THE IMPACT OF GOVERNMENT R&D SUBSIDIES ON SMEs IN KOREA

DO GOVERNMENT R&D SUBSIDIES MAKE SMEs MORE COMPETITIVE IN THE MARKET?

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By

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Thesis Advisor: Andrew S. Wise, Ph.D.

ABSTRACT

Assessing the Korea Technology Innovation Program for SMEs (KTIPS), which plays the biggest role in offering public money to SMEs in Korea, this paper examine the effects of the South Korean government R&D subsides on SMEs’ competitiveness. Since competitiveness of SMEs can be measured by sales growth, this paper studies the differences in sales growth between government R&D subsidy awardees and non-awardees during 2006–2008. The results do not support that government R&D subsidies awarded in 2006 have a statistically significant impact on SMEs’ sales growth between 2006 and 2008. However, the results suggest that younger companies, whose ages are not more than 3 years, may benefit from the subsidies.
ACKNOWLEDGEMENTS

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Last, but far from least, I would like to give special thanks to my wife, Suna Hwang and my daughter, Hyunju, for putting up with me during the long process of writing this paper.
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I. Introduction

This paper tries to answer the question of whether the South Korean government subsides to Small and Medium Enterprises (SMEs) to promote research and development (R&D) activities have a significant effect. As in other industrialized countries, Korean SMEs, generally defined as independent firms having fewer than 500 employees, have been a pillar of the Korean economy. According to Korean government statistics (2007), they account for 99 percent of all enterprises and 88 percent of all employees in Korea. A high portion of manufacturing comes from SMEs and the Korean economy depends heavily on the technological innovation of its SMEs in this area.

The Organization for Economic Cooperation and Development (OECD) also has emphasized that achieving technological innovation by way of R&D activities determines a country’s global competitiveness. Moreover, technology innovation is a major factor in achieving sustainable economic growth. As if reflecting this global trend, there have been increasing investments in R&D throughout OECD countries. All OECD countries are currently operating government-funded R&D programs to
stimulate innovation (Klette et al., 2000). Accordingly, government spending in OECD countries has accounted for a large portion of the R&D growth.¹

Korea is no exception to this trend. Its public sector R&D expenditure has increased every year. Between 1996 and 2006, it rose from $2.6 billion to $6.0 billion. Through its Small & Medium Business Administration (SMBA) established in 1996, the Korean government has offered the R&D grants to SMEs and has made the promotion of technologically innovative SMEs one of its most important policy initiatives.

However, as the government subsidies have grown larger, questions have arisen about their effectiveness. Some critics argue that the subsidies did not help SMEs become more competitive; rather, they helped some alleged “vampire” SMEs extend their lives, consequently ruining the healthy business environment for other SMEs.²

This paper focuses on the question of whether the government subsides for SMEs’ R&D had a positive impact on SMEs’ competitiveness. Among these R&D subsidy programs, the Korea Technology Innovation Program for SMEs (KTIPS) has played the biggest role in offering public money to SMEs. Thus, an assessment of the KTIPS will give a reasonable estimation of the overall impact of government R&D

¹ The GDP share of federal government R&D expenditures in the U.S. was raised from 0.68% ($66 billion) to 0.74% ($84 billion) between 2000 and 2006 (National Science Foundation, 2007).

² The Chosun Ilbo, one of the major newspapers in South Korea, ran the story that the Korean economy suffered from such companies under the headline “Vampire companies: traps for the Korean economy” (2005.1.26).
subsidies on SMEs. Since competitiveness of SMEs in the market can be measured by sales increase, this paper studies the differences in sales increases between SMEs which were accepted by the KTIPS and SMEs which were denied.

The paper is organized as follows: In Section II, I briefly discuss the related literature dealing especially with the two rationales for government intervention to private R&D investment. Section II also includes a discussion of the development of my hypotheses. Features of the KTIPS are discussed in Section III. The construction of the data set and methodology are discussed in Section IV. The analysis and results are discussed in Section V. And Section VI discusses conclusions, policy implications, and implications for further research. The paper aims at contributing to further discussion of effectiveness and efficiency of all government R&D subsidies, and to providing a method of evaluating that effectiveness.
II. The R&D Subsidization of Small and Medium Enterprises

1. Theoretical Background and Literature Review

The economics literature suggests three reasons for governments to intervene in SMEs’ R&D activities: positive spillover effects, compensation for asymmetric information, and SMEs’ special contribution to economic development. The arguments for government action regarding Korean R&D activities are no exception.

