The Impact of Government R&D Promotion Policy on Firm Performance: Evidence from Korea

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I. Motivation

1. Research and development (R&D) investment is considered as one of the most important factors for enhancing technological progress and thus economic growth (Romer, 1990; Grossman & Helpman, 1991; Aghion & Howitt, 1992; Capron & Potterie, 2004; Wang et al. 2007)

2. Absent of government intervention, R&D would be under- invested, which is socially sub-optimal, because

- Positive externalities due to incomplete appropriability of the results (Nelson, 1959; Arrow, 1962)
- Expected social rate of returns to R&D investment exceeds the private rate of returns (Leyden and Link, 1991; David et al. 2000)
- In particular, SMEs have high default risk and high capital costs

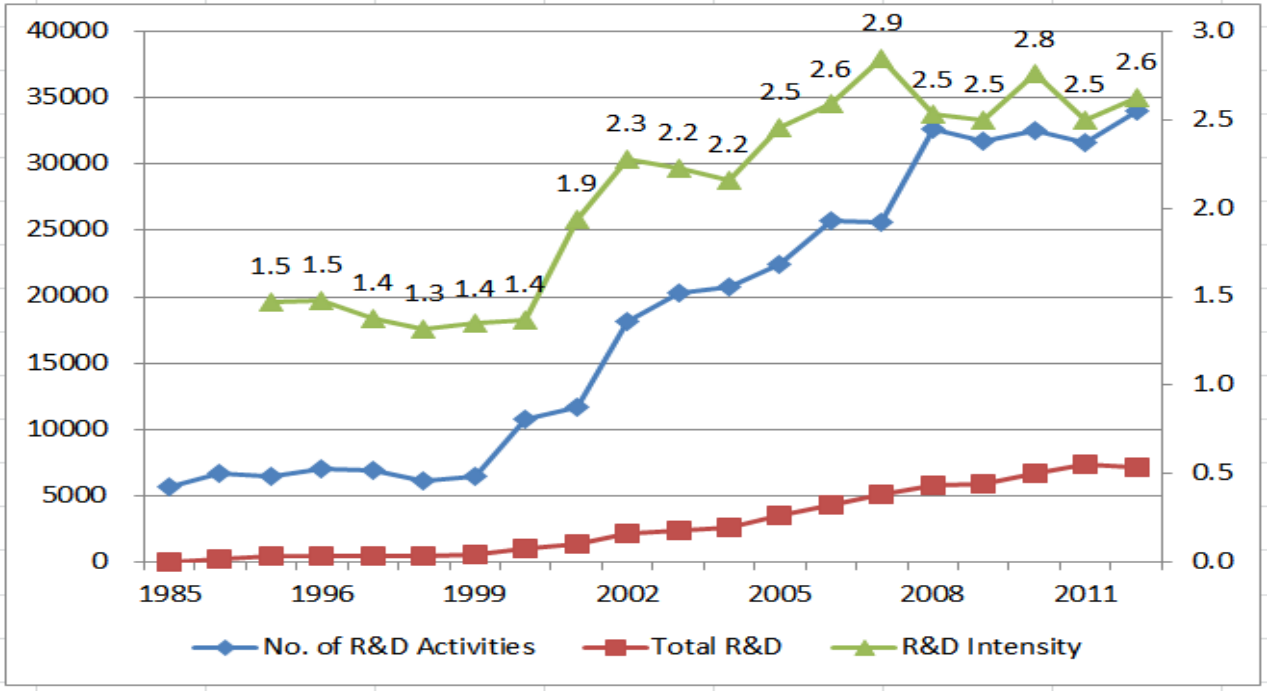
$\Rightarrow$ The central rationale for government R&D promotion policy such as subsidy is to correct this type of market failure.

$\Rightarrow$ In Korea there are expectations that the government R&D subsidy might also foster entrepreneurial activities and economic growth.

I. Motivation

- The amount of Korea's R&D expenditure is one of the highest in the world. The share of R&D expenditure to GDP was ranked second in the world in 2012.
- However, in Figure 1, the amount of R&D expenditure by SMEs was so low in 1985 when the government just started to exercise R&D promotion policy.
- Later, the total amount of R&D expenditure by SMEs increased significantly during 1985–1996 and then again from 1999 to 2007. It is notable that both periods coincide with active public R&D promotion policy such as government R&D subsidy.

