measured by the sum of project funds such as tax return, immediate levy and refund, tax

reduction, etc., and they are processed by adding one to select the natural logarithm. The more government subsidies and tax incentives are, the stronger the government's innovation support will be. (3) R&D personnel investment (LnR&Dperson) is measured by the number of R&D personnel, and it is processed by adding one to select the natural logarithm. (d) R&D expenditure investment (LnR&DSpend) is measured by the amount of R&D investment, and it is processed by adding one to select the natural logarithm.

3) Control variable: According to the literature on the factors affecting the innovation performance of enterprises, this paper selects the age of the enterprise (Age, the company's listing establishment period), the size of the enterprise (LnSize, the natural logarithm selected in the total assets of the listed company at the end of the year), the industry category (Industry, high-tech enterprise is 1, non-high-tech enterprise is 0), the nature of the enterprise (State, state-owned enterprises is 1, non-state-owned enterprise is 0), the degree of economic development of the registered place (Location, West, Central and Eastern three economic regions are expressed by 1, 2, 3 respectively), return on assets (ROA, the ratio of net profit to average asset balance), asset-liability ratio (LEV, ratio of total liabilities to total assets at the end of the year), the executive salary (LnSalary, the natural logarithm selected in the total amount of executive monetary salary), the current ratio (Current, the ratio of current assets to current liabilities at the end of the year), the earnings per share (EPS, the ratio of after-tax profits to the number of common shares), the shareholding ratio of the largest shareholder (Top1, shareholding ratio of the largest shareholder) and the duality (Dual, the CEO is also the chairman of the board to select 1, otherwise 0) as a control variables. At the same time, the model controls the year of the year (Year) and the industry (Industry).

IV. Empirical Test and Result Analysis

A. Descriptive Statistics

As can be seen from "Table I", the government subsidies are at least 0 (no government subsidies), the highest value is 22.333 (5,002,000,000 Yuan), and the standard deviation is 3.261. It can be seen that the enterprises have great differences in accepting government subsidies. From the perspective of innovation performance, the minimum number of innovation outputs is 0 (no patent output for the whole year), and the highest is 9.295 (10881); the lowest level of innovation complexity is 0, the highest value is 1.954 (6.055); the minimum quality of innovation output is 0, and the highest is 2.875 (16.723). It can be seen that the differences in innovation performance are different among enterprises. From the perspective of R&D investment, the minimum investment in R&D expenditure is 0, the highest is 25.025 (73,839,000,000 Yuan); the minimum investment of R&D personnel is 0, and the highest is 10.631 (41385). It can be seen that the innovation enthusiasm of enterprises is different, and there are huge differences in R&D investment.

TABLE I. Descriptive Statistics of Main Variables

Variable Name	Minimum Value	Maximum Value	Average	Standard Deviation
LnGov	0	22.333	15.856	3.261
Patent	0	9.295	2.582	2.037
AtoGInterval	0	1.954	0.585	0.397
GtoTInterval	0	2.875	1.320	0.834
LnR&DSpend	0	25.025	14.922	6.820
LnR&Dperson	0	10.631	4.645	2.530

B. Direct Effect and Mediating Effect Test

Before the regression analysis, the Pearson correlation analysis was carried out on the variables in the paper. The maximum correlation coefficient is 0.558, and the variance factor VIF is mostly below 2, indicating that the model does not have serious collinearity.

In columns (1)-(3) of "Table II", government subsidies and innovation output quantity, innovation complexity and innovation output quality are all significantly positively correlated at the 1% level. Research hypothesis 1a is supported, indicating that government subsidies are helpful to improve the level of innovation performance of enterprises. In column (4), government subsidies are significantly positively correlated with enterprise R&D expenditures investment at the 1% level. Research hypothesis 2a is supported, indicating that government subsidies have boosted R&D expenditures investment. In column (5), after adding R&D expenditure investment, the positive correlation between government subsidies and the number of innovation outputs is still established at a significant level of 1%, but the regression coefficient is changed from 0.065 to 0.034, which is obviously weakened, indicating that mediating effect of R&D expenditures investment is established, that is, government subsidies increase the investment in R&D expenditures of enterprises, thereby increasing the number of innovation output of enterprises. Similarly, from the data in columns (6) and (7), it can be seen that the mediating effect of R&D expenditures investment is in the complexity of government subsidies and innovation (the coefficient is reduced from 0.016 to 0.012) and the quality of innovation output (the coefficient is reduced from 0.040 to The 0.027) is still established, and the research hypothesis 3a is supported.