First, spillover effects are externalities of economic activities affecting those not directly involved. Nelson (1959) and Arrow (1962) argue that R&D has positive spillover effects; in other words, social returns for R&D will be larger than private returns. For example, new inventions and innovations can benefit competitors that quickly imitate and improve them, or can make consumers better off by providing the new products. Several results of empirical research support the presence of these R&D spillovers (Griliches, 1992, 1998; Jaffe, 1996).

However, because, as Nelson and Arrow argue, the inventive activity like R&D has an inherent characteristic of public goods, the private R&D investment is likely to be lower than the amount that is optimal for the society. A large theoretical and empirical literature has argued that companies lack the motivation to make R&D investment according to the point of view of society (Hall 2002a). Furthermore, other
works (Jewkes et al., 1958; Mansfield et al., 1997) indicate that small companies are more affected by spillover problems than big ones because they lack the ability to defend their intellectual property or to extract most of the rents in the product market. That is one reason that proponents of this policy urge the government to intervene and compensate SMEs for the gap between the private and social returns.

A second rationale for government to intervene in private R&D investment focuses on the information gaps between companies and potential investors. In general, companies engaging in R&D have better information about the economic potential of their R&D projects than prospective investors. Accordingly, the asymmetrical information problem can occur and thus the investors will under-invest in the R&D project (Akerlof, 1970).

Because of these informational asymmetries, financial economists argue that there are opportunities for government intervention. For example, venture capital companies are believed to assess companies accurately before investing and then monitoring them afterwards. But, according to Lerner (1999), their proportion in market investment is too limited to address these informational asymmetries. In addition, a few empirical studies suggest that smaller companies’ investment is more severely affected by financing constraints (Carpenter and Peterson, 2002b). Thus, government intervention can be rationalized by these facts.
Third, if SMEs make special contributions to economic development, government R&D subsidies to SMEs can be justified. According to Gregory et al. (2002), SMEs in Korea have played a significant role in the contemporary Korean economy; in particular, since the financial and economic crisis in 1997, SMEs have made remarkable contributions to the recovery of the economy.

However, even though market failure is identified and SMEs’ contribution to economy is documented, there are still problems. A number of political economy and public finance studies have warned that the interest groups or politicians who want to maximize their own benefits can distort government subsidy policies. The theory of regulatory capture indicates that government subsidies created to act in the public interest instead will act in favor of the groups that dominate the political process (Stigler, 1971; Peltzman, 1976; Becker, 1983).

These distortions can show up in different forms. One possible way is to transfer government R&D subsidies into direct increases in profits (Eisinger, 1988); another way is that officials who implement R&D subsidies can choose companies based only on their likely success, without considering if the subsidies are needed (Cohen and Noll, 1991; Wallsten, 1996).
And yet, the literature review generally supports the value of well-crafted government programs to support R&D, particularly for SMEs. I now develop hypotheses to examine whether Korean R&D support has been well-crafted.

2. Hypotheses Development

Based on the arguments presented above, I have developed three hypotheses.

_Hypothesis 1. Government R&D subsidies have a significant positive effect on sales growth._

If the government R&D subsidies solve the spillover problem and are not affected by other external factors such as political pressure, subsidy awardees should perform at least slightly better than non-awardees (Lerner, 1999). Accordingly, it is reasonable to think that better performance will be connected to annual sales growth. Therefore, the subsidy awardees should show larger sales growth than non-awardees. Ultimately sales growth should translate into economic growth, which provides general welfare benefits to Korean citizens.
Hypothesis 2. Among the SMEs which had government R&D subsidies, the amount of subsidy is positively related to sales growth.

If Hypothesis 1 is correct, there should be a positive relationship between the amount of subsidy and the effect on the firm. However, as Lerner (1999) and Meuleman and Maeseneire (2008) argue, given presence of certification effects, which make it easier for a firm to access to external financing by being certified as a grantee of the government, the amount of subsidy may not show an additional positive effect on the sales growth of awardees.

Hypothesis 2b. Among the SMEs which have government R&D subsidies, sales growth varies by industrial sector.