<Figure 1> R&D Expenditure of SMEs in Manufacturing Sectors
(Unit: Billion Korean Won, 1,000 Korean Won is equivalent to about 1 US dollar, %)



II. Purpose of Study

Types of Government R&D promotion policy to SMEs

1) *Government subsidy to SMEs*
2) Tax incentives: tax credit & tax exemption
3) Directly funded government R&D project
4) Financial loan to SMEs with low interest rate

We focus on *(1) government R&D subsidy* in this study.

- The issue of whether public R&D spending or government subsidy is complementary and additional to private spending or it substitutes for and tends to crowd out private R&D has been discussed in many prior studies.
- However, studies about how government R&D subsidies affect private companies in terms of their productivity are relatively hard to find. Furthermore, to the best of our knowledge, no prior studies have addressed the impact of the public R&D subsidies on the performance of Korean SMEs by using actual subsidy data provided by Korean government.
- This paper fills this gap and contributes to the literature by empirically investigating the productivity effect of government R&D subsidy with the help of a unique panel data set on public R&D subsidies for Korean manufacturing SMEs (listed and non-listed).

III. Model Specification

- Cobb-Douglas production function is given as ,

$$Q = AK^{\beta_1} L^{\beta_2}$$

- Total factor productivity *(A)* is assumed to depend on firm age *(Age),* private R&D investment *(R&D),* and education and job training expenses for employees *(Edu)* in the Cobb-Douglas function form:

(1) $$A = C(R\,\&\,D)^{\gamma_1+\gamma_2 D}(Edu)^{\beta_3}(Age)^{\beta_4}\,.$$

➢ If policy parameter $\gamma_2 > 0$ crowding-in effect of government R&D subsidy *(D)* on private R&D investment can be realized, which can have positive effect on productivity
(where, *D* =1 if SME get government subsidy, 0 otherwise)

III. Model Specification

- Substituting TFP, equation (1) into the Cobb-Douglas production function
- then Dividing both sides of the production function by labor (L) and taking logarithms

$$\ln(Q/L)_{i,t} = \beta_0 + \gamma_1 \ln(R\&D/L)_{i,t} + \gamma_2 \mathrm{D}_{i,t} \times \ln(R\&D/L)_{i,t} + \beta_1 \ln(K/L)_{i,t} + \alpha \ln L_{i,t} + \beta_3 \ln(Edu/L)_{i,t} + \beta_4 \ln(Age)_i$$

$$(i = 1, 2, \cdots, N \quad t = 1, 2, \cdots, T)$$

where $\beta_0 = \ln(\mathrm{C})$, and $\alpha = (\gamma_1 + \gamma_2 + \beta_1 + \beta_2 + \beta_3 - 1)$

III. Model Specification

- Considering Lach (2002) condition for counterfactual outcome, dynamic nature of productivity, industry and time(*Year*) effect

- Final model to estimate is:

$$\ln(Q/L)_{i,t} = \beta_0 + \alpha \ln L_{i,t} + \gamma_1 \ln(R\&D/L)_{i,t} + \gamma_2 (D_{i,t} \times \ln(R\&D/L)_{i,t})$$
$$+ \beta_1 \ln(K/L)_{i,t} + \beta_3 \ln(Edu/L)_{i,t} + \beta_4 \ln(Age)_i$$
$$+ \theta \ln(Q/L)_{i,t-1} + \sum_k \delta_k Industry_k + \sum_j \tau_j Year_j + \varepsilon_{i,t}$$

IV. Estimation Strategies

1. Control for endogeneity (simultaneous bias) of government R&D subsidy

- In 1st stage, get predicted values of government subsidy from logit model
- in 2nd stage, the predicted values are included as a independent variable in the DPD productivity model

