Government Subsidy, Research and Development Investment and Profitability
Evidence from Pharmaceutical Manufacturing Enterprises

Yuxuan Lian[1,a*], Jianfei Leng[1,b], Yining Zhu[1,c]

[1]*Business School, Hohai University Nanjing, China*
[*a]*lyx20010913@163.com*
[b]*ljf200209@163.com*
[c]*1515663108@qq.com*

Abstract
In the context of the normalization of epidemic prevention and control, the pharmaceutical manufacturing industry is facing new opportunities and challenges. Based on the panel data of 171 listed pharmaceutical manufacturing enterprises in China from 2017 to 2020, this paper uses a two-way fixed effects model to conduct an empirical study on the relationship between government subsidy, R&D investment and profitability. The results show that for the pharmaceutical manufacturing industry, government subsidy and R&D investment can significantly improve enterprise profitability; R&D investment plays a partial mediating role in the effect of government subsidy on enterprise profitability. Enterprises and government should take measures to encourage R&D investment in the pharmaceutical manufacturing industry.

Keywords-*pharmaceutical manufacturing industry; government subsidy; R&D investment; profitability; mediating effect*

1. INTRODUCTION

In March 2021, the 14th Five-Year Plan for National Economic and Social Development and the Outline of 2035 Vision Goals pointed out that innovation research and development is the winning point for pharmaceutical manufacturing enterprises to breakthrough performance growth and is the core driving force for the sustainable development of pharmaceutical manufacturing industry in the future. Therefore, it is imperative to strengthen R&D innovation support for pharmaceutical enterprises. In the situation of the normalization of epidemic prevention and control, the pharmaceutical manufacturing industry has become a necessary and basic industry for population and urban development. With the improvement of national health awareness and the development of the Internet medical industry, the pharmaceutical manufacturing industry is facing new opportunities and challenges in which government subsidy is playing an important role in the growth of the industry.

In such an environment, can government subsidy in China's pharmaceutical manufacturing industry promote enterprise profitability through the mediating role of R&D investment? At present, most of the research objects of domestic and foreign scholars focus on the overall data of listed enterprises in China's emerging industries or manufacturing industry, and the research scope is limited to the relationship between government subsidy and profitability; R&D investment and profitability; government subsidy and R&D investment. It is short of the research on the relationship between government subsidy, R&D investment and enterprise profitability that takes listed enterprises in the pharmaceutical manufacturing industry as samples. In this regard, the innovation of this paper is based on pharmaceutical manufacturing to explore the internal relationship between government subsidy, R&D investment and enterprise profitability, analyze the internal driving force and influence of government subsidy on the improvement of enterprise profitability, and make up for the deficiencies in the research field of the relationship between this three aspects, to provide effective suggestions for the development of the

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government's economic functions and enterprises' R&D activities.

2. THEORETICAL ANALYSIS AND HYPOTHESIS

2.1. Government Subsidy and Profitability

Government subsidy is an external resource of an enterprise, which can produce complementary effects with internal resources. The cash flow brought by government subsidy can provide more opportunities for the development of enterprises, thus playing a positive role in improving the profitability of enterprises. Qi Haitao, Yao Yufei, Guo Jing and Wang Wanqiu. (2021) adopt the PVAR model to measure the dynamic interaction between government subsidy intensity and enterprise profitability, and conclude that government subsidy can help improve enterprise profitability [1]. Rong Fengzhi and Zhong Xujuan (2020) find that the return on total assets of enterprises is significantly positively correlated with government subsidy, indicating that government subsidy can have a positive impact on the profitability of enterprises [2]. Wu Chaopeng and Tang Di (2016) believe that government departments can strengthen enforcement of intellectual property rights protection to improve enterprises' innovation ability and financial performance [3]. Therefore, the following hypothesis is proposed:

H1: There is a significantly positive correlation between government subsidy and enterprise profitability in China's pharmaceutical manufacturing industry.

