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Government Subsidy, Research and Development Expenditure and Independent Innovation of Enterprise*

Xiaoxu Kong
College of Business Administration
Capital University of Economics and Business
Beijing, China 100070

He Zhu**
Peking University HSBC Business School
Beijing, China 100872
**Corresponding Author

Yang Yu
Research Institute of Maritime Silk-Road (RIMS)
Peking University HSBC Business School
Beijing, China

***Abstract*—In recent years, the government's emphasis on corporate innovation and policy support has been increasing. It is necessary to analyze the effectiveness of government's innovation support policies. Based on the sample of 108 A-share listed companies from 2010 to 2014 and the GMM method of dynamic panel data, this paper examines the role of government subsidies for enterprise research and development expenditures and independent innovation results. According to this study, we can know that after controlling the enterprise scale and the number of scientific research personnel, government subsidies can significantly stimulate the research and development expenditure of the enterprise. The impact of government subsidies on the number of inventions and the number of designs is significantly positive. However, the impact on the number of utility models is not significant. This paper also analyzes the efficiency of government's innovation support with the DEA method. For the sample enterprises, the government innovation support policy has certain inefficiency.**

Keywords—government subsidy; enterprise research and development expenditure; enterprise independent innovation; GMM method of dynamic panel

I. INTRODUCTION

In recent years, under the guidance of the macro-strategy of the national innovation system, the Chinese government has invested a large amount of funds each year to encourage innovation. The main investment is to support innovative activities and technology-based science and technology service activities. As the government attaches more importance to corporate innovation and policy support, it is necessary to analyze the effectiveness of government innovation support policies.

The conclusions of scholars at home and abroad studying the effect of government R&D investment from a macro perspective are relatively uniform. Most studies believe that the government R&D investment has an inductive effect on corporate R&D expenditure. However, at the micro level, due to certain differences in sample selection and research methods, the unified research paradigm has not yet formed, leading to inconsistencies in the conclusions of the study. The existing academic achievements indicate that the government's innovation support policy will generate innovation incentives for enterprises. For example, Xu Zhi and Shi Ping (2005) found that the government's technology investment has significantly promoted corporate expenditure during the sample period. However, some scholars have analyzed that government research and innovation subsidies have an "extrusion" effect on R&D investment (Lv Jiuqin, Yu Dandan, 2011).

There are two main reasons why the above research conclusions are so different. At the methodological level, due to the different choices of measurement techniques, the research conclusions are not stable. At present, the academic community mainly uses three types of methods to study the effectiveness of government innovation support policies. The first category is the least squares method, including ordinary least squares method, two-stage least squares method, etc., such as the study of Yang Dewei and Tang Xiangxi (2011). The second category is the instrumental variable method. The representatives are the studies of Xing Fei and Zhang Jianhua (2009) and Zhang Jie et al. (2015). The third category is the application of differential GMM or system GMM for panel data analysis, such as the studies of Xie Weimin et al (2009) and Yang Xiangyang (2014). Second, the conclusions caused by the different sample data selection are not stable. Scholars analyze the sample of enterprises in different regions and industries, and the differences in the use of government innovation support policies by enterprises

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within the region and industry will inevitably affect the research conclusions.

This paper believes that the GMM method of application dynamic panel data has incomparable advantages over other methods in terms of the impact of government innovation support policies on enterprise innovation motivation and innovation results. First, the regression analysis using the ordinary least squares (OLS) method can reflect the influence of government support on enterprise innovation. However, it does not consider the estimation bias caused by the endogeneity of variables. Second, the instrumental variable method is scientifically effective. However, it is difficult to achieve at the actual operational level. And the selection of instrumental variables will have an impact on the research results to a large extent. Third, the GMM method of dynamic panel data can solve the relevant problems of unobservable variables and interpretation variables, or the bias caused by the omission of some important explanatory variables to some extent. It is especially important for empirical testing. Based on the above reasons, this paper chooses to apply the GMM method of dynamic panel data to study the impact of government innovation support policies on enterprise innovation.