2. Control for endogeneity (simultaneous bias) of private R&D investment

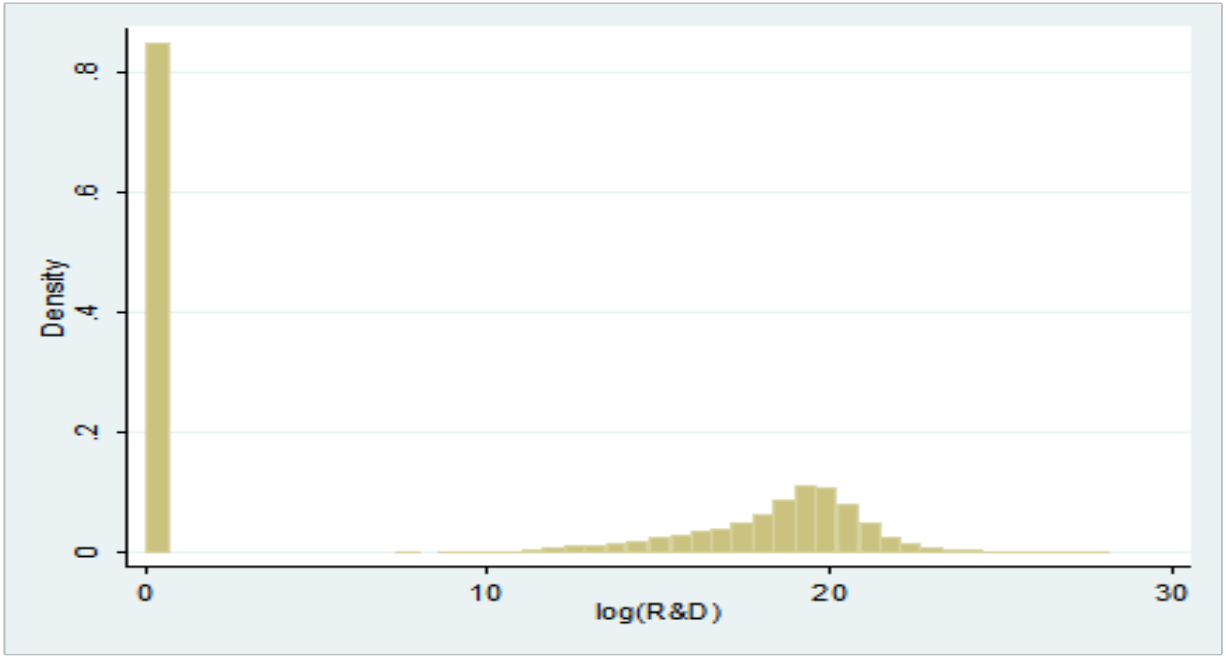
- in the 1st stage, use Tobit Model for private R&D to get expected value (distribution of private R&D investment: truncated at zero value, Figure 2)
- In the 2nd stage, use the expected value of private R&D

3. Reflect heterogeneity of firms and dynamic nature of productivity

- use GMM estimation on DPD Model (Arellano and Bond, 1991, Blundell and Bond, 1998; Arellano and Bover, 1995) in 2nd stage

IV. Estimation Strategies

<Figure 2> Distribution of private R&D investment: truncated at zero value



V. Data

The panel data to estimate the model is constructed by merging

* Financial data of the Korean manufacturing firms (National Information and Credit Evaluation, (NICE))

and

* Government R&D subsidy data (Small and Medium Business Administration (SMBA))

V. Data

R&D subsidy recipients by year

Year	No. of Firms w/o Subsidy	No. of Firms w/ Subsidy	Total No. of Firms
2000	3,932	143	4,075
2001	4,256	174	4,430
2002	4,565	172	4,737
2003	4,883	204	5,087
2004	5,189	231	5,420
2005	5,633	230	5,863
2006	6,166	258	6,424
2007	6,081	274	6,355
Total	40,705	1,686	42,391

VI. Variables

Variables	Definition/Description
VA	Value added = (operating surplus + labor costs + interest expenses + taxes & dues + depreciation & amortization). (definition from Korean Central Bank)
Ln(Q/L)	Dependent variable: Value-added productivity = Ln(VA/L)
Ln(K/L)	Capital Intensity = Ln(Fixed asset of the firm per employee)
Ln(L)	Ln(Number of employees)
Ln(Edu/L)	Ln(Education and job training expenses per employee)
Sales	Firm's total sales
R&D	R&D expenses = ordinary development expenses + ordinary research and development expenses + amortization of research and development expenses + changes of research and development expenses
Ln(R&D/L)	Ln(R&D/L)
Subsidy	Government financial subsidy for new technology development and technology transfer
D	D=1 if the firm received government R&D subsidy; Otherwise, D=0.
Ln(Age)	Firm age; Ln(2008-founding year)
Industry	A dummy variable; take the value 1 if the SME belongs to k industry and 0 otherwise,
Year	A dummy variable for a specific year