2.2. R&D Investment and Profitability

In the era of the knowledge economy, the technological capabilities and R&D outputs obtained by enterprises through R&D activities are the fundamental stone for their lasting economic benefits. Moreover, such unique resources and superior technologies are non-replicable in a certain period, which can help high-tech enterprises to obtain sustainable competitive advantages to the greatest extent. Zhengu Guihua and Chen Leili (2021) select the financial data of China's A-share listed enterprises and find that R&D investment has a significantly positive effect on corporate financial performance [4]. Cao Yang and Yi Qiqi (2018) take listed biomedical manufacturing enterprises in China as the research object and conclude that R&D investment of enterprises has a positive impact on the profit margin of the main business and can promote the improvement of enterprise profitability [5]. Therefore, the following hypothesis is proposed:

H2: There is a significantly positive correlation between R&D investment and enterprise profitability in China's pharmaceutical manufacturing industry.

2.3. Government Subsidy and R&D Investment

Government subsidy is conducive to reducing R&D costs, mitigating market risks, and strongly supporting enterprises' R&D and innovation activities. Du Tian and Liu Mingxu (2022) study the behavioral characteristics of government subsidy and R&D investment of listed enterprises by taking A-share listed enterprises in Shanghai and Shenzhen as research samples and find that government subsidy can promote the intensity and sustainability of enterprises' R&D investment [6]. Yang Kanglin and Xu Shiying (2021) select relevant data from 261 listed enterprises in the pharmaceutical industry for empirical analysis and conclude that government subsidy has an obvious incentive effect on enterprises' continuous R&D investment [7]. Therefore, the following hypothesis is proposed:

H3: There is a significantly positive correlation between government subsidy and R&D investment in China's pharmaceutical manufacturing industry.

2.4. Mediating Effect of R&D Investment

Government subsidy provides a financial guarantee for enterprises' R&D investment, reduces the cost and income risks brought by R&D activities, and encourages enterprises to actively carry out R&D activities, which is conducive to improving enterprises' profitability. The R&D investment links government subsidy with profitability as a mediation. Chen Tao and Zhao Jingjun find that government subsidy, R&D investment, and profit quality are positively correlated, and R&D investment has a mediating effect on the relationship between government subsidy and profit quality [8]. Wang Wei, Wu Jiaying and Zhang Pinfeng (2016) find that R&D investment has a complete mediating effect on the positive relationship between government subsidy and enterprise value [9]. Therefore, the following hypothesis is proposed:

H4: In the pharmaceutical manufacturing industry, R&D investment has a mediating effect on the positive relationship between government subsidy and enterprise profitability.

3. RESEARCH METHODS AND DESIGN

3.1. Data Sources

According to the industry classification standard of the China Securities Regulatory Commission 2012, this paper conducts targeted research on the pharmaceutical manufacturing industry, selects listed pharmaceutical manufacturing enterprises in China from 2017 to 2020 as research samples, and uses Stata16.0 software to process the sample data as follows: Remove ST and ST* sample enterprises; Remove samples with missing or abnormal data; To reduce the influence of extreme values, all

continuous variables except dummy variables are treated with the tail indentation in 1% quantile. After sorting and screening, 171 qualified sample enterprises were obtained, with a total of 684 samples. The original sample data of the measurement indicators involved in this paper mainly come from the CSMAR database and Wind database. The specific R&D input information comes from the disclosed annual reports of listed enterprises. All sample panel data are sorted out and statistically analyzed by Excel2019, Stata16.0 and other software.

3.2. Variable Definition

3.2.1. Dependent variable

Table 1 is the specific definition of each variable. In this paper, return on assets is selected as the measurement index of corporate profitability, reflecting the net profit created by each unit of assets. It has a certain comparable value for enterprises of different sizes, which is represented by ROA.

3.2.2. Independent variable

In this paper, the total amount of government subsidy is selected as the measurement index of government support to reflect the tangible or intangible assets that enterprises obtain free from the government, which is represented by Sub.