In addition, previous academic research focused on the impact of government support on corporate R&D expenditures (ie, the motivation for corporate innovation). However, these studies did not pay much attention to the research and the results of independent innovation. Therefore, this paper adopts the GMM method of dynamic panel data to examine the role of government subsidies for corporate R&D expenditures and independent innovation results. According to this study, we can know that after controlling the enterprise scale and the number of scientific research personnel, government subsidies can significantly stimulate the research and development expenditure of the enterprise. The impact of government subsidies on the number of inventions and the number of designs is significantly positive. However, the impact on the number of utility models is not significant. This paper also analyzes the efficiency of government's innovation support with the DEA method. For the sample enterprises, the government innovation support policy has certain inefficiency.

The innovations are reflected in the following two aspects. First, it should pay attention to the effect of government innovation support policies on R&D expenditures of enterprises, and also focus on the impact of government subsidies on independent innovation achievements (ie patents, utility models and designs). Second, the author also uses the DEA efficiency analysis method to study the inefficiency of the government's innovation support policy, which helps to guide the rational allocation of government innovation support at the micro level.

The rest are as the following. The second is the logical mechanism and research hypothesis of government subsidies to stimulate enterprise innovation. The third is research design. And the fourth is empirical analysis based on dynamic panel data, including the analysis of the role of government subsidies on R&D expenditure of enterprises, and the analysis of the role of government subsidies on independent innovation of enterprises. The fifth is the analysis of government innovation support efficiency based on DEA method. The sixth part summarizes the research conclusions of the full text.

II. THE LOGIC MECHANISM AND RESEARCH HYPOTHESIS OF GOVERNMENT SUBSIDY TO STIMULATE ENTERPRISE INNOVATION

First of all, from the historical evolution of enterprise technology innovation activities, the knowledge/technology in the innovation process has certain externalities. Especially, for some basic research, its social benefits far outweigh the private benefits, and the role of the government in it is particularly important. The government's incentive subsidy for enterprises reduces the innovation cost of enterprises, reduces the gap between private income and social benefits of innovation activities, and increases the return on investment of enterprises engaged in innovative activities, stimulating enterprises to increase R&D expenditure. Especially for high-tech enterprises listed on the GEM, the scale and other restrictions make the R&D projects of enterprises have high investment and high risks, and the R&D funds are short. If they can obtain government subsidies, they will generally expand the R&D scale and increase R&D investment. Therefore, the hypothesis 1 of this paper is proposed. There is significant positive correlation between government subsidies and R&D expenditures of enterprises. That is to say, government subsidies will stimulate the increase of R&D expenditures of enterprises.

Secondly, if Hypothesis 1 is set up, after receiving government subsidies, the company will increase the R&D investment for innovation activities. In the long run, it will bring certain innovations, which are reflected in the increase of invention number, utility models and designs. Therefore, the research hypothesis 2 of this paper is proposed. The government subsidies will have a significant positive impact on the independent innovation results of enterprises. Combined with the statistics in the patent research database of CAMAR China listed companies, the enterprise innovation results can be represented by three indicators: invention number, utility model number and design number. This paper has designed three second-level hypotheses as the following. Hypothesis 2a: government subsidy will increase the number of inventions significantly. Hypothesis 2b: government subsidies will significantly increase the number of utility models. Hypothesis 2c: government subsidies will significantly increase the number of corporate designs.

Finally, the government's support for the technology innovation activities is beneficial. For some industries and enterprises, the government's innovation support is increasing. However, it has not brought about a significant increase in the enterprise innovation and independent innovation results. It is mainly influenced by the different preferences of the government and enterprises on technology. This difference in preferences ultimately led to the government's support not meeting expectations, and the policy effect was not significant. From the perspective of input and output, it can be considered that the government's innovation support policy is less efficient. Therefore, the research hypothesis 3 of this paper is proposed. The government innovation incentive policy has certain inefficiency.