In column (1) of "Table III", government subsidies are significantly positively correlated with enterprise R&D personnel investment at the 1% level. Research hypothesis 2c is supported, indicating that government subsidies promote enterprise R&D personnel investment. In column (2), after the investment of R&D personnel, the positive correlation between government subsidies and the number of innovation outputs is still established at a significant level of 1%, but the regression coefficient is changed from 0.065 to 0.027, which is obviously weakened, indicating that mediating effect of R&D personnel investment is established, that is, government subsidies increase the input of enterprise R&D personnel investment, thereby increasing the number of innovation output of enterprises. Similarly, from the data in columns (3) and (4), it can be seen that the mediating effect of R&D personnel's investment in the complexity of government subsidies and innovation (the coefficient is

reduced from 0.016 to 0.013) and the quality of innovation output (the coefficient is reduced from 0.040 to The 0.027) is still established, and the research hypothesis 3b is supported.

TABLE II. GOVERNMENT SUBSIDIES, R&D CAPITAL INVESTMENT, AND INNOVATION PERFORMANCE REGRESSION RESULTS

Variable	(1) Patent	(2) Atoginterval	(3) Gtotinterval	(4) Lnr&D Spend	(5) Patent	(6) Atoginterval	(7) Gtotinterval
Constant term	-16.033*** (-27.5110)	-0.970*** (-7.202)	-3.015*** (-11.096)	-16.929*** (-8.692)	-14.717*** (-25.951)	-0.775*** (-5.788)	-2.446*** (-9.204)
LnGov	0.065*** (8.186)	0.016*** (8.960)	0.040*** (10.827)	0.405*** (15.225)	0.034*** (4.283)	0.012*** (6.362)	0.027*** (7.208)
LnR&D Spend					0.078*** (18.949)	0.012*** (11.930)	0.034*** (17.497)
Age	-0.028*** (-6.650)	-0.003*** (-3.258)	0.001 (0.613)	-0.155*** (-11.142)	-0.016*** (-3.841)	-0.001 (-1.400)	0.006*** (3.356)
LnSize	0.506*** (18.822)	0.021*** (3.398)	0.071*** (5.690)	0.660*** (7.344)	0.455*** (17.420)	0.014** (2.191)	0.049*** (4.017)
Tech	0.294*** (5.123)	0.160*** (12.088)	0.093*** (3.464)	0.784*** (4.085)	0.233*** (4.199)	0.151*** (11.548)	0.066** (2.550)
State	0.143*** (2.612)	0.016 (1.242)	0.057** (2.232)	0.414** (2.256)	0.111** (2.097)	0.011 (0.877)	0.043* (1.739)
Location	0.189*** (2.612)	0.032*** (4.667)	0.064*** (4.678)	0.389*** (3.972)	0.159*** (5.593)	0.027*** (4.055)	0.051*** (3.827)
ROA	0.010 (0.034)	-0.070 (-1.056)	-0.126 (-0.948)	-1.118 (-1.170)	0.097 (0.350)	-0.057 (-0.873)	-0.089 (-0.686)
LEV	0.094 (0.604)	-0.079** (-2.177)	-0.158** (-2.166)	-1.281** (-2.452)	0.194 (1.284)	-0.064* (-1.792)	-0.115 (-1.622)
LnSalary	0.322*** (8.212)	0.051*** (5.587)	0.088*** (4.814)	0.541*** (4.127)	0.280*** (7.381)	0.044*** (4.959)	0.070*** (3.928)
Current	-0.032*** (-3.645)	0.000 (-0.144)	-0.016*** (-3.909)	0.004 (0.142)	-0.032*** (-3.813)	0.000 (-0.170)	-0.016*** (-4.063)
EPS	0.191*** (3.376)	-0.013 (-0.986)	-0.016 (-0.610)	-0.096 (-0.509)	0.198*** (3.632)	-0.012 (-0.914)	-0.013 (-0.502)
Top1	-0.364** (-2.270)	-0.093** (-2.518)	-0.269*** (-3.591)	0.669 (1.247)	-0.416*** (-2.685)	-0.101*** (-2.764)	-0.291*** (-4.008)
Dual	0.073 (1.375)	0.005 (0.376)	-0.003 (-0.120)	0.222 (1.247)	0.056 (1.089)	0.002 (0.170)	-0.010 (-0.433)
Year/ Industry	control	control	control	control	control	control	control
F value	120.200	42.151	58.125	121.224	135.638	46.262	68.886
Adjust R2	0.440	0.214	0.274	0.442	0.478	0.235	0.316

[a.] Note: *** represents a significant level at 1%, ** represents a significant level at 5%, and * represents a significant level at 10%.