3.2.3. Mediating variable

Due to the differences in sizes, business scopes, products and services of various enterprises, to facilitate horizontal comparison, this paper finally selects R&D investment intensity as the explanatory variable to reflect the investment in capital, human resources and material resources of enterprises in R&D activities, which is represented by RD.

3.2.4. Control variables

Taking into account the influence of other variables on enterprise profitability, and referring to existing studies at home and abroad, the asset-liability ratio (Lev), total asset turnover (ATO), enterprise size (Size) and ownership concentration (Shrhfd) are selected as the control variables influencing the research results.

TABLE 1. VARIABLE DEFINITION

Variable types	Variable symbol	Variable name	Formula calculation
dependent variables	ROA	Return on assets	net profit/total assets
independent variable	Sub	government subsidy	ln（total government subsidy）
Intermediary variable	RD	R&D investment intensity	R&D expenditure/revenue
Control variables	Lev	asset-liability ratio	total liabilities/total assets
	ATO	total asset turnover	sales revenue/total assets
	Size	enterprise size	ln（total assets at end）
	Shrhfd	ownership concentration	ratio of the largest shareholder holding

3.3. Model Construction

Based on the method of Wen Zhonglin (2005) [10], this paper constructs the following four models to verify H1, H2, H3 and H4 respectively:

$$ROA_{it} = \beta_0 + \beta_1 Sub_{it} + \beta_2 Lev_{it} + \beta_3 ATO_{it} + \beta_4 Size_{it} + \beta_5 Shrhfd_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (1)$$

$$ROA_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 Lev_{it} + \beta_3 ATO_{it} + \beta_4 Size_{it} + \beta_5 Shrhfd_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (2)$$

$$RD_{it} = \beta_0 + \beta_1 Sub_{it} + \beta_2 Lev_{it} + \beta_3 ATO_{it} + \beta_4 Size_{it} + \beta_5 Shrhfd_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (3)$$

$$ROA_{it} = \beta_0 + \beta_1 Sub_{it} + \beta_2 RD_{it} + \beta_3 Lev_{it} + \beta_4 ATO_{it} + \beta_5 Size_{it} + \beta_6 Shrhfd_{it} + \lambda_t + \mu_i + \varepsilon_{it} \quad (4)$$

i stands for public enterprise; t stands for year; β_0 represents constant term; λ_t represents the time effect that does not vary with individuals; μ_i represents the individual effect that does not vary with time; ε_{it} is the random error term.

4. RESULTS & DISCUSSION

4.1. Descriptive Statistical

As can be seen from the descriptive statistical results in Table 2, the average return on assets of the pharmaceutical manufacturing industry in our country is 0.058; the standard deviation is 0.066, and the minimum value is negative, indicating that the industry has a high degree of dispersion; the profitability and development level of different enterprises are differentiated, and there is a certain gap in strength. From the perspective of government subsidy, the maximum and minimum values are 12.90 and 19.56 respectively, and the average value

is 16.75, indicating that there is a small difference in government subsidy to pharmaceutical manufacturing enterprises with a relatively average allocation, and such support exists with certain universality. From the data on R&D investment intensity, its mean value is 0.059; the median is 0.040; and the maximum value is as high as 0.370, indicating that the comprehensive R&D level of China's pharmaceutical manufacturing industry is relatively high. As the industry attaches more importance to R&D performance, the R&D strength among enterprises is gradually expanding.

TABLE 2. DESCRIPTIVE STATISTICAL RESULTS

variable	N	mean	p50	sd	min	max
ROA	684	0.058	0.055	0.066	-0.212	0.216
Sub	684	16.75	16.84	1.333	12.90	19.56
RD	684	0.059	0.040	0.054	0.010	0.370
Lev	684	0.32	0.30	0.16	0.05	0.76
ATO	684	0.516	0.499	0.216	0.113	1.205
Size	684	22.23	22.20	0.94	20.38	24.77
Shrhfd	684	0.32	0.30	0.13	0.09	0.68

