ISSN : 0974 - 7435 Volume 10 Issue 21

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(21), 2014 [13329-13335]

Crowding-in or crowding-out effect of S&T input of government on R&D expenditure of enterprise in China

Zhang Dan[1], Wu Daoyou[1*]

[1]Zhejiang University of Finance & Economics, (CHINA)

***School of Business Administration, Zhejiang University of Finance &Economics, Hangzhou, (CHINA)**

Email: wudaoyou2015@163.com

ABSTRACT

Current conclusions about the effect of the government S&T input on the enterprise R&D expenditure are inconsistent, including crowding-in and crowding-out, and the reason may lie in shorter lag phase selected by the model (i.e. one year) and neglecting the influence of other factors. With consideration of the rapid development of GDP and longer lag phase of the S&T input policy in China, the paper brings in GDP as a moderating variable and selects a two-year lag phase to build a dynamic panel data model for analysis. The results show that a large amount of direct input in S&T resources of the government can not improve the enterprise R&D expenditure in current year and the next year, but will generate crowding-out effect on the enterprise R&D expenditure in the third year; the higher the GDP growth rate is, the weaker the crowding-out effect of the government S&T input on the enterprise R&D expenditure is. However, informatization level and hi-tech industry development have no significant moderating effect on the relationship between the government S&T input and enterprise R&D expenditure.

KEYWORDS

Crowding-in or crowding –out; S&T input of government; R&D expenditure; China.

INTRODUCTION

Chinese government continues to increase S&T input in response to market failure in S&T resources allocation, but controversy remains about the influence of such corrective action on the enterprise R&D expenditure. In fact, the S&T expenditure of Chinese national finance in 2012 was RMB 560.01 billion Yuan, with an increase of RMB 80.31 billion Yuan over last year, increasing by 16.7%. However, the enterprise is short of R&D input initiative, with the R&D input of Chinese enterprises taking up less than 1% of the sales revenue, far below 2.5%-4% of developed countries, and the dominant role of technological innovation in the enterprise needs to be strengthened. In theory, the research on the relationship between the S&T input of the government and R&D expenditure of the enterprise is also disputable. Some scholars considered that S&T input of the government has crowding-in effect on R&D input of the enterprise. A prominent research is that OECD pointed out that S&T input of the government had positive effect on R&D input of the enterprise and the well-designed government investment plan would have lever effect on the enterprise R&D in the research report of *The Effect of Public R&D Expenditure on Enterprise R&D* in 2000. But some scholars considered that S&T input of the government had crowding-out effect on R&D input of the enterprise. A prominent research is the idea of crowding-out effect proposed by Terence Kealey, namely national S&T input would replace the enterprise R&D input. Actually, different scholars had different research results due to different models, sample data and methods, etc. [1-3]. Making selection and judgment for the elements influencing the relationship between Chinese government S&T input and enterprise R&D expenditure, which not only has theoretical significance for further research, but also has practical significance for standardizing the government S&T input.

THEORY MODEL AND DATA COLLECTION

Theory model

Researches often take the enterprise R&D expenditure as dependent variables and the government S&T input as independent variable in existing research, and then analyze the coefficient of the government S&T input variable in final model to test the crowding-in and out effect. If the coefficient is positive and remarkable, the government S&T input will have crowding-in effect on the enterprise R&D expenditure; if the coefficient is negative and remarkable, the government S&T input will have crowding-out effect on the enterprise R&D expenditure [4-5]. Considering that the dynamic panel data model can solve such questions as missing variable, self correlation and heteroscedasticity, this paper build following dynamic panel data model:

$$I_{it} = \alpha + \beta_1 I_{it\text{-}1} + \beta_2 I_{it\text{-}2} + \beta_3 F_{it} + \beta_4 F_{it-1} + \beta_5 F_{it-2} + \beta_6 G_{it-1} + \beta_7 G_{it-2} + \sum_{t=2007}^{2011} \beta_t year_t + \varepsilon_{it} \quad \textbf{(1)}$$

Where, I_{it} refers to the enterprise R&D expenditure of district i in t year. F_{it} refers to the government S&T input of district i in t year, and G_{it} refers to the GDP growth rate of district i in t year. Refer to the investment model built by Agosin and Mayer (2000). $G_{it\text{-}1}$ and $G_{it\text{-}2}$ are introduced. $year_t$ refers to different years. α refers to constant term and ε_{it} refers to the error term.