VII. Estimation Results

Descriptive statistics for all sample and DID Sample (million Won)

	Full Sample			DID Sample		
	Large	**SMEs**	**t-value**	**Large**	**SMEs**	**t-value**
Gov R&D subsidy	1.64	3.68	6.25**	1.42	2.77	4.70**
Private R&D	6,150	1,710	-23.03**	6,160	1,710	-22.93**
VA	70,300	3,210	-60.08**	70,400	3,220	-59.76**
Sales	735,000	30,200	-47.05**	736,000	30,300	-46.81**
No. of Employees	1,394.3	79.77	-62.66**	1,395.4	80.09	-62.31**

VII. Estimation Results

Table 1. Effects of R&D subsidies on static labor productivity: traditional RE & FE Model

Variables	*Pooled OLS*	*RE*	*FE*
Ln(K/L)	0.151***	0.145***	0.151***
	(0.003)	(0.005)	(0.005)
Ln(L)	-0.216***	-0.285***	-0.300***
	(0.004)	(0.007)	(0.006)
Ln(R&D/L)	0.012***	0.013***	0.015***
	(0.000)	(0.000)	(0.000)
Ln(R&D/L)*D	-0.003	-0.001	0.000
	(0.002)	(0.001)	(0.002)
Ln(Age)	0.032***	0.075***	
	(0.007)	(0.012)	
Year Dummy	Yes	Yes	Yes
Industry Dummy	Yes	Yes	NA
$\overline{R}^2$	0.0169	0.198	0.192
H_0: No Hetero		18260.1***	5.52***
No. of Obs	39,084	39,084	39,084

VII. Estimation Results

Table 2. Effects of R&D subsidies on labor productivity: 2 Stage Model

Variables	*2 Stage-RE*	*Tobit/Logit-RE*
Ln(K/L)	0.007	0.066***
	(0.095)	(0.003)
Ln(L)	-0.362***	-0.311***
	(0.115)	(0.007)
E(Ln(R&D/L))	0.324***	0.181***
	(0.082)	(0.010)
E(Ln(R&D/L))*E(D)	-7.096***	0.029***
	(1.816)	(0.002)
Ln(Age)	-0.366*	-0.043***
	(0.189)	(0.006)
$Ln(VA/L)_{t-1}$		0.537***
		(0.005)
Year Dummy	Yes	Yes
Industry Dummy	Yes	Yes
$\bar{R}^2$	0.001	0.517
No. of Obs	30,078	30,078

VII. Estimation Results

Table 3. Effects of R&D subsidies on dynamic labor productivity: Tobit/Logit-GMM Model

Variables	*Tobit/logit-GMM*
Ln(K/L)	0.181***
	(0.008)
Ln(L)	-0.471***
	(0.011)
Ln(Edu/L)	0.021***
	(0.001)
$Ln(VA/L)_{t-1}$	0.348***
	(0.011)
E(Ln(R&D/L))	0.115***
	(0.016)
E(Ln(R&D/L))*E(D)	0.030***
	(0.004)
Year Dummy	Yes
Industry Dummy	No
Wald Chi	4981.1***
No. of Obs	30,078

VIII. Conclusion

- Our empirical results point in one clear direction:

the public subsidy stimulates private R&D investment in SMEs thus affecting productivity and firm performance positively.
Several possible explanations for this positive effect have been offered including cost sharing, risk sharing, and the inducement of external investment through the provision of qualitative information to investors to facilitate decision making.

- Our empirical findings provide at least partial support to the Korean government R&D promotion policy for SMEs through subsidy.

In the absence of government policy intervention, the R&D investment in Korean SMEs could get to a socially suboptimal level.
Such subsidies seem to enhance firm productivity indirectly through stimulating private R&D investment and thus become a potential driver of economic growth.

- It is our conjexture that by stimulating corporate R&D investment and enhancing productivity the government measures have also contributed to fostering entrepreneurial activity in knowledge-intensive manufacturing fields.

The next step will be to empirically show if, how, and why this might have happened.