4.2. Correlation Analysis

In this paper, the software Stata16.0 is used to conduct the Pearson correlation test for each variable, and the multicollinearity problem was tested by a variance inflation factor. The results are shown in Table 3. At the confidence level of 1%, the independent variable government subsidy and the mediating variable R&D investment are significantly positive correlations, which initially support H1, H2 and H4. There is a significantly positive correlation between the independent variable government subsidy and the intermediary variable R&D investment intensity at a 1% confidence level, which initially supports H3. The VIF values of all variables are far less than the specified critical value 10, which can preliminarily exclude the influence of multicollinearity on the results and carry out regression.

TABLE 3. CORRELATION ANALYSIS RESULTS

	ROA	Sub	RD	Lev	ATO	Size	Shrhfd
ROA	1						
Sub	0.301***	1					
RD	0.660***	0.150***	1				
Lev	-0.255***	-0.094**	-0.142***	1			
ATO	0.322***	0.0450	0.234***	-0.0500	1		
Size	0.094**	-0.0170	0.0330	0.089**	0.121***	1	
Shrhfd	0.230***	0.0620	0.149***	-0.0550	0.106***	0.124***	1
VIF	1.06	1.03	1.11	1.04	1.08	1.04	1.05

Note: ***; ** * represent significant at the confidence coefficient of 1%, 5% and 10% respectively.

4.3. Regression Analysis

Model (1) is used to test the influence of government subsidy on the profitability of pharmaceutical manufacturing enterprises. From the regression results in Table 4, the correlation coefficient between government subsidy and enterprise profitability is 0.008, which is a significantly positive correlation at the confidence level of 1%, that is, the profitability of enterprises will increase by 0.008 units when government subsidy increases by 1 unit. Therefore, government subsidy has a significantly positive impact on the improvement of enterprise profitability. Hypothesis 1 is true.

Model (2) is used to test the impact of R&D investment intensity on the profitability of pharmaceutical manufacturing enterprises. From the regression results in Table 4, the correlation coefficient between R&D investment intensity and enterprise profitability is 0.423, which is a significantly positive correlation at the confidence level of 1%, that is, an increase of 1 unit in R&D investment intensity will bring enterprises' profitability improvement of 0.423 units. Therefore, R&D investment has a significantly positive impact on the improvement of enterprise profitability. Hypothesis 2 is true.

Model (3) is used to test the influence of government subsidy on the R&D investment of pharmaceutical manufacturing enterprises. From the regression results in Table 4, the correlation coefficient between government subsidy and R&D investment intensity is 0.002, which is a significantly positive correlation at the confidence level of 10%, that is, an increase of 1 unit in R&D investment intensity will bring an increase of 0.002 unit in enterprise profitability. Therefore, government subsidy has a significantly positive impact on the improvement of the R&D investment. Hypothesis 3 is true.

The results of H1, H2 and H3 indicate the possibility of mediating effect between government subsidy, R&D investment and enterprise profitability. In this regard, this paper constructs model (4) to further verify the mediating role of R&D investment in the positive relationship between government subsidy and enterprise profitability of pharmaceutical manufacturing enterprises . From the regression results in Table 4, the independent variable Sub has a significantly positive correlation with the dependent variable ROA at the confidence level of 1%,

with a regression coefficient of 0.007. Although R&D investment exists, government subsidy still has a significant impact on enterprise profitability, indicating that R&D investment plays a partial mediating effect on the relationship between government subsidy and corporate profitability in pharmaceutical manufacturing industry. According to Wen Zhonglin's research (2005), the mediating effect accounts for 10.1% (0.002 × 0.404/0.008) of the total effect, that is, the R&D investment of pharmaceutical manufacturing enterprises plays a 10.1% role in the process of government subsidy promoting enterprise profitability. Hypothesis 4 is true.