Considering effects of the government S&T input on the enterprise R&D expenditure may be variable in different situations, moderating variables are introduced for analysis. Currently, China emphasizes the informatization construction which is carried out in all regions, including mobile communication network and broadband services construction, etc. Therefore, informatization level is introduced as a moderating variable, and as the major field of innovation, hi-tech industry development may have moderating effect on the relationship between the government S&T input and the enterprise R&D expenditure [6-7]. Finally, GDP growth rates of different areas are different, which may generate moderating effect as well, so the model (2), (3) and (4) with moderating variables introduced are built.

$$\begin{aligned} I_{it} = {} & \alpha + \beta_1 I_{it\text{-}1} + \beta_2 I_{it\text{-}2} + \beta_3 F_{it} + \beta_4 F_{it-1} + \beta_5 F_{it-2} + \beta_6 G_{it-1} + \beta_7 G_{it-2} \\ & + \beta_8 IN_{it} + \beta_9 IN_{it-1} + \beta_{10} IN_{it-2} + \beta_{11} F_{it} IN_{it} + \sum_{t=2007}^{2011} \beta_t year_t + \varepsilon_{it} \end{aligned} \quad \textbf{(2)}$$

$$\begin{aligned} I_{it} = {} & \alpha + \beta_1 I_{it\text{-}1} + \beta_2 I_{it\text{-}2} + \beta_3 F_{it} + \beta_4 F_{it-1} + \beta_5 F_{it-2} + \beta_6 G_{it-1} + \beta_7 G_{it-2} \\ & + \beta_8 HI_{it} + \beta_9 HI_{it-1} + \beta_{10} HI_{it-2} + \beta_{11} F_{it} HI_{it} + \sum_{t=2007}^{2011} \beta_t year_t + \varepsilon_{it} \end{aligned} \quad \textbf{(3)}$$

$$I_{it} = \alpha + \beta_1 I_{it\text{-}1} + \beta_2 I_{it\text{-}2} + \beta_3 F_{it} + \beta_4 F_{it-1} + \beta_5 F_{it-2} + \beta_6 G_{it-1} + \beta_7 G_{it-2} + \beta_8 F_{it} G_{it} + \sum_{t=2007}^{2011} \beta_t year_t + \varepsilon_{it} \quad (4)$$

Where IN_{it} refers to the informatization level of district i in t year, and HI_{it} refers to the hi-tech industry development situation of district i in t year.

Data collection

Variables involved in the research include the government S&T input (F), enterprise R&D expenditure (I), GDP growth rate (G), informatization level (IN) and the proportion of the added value of hi-tech industry to the industrial added value (HI). The data is from statistics departments of Zhejiang Province, including the data of 90 districts and counties during 2007-2011. The calculation formulas of variables are shown in TABLE 1, and the descriptive statistics results are shown in TABLE 2:

TABLE 1: List of variables

Variables	Definition of the Variables
government S&T input(F)	financial allocation for S&T /GDP
enterprise R&D expenditure(I)	R&D expenditure / prime operating revenue
GDP growth rate(G)	(current year GDP-last year GDP)/ last year GDP
informatization level(IN)	data from statistics departments of Zhejiang Province
Development of hi-tech industry(HI)	(added value of hi-tech industry / the industrial added value)*100

TABLE 2: Descriptive statistics results

Variables	Observations	Mean	Standard Deviation	Min	Max
F	450	1.3624	0.7277653	0.1	5.92
I	450	0.2824662	0.1395738	0.0270582	1.093767
G	450	0.1572481	0.1380838	-0.3724299	1.829766
IN	450	226.9295	126.5408	63.54	576.47
HI	450	21.32696	16.48275	0	89.36

MODEL TEST AND ANALYSIS

System GMM is applied to estimate the dynamic panel data model of the relationship between the government S&T input and the enterprise R&D expenditure with the data processing software of Stata12.0. First the model (1) is tested, then the models (2), (3) and (4) with the moderating variables including informatization level, hi-tech industry development and GDP growth rate are tested, and finally robustness of the model is analyzed.