III. RESEARCH DESIGN

A. Model Setting and Sample Data:

1) Model setting: In the real world, many economic relations are dynamic. Sometimes it is necessary to introduce lag items to explain these economic relations. The dynamic panel data model, that is, the lagging term of the explained variable is included in the interpretation term of the panel data model to reflect the dynamic lag effect. This paper designs a dynamic panel data model. The basic form of the dynamic panel data model is as follows:

$$Y_{it} = Y_{it-1} + \sum_{i=1}^{n} \beta_i x_{it} + \varepsilon_{it}$$

Y_{it} is the explained variable; x_{it} is the explanatory variable; β_i is the coefficient; ε_{it} stochastic disturbance term.

Under the analytical framework of this paper, variables are given practical meaning. Y_{1it} is the enterprise R&D expenditure. Y_{2it}, Y_{3it}, and Y_{4it} are the independent innovation achievements of the enterprise, representing the number of newly applied inventions, utility models and designs each year. X_{it} is innovative support for the enterprise. i represents the enterprise. t represents time. t-1 represents lagging period. β_i is the parameter to be estimated. The empirical analysis model of this paper is obtained as follows:

- Model 1: $$RD_{it} = RD_{it-1} + \beta_1 GOVS_{it} + \beta_2 SCAL_{it} + \beta_3 NUMS_{it} + \varepsilon_{it}$$
- Model 2a: $$INVENTION_{it} = RD_{it-1} + \beta_1 GOVS_{it} + \beta_2 SCAL_{it} + \beta_3 NUMS_{it} + \varepsilon_{it}$$
- Model 2b: $$UTILITY_{it} = RD_{it-1} + \beta_1 GOVS_{it} + \beta_2 SCAL_{it} + \beta_3 NUMS_{it} + \varepsilon_{it}$$
- Model 2c: $$DESIGN_{it} = RD_{it-1} + \beta_1 GOVS_{it} + \beta_2 SCAL_{it} + \beta_3 NUMS_{it} + \varepsilon_{it}$$

In the above model, RD stands for enterprise R&D investment. INVENTION, UTILITY and DESIGN represent the number of newly applied inventions, utility models and designs each year. GOVS represents the government's R&D subsidy for enterprise innovation. SCAL represents the scale of the company. NUMS represents the number of corporate R&D personnel.

B. Data Source and Variable Definition

The basic data used in this paper mainly comes from CSMAR database and RESSET financial research database. The sample period spans from 2010 to 2014. After removing the enterprise samples with incomplete data information, the valid sample is 108 A-share listed company.

1) Enterprise R&D expenditure: The enterprise R&D expenditure is the R&D expenses incurred by the enterprise for the scientific and technological innovation activities. The specific data comes from the patent research database of CSMAR China listed company.

2) The independent innovation results of enterprises: The independent innovation results of enterprises include the number of inventions, utility models and designs. The specific data comes from the patent research database of CSMAR China listed company.

3) Government subsidy: The specific data comes from the database of financial statements of CSMAR China listed companies. It should be pointed out that the direct use of current government subsidies for empirical testing may lead to bias in the estimation results. From the actual situation, when the government department puts the subsidy to the enterprise, it usually needs to follow a certain process, and the actual fund allocation often needs certain time. Under this circumstance, although the government subsidies can be observed in the year, there has different degrees of time lag in the real disposable funds of corporate. To accurately estimate the impact of government subsidies, this paper refers to the study of Yang Xiangyang and Tong Xinle (2014), and adopts the value of lagging periods of government subsidy.

4) Control variables: Regarding the control variables, this paper refers to the practice of similar literature, and considers the scale of the enterprise and the number of R&D personnel. The scale of the enterprise is represented by the total assets in the listed company's balance sheet. The specific data comes from the financial statement database of CSMAR China listed companies. The number of R&D personnel in the company is based on the number of people engaged in scientific research and technology research and development published in the annual report of the listed company. The data comes from RESSET Financial Research Database.