TABLE 4 REGRESSION ANALYSIS RESULTS

Variable	(1) ROA	(2) ROA	(3) RD	(4) ROA
Sub	0.008***		0.002*	0.007***
	(4.18)		(1.75)	(3.84)
RD		0.423***		0.404***
		(5.18)		(5.32)
Lev	-0.028*	-0.029**	-0.004	-0.027*
	(-1.89)	(-2.08)	(-0.43)	(-1.93)
ATO	0.155***	0.111***	0.124***	0.105***
	(5.25)	(3.34)	(4.25)	(3.39)
Size	0.059***	0.049***	0.023*	0.050***
	(3.64)	(3.05)	(1.85)	(3.31)
Shrhfd	0.102*	0.043	0.120**	0.054
	(1.78)	(0.72)	(2.26)	(1.02)
Constant	-1.465***	-1.101***	-0.585**	-1.229***
	(-4.10)	(-3.08)	(-2.08)	(-3.65)
enterprise	Control	Control	Control	Control
Year	Control	Control	Control	Control
R-squared	0.286	0.351	0.128	0.384
R2-adj	0.277	0.344	0.117	0.376
F	20.04***	22.44***	6.035***	23.78***

Note: ***; ** * represent significant at the confidence coefficient of 1%, 5% and 10% respectively.

5. CONCLUSION

Taking panel data of 171 pharmaceutical manufacturing enterprises from 2017 to 2020 as samples, this paper adopts a two-way fixed effects model to conduct empirical regression analysis. It indicates that: government subsidy has a positive effect on the improvement of enterprise profitability; R&D investment can promote the improvement of enterprise profitability; government subsidy can influence enterprise profitability through a partial mediating effect of R&D investment.

This paper puts forward the following suggestions:

5.1. Play Policy's Leading Role

The multi-level policy support and system bring new opportunities for the development of China's pharmaceutical manufacturing industry. Therefore, on the one hand, the government should speed up the transformation of its functions, based on the development status of the pharmaceutical industry, to construct a long-term subsidy mechanism for R&D investment, scientifically formulate the subsidy fund amount, supervise the approval process of government subsidy fund, and provide economic guarantee for R&D investment activities of the pharmaceutical manufacturing industry. On the other hand, the government should speed up the improvement of relevant laws and regulations to strengthen the protection of R&D patents and create a good market environment for R&D competition. Enterprises are encouraged of building a new policy-oriented cooperative R&D platform and cooperate with universities and research structures to share resources. It is beneficial to break the closed patterns of independent research and development, and comprehensively improve the core competitiveness of the pharmaceutical manufacturing industry.

5.2. Increase R&D Investment

At present, China is gradually transforming from a "pharmaceutical giant" to a "pharmaceutical power". R&D investment plays a key role in the overall innovation transformation of the industry. Therefore, on the one hand, enterprises should combine the policy orientation, relying on their advantages, to match the market demand and accurately position the direction of innovative research and development. Enterprises should gradually increase R&D investment within the range of controllable risks, introduce high-quality R&D talents and build a first-class pharmaceutical R&D team to form their core technology advantages. On the other hand, enterprises should shift their R&D investment from generic drugs to innovative drugs. The pharmaceutical manufacturing industry should enter the new stage of "independent innovation" from the original "combination of imitation and innovation", to seize market share as soon as possible and expand the profit space of enterprises.

5.3. Adhere to Long-term Profit Orientation

Adhering to long-term profit orientation is the inherent requirement for enterprises to achieve sustainable development. Both the government and enterprises should fully understand the important role of R&D investment in the process of improving enterprises' profitability through government subsidy and constantly optimizing their behaviors. On the one hand, while making use of government subsidy, enterprises should constantly increase the allocation of funds for drug R&D to maximize the mediating effect of R&D investment and to promote the improvement of enterprise profitability. On the other hand, the government should increase the policy support for R&D innovation, focus on increasing the subsidy amount of enterprise R&D investment, optimize the allocation of government resources to help pharmaceutical manufacturing enterprises truly upgrade the value chain from materials to preparations, and to

ensure the sustainable growth of enterprise profitability in the future.

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