Effect of the government S&T input on the enterprise R&D expenditure

Effect of the government S&T input on the enterprise R&D expenditure is analyzed by model (1), with the results shown in TABLE 3. The whole model passes test with Prob.=0.0000, and Prob > z=0.3587 shows that there is no serial correlation in the model, and Prob > chi2=0.8526 shows that there is no excessive identification in the model. Enterprise R&D expenditure in year 1 has remarkable positive effect on enterprise R&D expenditure in year 2(the coefficient is 0.9076141, P value is 0.000), and government S&T input in year 1 has remarkable negative effect on enterprise R&D expenditure in year 3(the coefficient is -1.499637, P value is 0.000), and other coefficients are not significant.

Effect of the government S&T input on the enterprise R&D expenditure under different informatization levels

Effect of the government S&T input on the enterprise R&D expenditure under different informatization levels is analyzed by model (2), with the results shown in TABLE 4. The whole model passes test with Prob.=0.0000, and Prob > z=0.3957 shows that there is no serial correlation and Prob > chi2=0.8576 shows that there is no excessive identification in the model. Enterprise R&D expenditure in year 1 has significant positive effect on enterprise R&D expenditure in year 2(the coefficient is 0.9174243, P value is 0.000), and government S&T input in year 1 has significant negative effect on enterprise R&D expenditure in year 3(the coefficient is -1.582532, P value is 0.000). The informatization level has no significant effect on the enterprise R&D expenditure (P values are greater than 0.05) and has no significant moderating effect on the relationship between the government S&T input and the enterprise R&D expenditure (P value is greater than 0.05), and other variable coefficients are not significant.

TABLE 3: Dynamic model(1)(GMM)

Variables	Coef.	Std. Err.	P	95% Conf. Interval	
_cons	.351482	.2028618	0.083	-.0461199	.7490839
I (t-1)	.9076141	.0822632	0.000	.7463812	1.068847
I (t-2)	.1041758	.1388334	0.453	-.1679328	.3762843
F	-.250135	.4160485	0.548	-1.065575	.5653052
F (t-1)	.6305332	.6106999	0.302	-.5664166	1.827483
F (t-2)	-1.499637	.3567699	0.000	-2.198893	-.8003812
G (t-1)	-.0213339	.1572351	0.892	-.329509	.2868411
G (t-2)	.1905018	.2099248	0.364	-.2209432	.6019468
Wald chi2			217.28		
Prob.			0.0000		
serial correlation (Arellano-Bond test)	Prob > z=0.3587			no serial correlation	
over identification(Sargan test)	Prob > chi2=0.8526			no over identification	

TABLE 4: Dynamic model(2)(GMM)

Variables	Coef.	Std. Err.	P	95% Conf. Interval	
_cons	.3437319	.4226555	0.416	-.5423894	1.299599
I (t-1)	.9174243	.1020293	0.000	.7174506	1.117398
I (t-2)	.131378	.1420914	0.355	-.147116	.4098719
F	-.5615525	.5783851	0.332	-1.695167	.5720615
F (t-1)	.5510402	.5394302	0.307	-.5062234	1.608304
F (t-2)	-1.582532	.3733459	0.000	-2.314277	-.8507877
G (t-1)	-.0187633	.1734428	0.914	-.3587049	.3211783
G (t-2)	.1611153	.2152838	0.454	-.2608333	.5830638
IN	.0001175	.0014873	0.937	-.0027976	.0030325
IN (t-1)	.0002636	.0014972	0.860	-.0026709	.0031981
IN (t-2)	-.0001027	.0015892	0.948	-.0032174	.003012
F×IN	.0405517	.0626654	0.518	-.0822702	.1633736
Wald chi2			207.61		
Prob.			0.0000		
serial correlation (Arellano-Bond test)	Prob > z=0.3957			no serial correlation	
over identification(Sargan test)	Prob > chi2=0.8576			no over identification	

Effect of the government S&T input on the enterprise R&D expenditure under different levels of development of hi-tech industry

Effect of the government S&T input on the enterprise R&D expenditure under different levels of development of hi-tech industry is analyzed by model (3), with the results shown in TABLE 5. The whole model passes test with Prob.=0.0000, and Prob > z=0.3314 shows that there is no serial correlation in the model, and Prob > chi2=0.8684 shows that there is no excessive identification in the model. Enterprise R&D expenditure in year 1 has significant positive effect on enterprise R&D expenditure in year 2 (the coefficient is 0.9079558, P value is 0.000), and government S&T input in year 1 has significant negative effect on enterprise R&D expenditure in year 3(the coefficient is -1.482679, P value is 0.000). Development level of hi-tech industry has no significant effect on the enterprise R&D expenditure (P values are all greater than 0.05) and has no significant moderating effect on the relationship between the government S&T input and enterprise R&D expenditure (P value is greater than 0.05), and other coefficients are not significant.