C. Descriptive Statistics of Variables

This paper use Eviews 7.0 software to perform the descriptive statistical analysis of the sequence groups. The basic descriptive statistics of each variable are obtained as shown in "Table I". From "Table I", we can know that from 2010 to 2014, the average R&D expenditure of the sample company is 43,139,649 yuan, and the mean of newly applied inventions, utility models and designs is 52 pieces, 15 pieces and 4 pieces per year, respectively. The mean of government subsidies is 53,441,204 yuan. The mean of assets representing enterprise scale is 4.58E+09 yuan. The average number of employees engaged in research and development work is 748.88810. From the bias of the median and the average, in addition to the concentrated distribution of utility models and designs, the distribution of the remaining variables is relatively scattered. In summary, it can be seen from the descriptive statistics that at the level of each variable, the gap among sample companies is large.

TABLE I. DESCRIPTIVE STATISTICAL ANALYSIS OF VARIABLES

	Mean	Median	Maximum	Minimum value	Standard deviation
RD	43139649	0.000000	3.48E+09	0.000000	2.58E+08
INVENTION	51.89591	3.000000	5241.000	0.000000	370.6437
UTILITY	14.81413	2.000000	749.0000	0.000000	62.59734
DESIGN	3.973978	0.000000	134.0000	0.000000	15.09360
GOVS	53441204	9348245.	2.37E+09	0.000000	2.07E+08
SCAL	4.58E+09	1.57E+09	1.09E+11	1.30E+08	1.27E+10
NUMS	748.8810	216.0000	30876.00	25.00000	2820.888

In order to further verify the change of the sample company as a whole in the time dimension, the mean and standard deviation were statistically analyzed in each year. The results are shown in "Table II". In "Table II", in addition to the utility model and the design, the mean of all the variables vary greatly in the time dimension, and there is no uniform trend in the change. Secondly, regarding the standard deviation, the enterprise R&D expenditure and design are stable year by year. The standard deviation of other indicators is also larger in different years. This shows that the gap among sample companies is changing as the year changes.

TABLE II. THE STATISTICS OF MEAN AND STANDARD DEVIATION IN EACH YEAR

Variable		RD	INVENTION	UTILITY	DESIGN	GOVS	SCAL	NUMS
2010	***Mean***	18347546	60.05556	10.48148	3.555556	36741069	3.83E+09	598.1852
	Standard deviation	0.000000	2.000000	1.000000	0.000000	7399607.	1.23E+09	154.5000
2011	***Mean***	29543300	59.32407	15.31481	4.796296	61375575	4.97E+09	727.3889
	Standard deviation	0.000000	3.000000	2.000000	0.000000	8975788.	1.49E+09	190.5000
2012	***Mean***	42752566	59.49533	19.56075	3.102804	51769781	4.28E+09	788.3645
	Standard deviation	0.000000	4.000000	4.000000	0.000000	10281731	1.51E+09	216.0000
2013	***Mean***	54004005	44.96296	15.19444	3.555556	59477606	4.66E+09	790.2407
	Standard deviation	0.000000	4.000000	3.000000	0.000000	9038270.	1.70E+09	236.0000
2014	***Mean***	71308060	35.56075	13.55140	4.859813	57867494	5.17E+09	841.4486
	Standard deviation	0.000000	4.000000	1.000000	0.000000	10687789	1.94E+09	247.0000

In summary, it can be seen from the above descriptive statistical analysis that the distribution and development status of sample companies vary widely at both the cross-section level and the time level. In this case, if this paper uses OLS to make the estimation, it is difficult to describe the change in the gap, and the resulting regression coefficient is likely to be biased. Therefore, this paper chooses to use panel regression to estimate the sample. On the basis of controlling individual differences and time differences, it conducts an in-depth study on the impact of government innovation support policies on enterprise innovation.

D. Discussion on the Applicability of Dynamic Panel GMM Method

In the past, when scholars studied the impact of government innovation support policies on enterprises, they usually used the ordinary least squares (OLS) to make the regression analysis. It can reflect the impact of government support on enterprise innovation. However, the scholars did not consider estimation deviation caused by the endogeneity of variables. In addition, Xie Weimin (2009) and other scholars have found that the impact of government innovation support policies on corporate innovation behavior is lagging. At the same time, this lag is not only reflected in the lag of the explanatory variable to the dependent variable, but also in the influence of the previous dependent variable on the current dependent variable. That is to say, the innovative behavior of the enterprise in the early stage will have an impact on the current innovation behavior. Therefore, the research in this paper needs to add the lag term of the dependent variable to the explanatory variable, but this will inevitably cause endogeneity problems. In the dynamic panel model, the delayed period of the explained variable as an explanatory variable is likely to cause the explanatory variable being correlated with the random disturbance term, which leads to the biased and inconsistent parameter estimation. And it may affect the final test result.