TABLE III. GOVERNMENT SUBSIDIES, R&D PERSONNEL INVESTMENT, INNOVATION PERFORMANCE REGRESSION RESULTS

Variable	(1) LnR&D Person	(2) Patent	(3) AtoGInterval	(4) GtoTInterval
Constant term	-11.158*** (-15.987)	-12.787*** (-22.825)	-0.711*** (-5.185)	-1.906*** (-7.072)
LnGov	0.129*** (13.597)	0.027*** (3.613)	0.013*** (7.244)	0.027*** (7.468)
LnR&D Person		0.291*** (26.188)	0.023*** (8.536)	0.099*** (18.615)
Age	-0.054*** (-10.916)	-0.012*** (-3.001)	-0.002* (-1.936)	0.007*** (3.476)
LnSize	0.363*** (11.260)	0.401*** (15.695)	0.013** (2.032)	0.035*** (2.874)
Tech	0.538*** (7.823)	0.138** (2.542)	0.148*** (11.159)	0.039 (1.507)
State	0.180*** (2.733)	0.091* (1.769)	0.012 (0.919)	0.039 (1.585)
Location	0.151*** (4.297)	0.145*** (5.265)	0.028*** (4.173)	0.049*** (3.696)

Variable	（1）	（2）	（3）	（4）
	LnR&D Person	***Patent***	***AtoGInterval***	***GtoTInterval***
ROA	-0.022	0.016	-0.069	-0.124
	（-0.065）	（0.061）	（-1.056）	（-0.963）
LEV	-0.277	0.175	-0.072**	-0.130*
	（-1.478）	（1.193）	（-2.014）	（-1.849）
LnSalary	0.316***	0.230***	0.043***	0.057***
	（6.734）	（6.229）	（4.790）	（3.185）
Current	-0.009	-0.029***	0.000	-0.015***
	（-0.890）	（-3.557）	（-0.037）	（-3.808）
EPS	0.161**	0.144***	-0.017	-0.032
	（2.379）	（2.716）	（-1.281）	（-1.258）
Top1	-0.205	-0.305**	-0.089**	-0.248***
	（-1.066）	（-2.025）	（-2.407）	（-3.432）
Dual	0.102	0.044	0.002	-0.013
	（1.603）	（0.871）	（0.184）	（-0.548）
Year/ Industry	control	control	control	control
value	140.716	152.923	43.647	70.532
Adjust R2	0.480	0.508	0.225	0.321

[a.] Note: *** represents a significant level at 1%, ** represents a significant level at 5%, and * represents a significant level at 10%.

C. Robustness Test

In order to ensure the reliability of the research results, this paper has done the following robustness tests: (1) 1% Winsorize processing of continuous variables; (2) taking government subsidies as dichotomous dummy variable, with government subsidies taking 1, otherwise 0; (3) performing a yearly test on the sample. After the above treatment, the main research conclusions are not substantially different from the paper.

V. CONCLUSION

Innovation is the strategic support for China's construction of a modern economic system, and it is a "new prescription" for dealing with the "new normal" of the economy (Xu Yu, Feng Junke, 2017). This paper takes the data of listed companies in 2012-2016 as the research object, and empirically tests the impact of government subsidies on the innovation performance of enterprises and the mediating effect of R&D investment. Research indicates: (1) The higher the government subsidies are, the better the innovation performance of the enterprise will be, that is, the government subsidies increase the motivation and ability of the enterprise's technological innovation, and have a positive impact on the innovation performance of the enterprise. Increasing the government subsidies will help to improve the number of innovation outputs, innovation complexity and quality of innovation output. (2) The greater the government subsidies are, the greater the investment in R&D of enterprises will be, that is, government subsidies increase the enthusiasm of enterprises for innovation, and play a vital role in increasing R&D expenditures and R&D personnel investment. (3) R&D investment plays a mediating role between government subsidies and innovation performance, that is, government subsidies ultimately improve the innovation output of enterprises through the improvement of R&D investment. It can be seen that under the current capital market conditions in China, the positive role of government subsidies is obvious. Continued increase of government subsidies is a key factor in improving R&D investment and increasing enterprise innovation performance.

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