TABLE 5: Dynamic model(3)(GMM)

Variables	Coef.	Std. Err.	P	95% Conf. Interval	
_cons	.2747301	.2642328	0.298	-.2431566	.7926169
I (t-1)	.9079558	.1105857	0.000	.6912119	1.1247
I (t-2)	.1023628	.1421657	0.472	-.1762769	.3810024
F	-.2997134	.4046724	0.459	-1.092857	.49343
F (t-1)	.4371972	.5934133	0.461	-.7258715	1.600266
F (t-2)	-1.482679	.3971632	0.000	-2.261104	-.7042531
G (t-1)	-.0461863	.1682586	0.784	-.3759671	.2835946
G (t-2)	.1396398	.2002922	0.486	-.2529256	.5322053
HI	.0040558	.0073317	0.580	-.010314	.0184255
HI (t-1)	.0045464	.0059716	0.446	-.0071578	.0162506
HI (t-2)	-.00125	.0053609	0.816	-.0117572	.0092572
G×HI	-.0042286	.0229488	0.854	-.0492074	.0407502
Wald chi2			113.93		
Prob.			0.0000		
serial correlation (Arellano-Bond test)	Prob > z=0.3314			no serial correlation	
over identification(Sargan test)	Prob > chi2=0.8684			no over identification	

Effect of the government S&T input on the enterprise R&D expenditure under different levels of GDP growth rate

Effect of the government S&T input on the enterprise R&D expenditure under different levels of GDP growth rate is analyzed by model (4), with the results shown in TABLE 6. The whole model passes test with Prob.=0.0000. Prob > z=0.3779 shows that there is no serial correlation in the mode and Prob > chi2=0.9024 shows that there is no excessive identification in the model. Enterprise R&D expenditure in year 1 has significant positive effect on enterprise R&D expenditure in year 2(the coefficient is 0.8709442, P value is 0.000). Government S&T input in year 1 has significantly negative effect on enterprise R&D expenditure in year 3(the coefficient is -1.394226, P value is 0.000), and GDP growth rate level in year 1 has significant positive effect on the enterprise R&D expenditure in year 3(the coefficient is 0.3192202, P value is 0.041) and has significant negative moderating effect on the relationship between the government S&T input and the enterprise R&D expenditure (the coefficient is -0.0367905, P value is 0.004), and other coefficients are not significant.

TABLE 6: Dynamic model(4)(GMM)

Variables	Coef.	Std. Err.	P	95% Conf. Interval	
_cons	.2637968	.1926181	0.171	-.1137277	.6413214
I (t-1)	.8709442	.0869475	0.000	.7005302	1.041358
I (t-2)	.1010922	.1323615	0.445	-.1583315	.3605159
F	-.164716	.3773962	0.663	-.9043989	.5749669
F (t-1)	.7494788	.5833764	0.199	-.3939179	1.892876
F (t-2)	-1.394226	.3473335	0.000	-2.074987	-.713465
G (t-1)	.1645277	.1285267	0.201	-.0873801	.4164355
G (t-2)	.3192202	.1560169	0.041	.0134326	.6250077
F×G	-.0367905	.0128049	0.004	-.0618877	-.0116933
Wald chi2			249.02		
Prob.			0.0000		
serial correlation (Arellano-Bond test)	Prob > z=0.3779			no serial correlation	
over identification(Sargan test)	Prob > chi2=0.9024			no over identification	

Robustness Test

Control variables such as the area attribute, industrial added value and patent number and etc. are introduced to the model to conduct the robustness test, and the results show no significant change. Actually the results of model (1), (2), (3) and (4) are consistent, which also verify the robustness of the model.