Arellano and Bond (1991), Blundell and Bond (1998) proposed GMM estimation. According to the setting of moment conditions, the endogeneity and hysteresis problems among variables are well solved. GMM (Generalzed method of moments) is a kind of estimation method based on the fact that the actual parameters of the model satisfy certain moment conditions, which is the generalization of the moment estimation method. As long as the model is set correctly, it is always possible to find several moment conditions that the actual parameters of the model satisfy. And then, it will use GMM estimation.

Compared with traditional econometric estimation methods, GMM has the following advantages. First, traditional econometric estimation methods, such as ordinary least squares method, instrumental variable method and maximum likelihood method have their own limitations. Namely, the parameter estimator must be a reliable estimator when certain assumptions are met, for example, the random error term of the model obeys normal distribution or known distribution, and the GMM does not need to know the exact distribution information of the random error term. It allows random error terms to have heteroscedasticity and sequence correlation. The resulting parameter estimators are more efficient than other parameter estimation methods. Second, the GMM method can solve the correlation between unobservable variables and explanatory variables to some extent, or the bias caused by the omission of some important explanatory variables. It is difficult to include all possible significant explanatory variables in any model design, which is particularly important for empirical testing. Third, there is certain endogeneity among enterprise R&D investment, the self-output innovation of the enterprise, the enterprise scale, government subsidies and other explanatory variables. Direct regression analysis will lead to significant deviation of the estimation results. GMM estimation method based on the dynamic panel data model can better eliminate the endophytism.

Based on the above analysis, this paper analyzes the impact of government subsidies on corporate R&D expenditure and enterprise independent innovation with the generalized moment estimation method (GMM).

IV. EMPIRICAL ANALYSIS BASED ON DYNAMIC PANEL DATA

A. The Role of Government Subsidies in Corporate R&D Expenditure: Stimulation or Squeeze

1) Testing result of Variable correlation: Before estimating the parameter of the model, the variable correlation should be first tested. The testing results of the variable correlation involved in the model 1 are shown in "Table III". On the one hand, from the correlation between explanatory variables and other explained variables, government subsidies, the enterprise scale and the number of enterprise R&D personnel are highly correlated with R&D expenditures. On the other hand, the correlation between government subsidies, enterprise scale, and enterprise R&D personnel is not low. That is to say, the model may have a certain degree of multicollinearity. However, the enterprise scale and the number of enterprise R&D personnel are only used as control variables of the model, this paper will retain these data.

TABLE III. TESTING RESULTS OF VARIABLE CORRELATION (MODEL 1)

	RD	GOVS	SCAL	NUMS
RD	1	0.657367	0.742116	0.898521
GOVS	0.657367	1	0.627831	0.504536
SCAL	0.742116	0.627831	1	0.813334
NUMS	0.898521	0.504536	0.813334	1

2) Dynamic panel GMM estimation results: This paper uses Eviews 7.0 software to make the GMM estimation of Model 1. The results are shown in "Table IV".

TABLE IV. GMM-BASED MODEL ESTIMATION RESULTS (MODEL 1)

Variable	Parameter estimation result	Standard deviation	t statistics	P ratios
RD(-1)	1.098289	0.004199	261.5394	0.0000
GOVS1	0.073484	0.010011	7.340645	0.0000
SCAL	0.001338	0.000335	3.995503	0.0001
NUMS	-9329.216	3405.923	-2.739115	0.0065
J-statistics: 4.609098; the sequence of instrumental variable: 6				

The GMM estimation of the dynamic panel data does not have the goodness of fit and the F statistic of the classical regression analysis. However, it takes the Sargan test by using the J statistic. In the null hypothesis, the model is over-constrained correctly. If the sargan test is rejected, the model is set incorrectly. The P value of the J statistic can be calculated by the chidist (x, ir-v) function. d is the value of the J statistic. ir is the rank of the instrument variable. v is the number of parameters to be estimated. From the estimation results of Model 1 in "Table IV", J=4.609098, ir=11, v=3. From the P value of sargan test (0.7984), the selection of the tool variables is reasonable, and the model 1 is set correctly.

3) Interpretation of model results: As can be seen from "Table IV", the parameter estimation result corresponding to the government subsidy is 0.073484. The accompanying probability of the T test is P=0.0000, indicating that the government subsidy is significantly positively correlated with the enterprise R&D expenditure. The government subsidizes companies to encourage innovation activities. This will stimulate independent innovation. And corporate R&D expenditure will increase significantly. Hypothesis 1 is supported.

The results in "Table IV" also show that the level of enterprises R&D expenditure is also significantly positively correlated with the scale of enterprises. The enterprises with large scales have stronger willingness to carry out innovation activities. And they will pay more attention to innovation activities. This is reflected in the increase of R&D expenditure.

B. The Role of Government Subsidies for Independent Innovation of Enterprise: Stimulation or Inhibitions

1) Testing result of variable correlation: Before estimating the parameter of the model, the correlation test of the variables should be first carried out. The testing results of the correlation among the variables involved in the model 2a, the model 2b and the model 2c are shown in "Table V". On the one hand, from the correlation between explanatory variables and explained variables, the government subsidies, the enterprise scale and the number of R&D personnel are highly correlated with enterprise inventions, utility models and designs. On the other hand, the correlation among each explanatory variable is not low. That is to say, the model may have a certain degree of multicollinearity problem. However, the enterprise scale and the number of R&D personnel of the enterprise are the control variables of the model. We can make the same processing as Model 1, and all variables are retained.

TABLE V. TESTING RESULTS OF VARIABLE CORRELATION (MODEL 2A, MODEL 2B, MODEL 2C)

	INVENTION	UTILITY	DESIGN	GOVS	SCAL	NUMS
INVENTION	1	0.52784	0.651161	0.546569	0.746646	0.847212
UTILITY	0.52784	1	0.460528	0.522567	0.630874	0.351022
DESIGN	0.651161	0.460528	1	0.473178	0.623708	0.716524
GOVS	0.546569	0.522567	0.473178	1	0.627831	0.504536
SCAL	0.746646	0.630874	0.623708	0.627831	1	0.813334
NUMS	0.847212	0.351022	0.716524	0.504536	0.813334	1

2) Dynamic panel GMM estimation results: We will use Eviews 7.0 software to make GMM estimation of model 2a, model 2b and model 2c. The results are shown in "Table VI".

TABLE VI. GMM-BASED MODEL ESTIMATION RESULTS (MODEL 2A, MODEL 2B, MODEL 2C)

	Model 2a		Model 2b		Model 2c	
	coefficient	*P ratios*	*coefficient*	*P ratios*	*coefficient*	*P ratios*
RD(-1)	1.095344	0.0000	-0.033736	0.3529	0.306204	0.0000
GOVS1	1.75E-07	0.0017	1.39E-08	0.7491	3.66E-08	0.0448
SCAL	2.85E-08	0.0437	-3.57E-09	0.0057	-2.91E-09	0.1347
NUMS	0.009317	0.7877	0.020872	0.0060	-0.007121	0.2448
Sargan test	J-statistics: 3.410590 The rank of instrumental variable: 6		J-statistics: 1.783121 The rank of instrumental variable: 6		J-statistics: 2.451365 The rank of instrumental variable: 6	

The sargan test is performed on model 2a, model 2b and model 2c. The results are as the following. In model 2a, J=3.410590, ir=6, v=3. The P ratio (0.3325) verified by sargan test shows that the selection of instrument variables is reasonable. The model is set correctly. In model 2b, J=1.783121, ir=6, v=3. The P ratio (0.6186) verified by sargan test shows that the selection of tool variables is reasonable, and the model is set correctly. In model 2c, J=2.451365, ir=6, v=3. The P ratio (0.4841) verified by sargan test shows that the selection of tool variables is reasonable, and the model is set correctly.