RESULT AND DISSCUSS

There are inconsistent conclusions about the effect of the government S&T input on the enterprise R&D expenditure, and the paper analyzed the crowding-in & crowding-out effect of the government S&T input on the enterprise R&D expenditure with the dynamic panel data of 90 districts and counties of Zhejiang Province in China during 2009-2011. The conclusions include:

(1) A mass of direct investment in S&T resources by the government can not improve the initiative of the enterprise R&D expenditure in the current year and next year but generate crowding-out effect on the enterprise R&D expenditure in the third year. After the government S&T input increased, the enterprise R&D expenditure on current year and next year will not be affected significantly. Main reasons may be: (a) for the enterprise, it is hard to adjust the enterprise R&D expenditure in the short term, including termination or proceeding of implemented R&D project and redistribute existing innovation resources, etc. Besides, the enterprise has the difficulty in seizing the government's S&T policy direction in the short term; (b) for the government, implementation of S&T input policy and generation of effects have some hysteretic nature. Therefore, the change of the enterprise R&D expenditure was not significant on current year and next year. In the third year, once the government S&T input policy was implemented, the government scientific research department, colleges and scientific research institutions, etc. would produce amounts of effective scientific and technological achievements, which could reduce the difficulty and initiative of the enterprise's independent R&D and the enterprise R&D expenditure will reduce notably when it can adjust existing R&D expenditure.

(2) In the area with higher GDP growth rate, the crowding-out effect of the government S&T input on the enterprise R&D expenditure is weaker. GDP growth rate can reflect the speed of local economic development. In the area with faster speed of economic development, its innovation system may be perfect, which includes the dominant role of the enterprise's technological innovation and the guiding function of the government S&T input stronger, so as to result in the crowding-out degree of the government S&T input on the enterprise R&D expenditure dropping. About these two factors of informatization level and hi-tech industry development discussed frequently in practice, the research data does not show that they will have notable effect on the relationship between the government S&T input and the enterprise R&D expenditure.

CONCLUSIONS

The market failure argument resting on the 'public good' nature of innovations, which deters full appropriation and leads the level of enterprise innovation below the socially optimal level, drives this agreement. Furthermore, capital market imperfections leading to financial constraints on risky projects, such as R&D activities, also contribute to reducing the enterprise R&D investment below the socially optimal level. Government S&T input are used as policy instruments to fill the gap between the enterprise and the socially optimal levels of R&D investment. Accordingly, many empirical studies have aimed at assessing the causal effect of government S&T input on enterprise R&D investment.

Our review of the empirical literature on the impact of government S&T input on the enterprise R&D yields the following conclusions. First, most studies have concentrated on developed countries, mainly the US and the EU countries, and there is little evidence for other countries, particularly developing and emerging countries. Second, the empirical evidence on the effectiveness of government S&T input is mixed and therefore inconclusive. We believe that, in addition to methodological differences, the theoretical framework of analysis, the population under study (e.g. the country and sample period, the type of firms) and the sources might determine whether the additionality or the substitution effect is observed.

Our survey shows that most of effectiveness of government S&T input on enterprise R&D have been addressed separately in different studies. We believe that a mass of direct investment in S&T resources by the government can not improve the initiative of the enterprise R&D expenditure in the current year and next year but generate crowding-out effect on the enterprise R&D expenditure in the third year. In the area with higher GDP growth rate, the crowding-out effect of the government S&T input on the enterprise R&D expenditure is weaker. GDP growth rate is taken seriously by wide range of theory scholars and practice workers.

Although the paper have obtained some achievements, adopting district & county data for analysis is not only decided by characteristic of "province strong and municipality (county) weak" in the government S&T input and the enterprise R&D expenditure in China but also restricted by the informatization level data acquisition. If adopting national, regional or provincial data may be more convincing, and the lag phase of the effect of the government S&T input on the enterprise R&D expenditure may be longer in these levels. Moreover, analysis is only conducted in total amounts in the research, not in the structure of government S&T input. Therefore, the effect of the structure of government S&T input on the enterprise R&D expenditure will be analyzed next step. For example, acquire sub-sector data and check the effect of the government S&T input on the enterprise R&D expenditure in different industries.

ACKNOWLEDGEMENT

This research was sponsored by NSFC (NO.71402160); Zhejiang provincial natural science foundation of China (NO.LQ13G020004; LQ14G020014); Zhejiang Provincial Key Research Base of Humanistic and Social Sciences in Hangzhou Dianzi University(NO. ZD02-2014ZB3；ZD02-201401)

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