3) Interpretation of model results: It can be seen from “Table 6” that the parameter estimation result corresponding to the government subsidy in model 2a is 1.75E-07. The accompanying probability of the T test is P=0.0017, indicating that the government subsidy is significantly positively correlated with the number of enterprise inventions. The hypothesis 2a is supported. The parameter estimation result corresponding to the subsidy is 1.39E-08, and the accompanying probability of the T test is P=0.7491, indicating that for the sample enterprises, the impact of government subsidies on the number of utility models is not significant. The hypothesis 2b is not supported. The parameter estimation result corresponding to the subsidy is 3.66E-08, and the accompanying probability of the T test is P=0.0448, indicating that the government subsidy is significantly positively correlated with the number of corporate designs, and hypothesis 2c is also supported.

V. ANALYSIS OF GOVERNMENT INNOVATION SUPPORT EFFICIENCY BASED ON DEA METHOD

According to the empirical analysis based on dynamic panel data, the positive impact of government subsidies on R&D expenditures of enterprises is significant. However, the impact on the independent innovations of enterprise, namely, the inventions, utility models and designs, is uncertain. Therefore, the policy measures adopted by the government to encourage enterprises to carry out innovation activities are likely to be inefficient. Combined with the DEA method, we can analyze the efficiency of government innovation support policies. In order to simplify the analysis, this part only selects the input-output data of the sample companies in the "computer, communication and other electronic equipment manufacturing industry" published by China Securities Regulatory Commission (2012 edition) in 2014 for the analysis on government innovation support efficiency.

A. Selection of Indicators

According to the analysis above, the government subsidy scale and government R&D expenditure are taken as input variables, and the sum of invention, utility model and design is taken as the output variable. Based on the DEA method, the efficiency of government innovation support to promote independent innovation of enterprises is measured. "Table VII" shows the input-output data of 13 sample companies in the "Computer, Communications and Other Electronic Equipment Manufacturing Industry" in 2014.

TABLE VII. THE INPUT-OUTPUT DATA OF SAMPLE ENTERPRISE IN "COMPUTER, COMMUNICATIONS AND OTHER ELECTRONIC EQUIPMENT MANUFACTURING" (2014)

Stock Code	**Corporate Name**	**output indicators**	**input indicators**	
		Invention, utility model Design (piece)	***government subsidy (yuan)***	***R&D expenditure (yuan)***
000063	Zhongxing Telecommunication Equipment Corporation	1031	0	3483505000
000100	TCL Corporation	160	1528368000	1048372000
000725	BOE Technology Group Co., Ltd.	2648	830471170	0
000970	Beijing Zhongke Sanhuan Hi-tech Co., Ltd.	11	19073962	0
002308	VTRON Technology Co.,Ltd.	262	24355076	0
002362	Hanvon Technology Co.,Ltd.	27	14893500	1498659
002415	Hangzhou Hikvision Digital Technology Co.,Ltd.	194	844526976	0
002426	Suzhou Shengli Precision Manufacturing Technology Co., Ltd.	24	7490398	0
002429	Shenzhen MTC Co., Ltd.	13	59863659	0
002465	Guangzhou Haige Communications Group Intercoporate Conpanny	41	98870571	6370737
002475	LuXshare Intercorporate Conpanny	11	59945521	0
300065	Beijing Hailander Digital Technology Co., Ltd.	7	15295806	0
300083	Guangdong JANUS Intelligent Group Corporation Limited	90	9786628	1351528

1) DEA analysis results: The DEAP2.1 software was used to analyze the efficiency of government innovation support of 13 sample companies, and the results shown in "Table VIII" were obtained, including comprehensive efficiency, pure technical efficiency and scale efficiency.

TABLE VIII. DEA TECHNICAL EFFICIENCY MEASUREMENT RESULTS

Corporate Name	**comprehensive efficiency**	**pure technical efficiency**	**scale efficiency**	**returns to scale**
Zhongxing Telecommunication Equipment Corporation	1.000	1.000	1.000	—
TCL Corporation	0.756	0.992	0.762	drs
BOE Technology Group Co., Ltd.	0.940	1.000	0.940	drs
Beijing Zhongke Sanhuan Hi-tech Co., Ltd.	0.911	0.945	0.964	drs
VTRON Technology Co.,Ltd.	1.000	1.000	1.000	—
Hanvon Technology Co.,Ltd.	0.594	0.689	0.862	drs
Hangzhou Hikvision Digital Technology Co.,Ltd.	0.824	0.849	0.970	drs
Suzhou Shengli Precision Manufacturing Technology Co., Ltd.	1.000	1.000	1.000	—
Shenzhen MTC Co., Ltd.	1.000	1.000	1.000	—
Guangzhou Haige Communications Group Intercoporate Conpanny	0.827	0.862	0.959	drs

Corporate Name	comprehensive efficiency	pure technical efficiency	scale efficiency	returns to scale
LuXshare Intercorporate Conpanny	0.692	0.693	0.999	irs
Beijing Hailander Digital Technology Co., Ltd.	1.000	1.000	1.000	—
Guangdong JANUS Intelligent Group Corporation Limited	0.802	1.000	0.802	drs
Mean	0.873	0.925	0.943	

[a] Note: irs, drs respectively indicate that the scale returns are constant. The scale returns are increasing, and the scale returns are decreasing.

As can be seen from "Table VIII", there are 5 companies with comprehensive efficiency of 1 among the 13 sample companies, and the remaining 8 companies are relatively inefficient. The hypothesis 3 is supported. Overall, the comprehensive efficiency of the 13 sample companies was 0.873, indicating that 12.7% of government subsidies were wasted. The government could use other methods to encourage the enterprise innovation to increase innovation output or appropriately reduce government subsidies for certain enterprises. Inefficiency includes technical inefficiency and scale inefficiency.

The comprehensive efficiency type of enterprise refers to the enterprises with comprehensive efficiency, technical efficiency and scale efficiency of 1. The five sample enterprises with comprehensive efficiency of 1 are all efficient. This type of enterprises is in the stage of constant scale returns. Therefore, it is not necessary to reduce input or increase output. It just needs to maintain the scale of existing government subsidies.

Pure technological inefficiency means that the scale efficiency is 1, and the technical efficiency is less than 1. The inefficiency comes from the pure technological inefficiency. The comprehensive efficiency needs to be increased by improving the technical efficiency. There is no enterprise with pure technology inefficiency in "Table VIII". Scale inefficiency means that the technical efficiency is 1. However, the scale efficiency is less than 1. The inefficiency comes from the scale inefficiency. There is no enterprise with scale inefficiency in "Table 8".

VI. CONCLUSION

This paper examines the role of government subsidies for corporate R&D expenditures and corporate independent innovations, taking 108 A-share listed companies in 2010-2014 as samples. Based on the analysis of relevant literature and the analysis of the logical mechanism of government subsidies to stimulate enterprise innovation, it is proposed that government subsidies can stimulate enterprises to carry out innovation activities and increase R&D expenditures, which will have a positive impact on the independent innovation results of enterprises. After controlling the enterprise scale and the number of scientific researchers, government subsidies can significantly stimulate R&D expenditures. The hypothesis 1 is supported. The verification results of Hypothesis 2 indicate that the influence of government subsidy on the number of inventions and design is obviously positive. However, the impact on the number of utility models is not significant. Hypothesis 2a and Hypothesis 2c are supported, and the hypothesis 2b is not supported. On this basis, this paper uses the DEA method to analyze the efficiency of government innovation support. For sample companies, the government innovation support policy has certain inefficiency. Hypothesis 3 is supported.

The results of this paper generally support the positive role of government subsidies in stimulating corporate innovation. The policy implication of the research is that it is necessary for the government to support the enterprise to improve the independent innovation capability. However, there is certain inefficiency in the government subsidy. It is necessary to design a more reasonable government innovation support policy implementation plan to optimize the effect of government support on corporate innovation.

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