According to Gregory et al. (2002), Korean industry has moved towards a knowledge-based economy. Considering this trend, the effect of the R&D subsidies should vary according to the industry. For example, information technology or the electronic industries may show better performance than a traditional manufacturing industry such as the machinery industry.
III. Features of the Korea Technology Innovation Program for SMEs (KTIPS)

The KTIPS was initiated by the SMBA in 1997 under the Act of Enhancing Technology Innovation for SMEs. The ultimate goal of this program is to improve the competitiveness of SMEs and to achieve sustainable economic growth by supporting SMEs’ R&D activities. According to the Korea National Assembly Budget Office (KNABO), from 1997 to 2009, the KTIPS provided $1,447 million to 19,475 SMEs. As of 2009, the KTIPS accounts for 56.2% ($238.2 million) of the total SMBA R&D budget. Table 1 shows the recent trend of KTIPS’s annual budget and its success rate.3

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual budget (million $)</td>
<td>117.4</td>
<td>128.5</td>
<td>145.1</td>
<td>181.3</td>
</tr>
<tr>
<td>Success Rate</td>
<td>92.0%</td>
<td>94.3%</td>
<td>94.5%</td>
<td>94.5%</td>
</tr>
</tbody>
</table>

(Source: KNABO, Assessment of the KTIPS, May 2009)

The KTIPS mostly supports the R&D projects that can be developed and commercialized within 2 years. Moreover, to raise the possibility of the R&D project

---

3 The success rate does not refer to business success, but it is determined by the KEIT; KEIT assesses the progress and performance of the R&D project.
success and minimize the moral hazard of awardees, the KTIPS support cannot exceed 75% of the total budget of the R&D project; awardees are required to provide the rest.4

In selecting awardees, the Korean Evaluation Institute of Industrial Technology (KIET), which is a government-affiliated organization and manages government-supported R&D projects, assesses applicants in three phases – a paper assessment in the first phase, an on-site and management assessment in the second phase, and a feasibility assessment in the last phase.

In evaluating the performance of the KTIPS, the KNABO (2009) concluded that the program has a positive and significant effect in raising the R&D expenditures of KTIPS awardees, compared to non-awardees. However, the KNABO could not determine whether the KTIPS also has a significant effect on awardees’ competitiveness or sales growth.

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4 A company awarded a government R&D grant and insulated from risk of losing its own money may have an incentive to act inappropriately (from the view point of the government), because the government usually cannot completely monitor the company.
IV. The Data and Analytic Model

1. The Data and Variables

This paper examines results of the KTIPS program during 2006–2008. The basic data were created by KEIT and consist of panel datasets of 4,451 Korean SMEs that applied to KTIPS in 2006. Among these SMEs, the number of awardees was 1,779. But, because most of the SMEs did not report their sales and the number employees over a 3-year period (2006-2008), the Korea Enterprise Data Co., Ltd. helped to fill out the missing data. As a result, the sample selected for the present study is comprised of 684 SMEs, including 341 awardees. All firms in the sample were in the manufacturing sector. All were independently owned, for-profit businesses, and all retained these characteristics up to the end of 2008. Table 2, 3, and 4 report the size, industry distribution, and age of the sample firms.

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Mean Age in years (2006)</th>
<th>Mean Sales (Million $)</th>
<th>Mean Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awardees</td>
<td>341</td>
<td>9.2</td>
<td>11.5</td>
<td>13.1</td>
</tr>
<tr>
<td>Non-Awardees</td>
<td>343</td>
<td>9.4</td>
<td>11.7</td>
<td>13.1</td>
</tr>
<tr>
<td>Total</td>
<td>684</td>
<td>9.3</td>
<td>11.6</td>
<td>13.1</td>
</tr>
</tbody>
</table>

Table 2: Sample firms’ statistics
Table 3: Distribution of sample firms by industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>Awardees</th>
<th>Non-Awardees</th>
<th>Non-Awardees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Machinery</td>
<td>134</td>
<td>133</td>
<td>267</td>
</tr>
<tr>
<td>Electric and Electronic</td>
<td>85</td>
<td>100</td>
<td>185</td>
</tr>
<tr>
<td>Fabrics and Chemistry</td>
<td>62</td>
<td>62</td>
<td>124</td>
</tr>
<tr>
<td>Information Technology</td>
<td>54</td>
<td>44</td>
<td>98</td>
</tr>
<tr>
<td>Other industry</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>341</td>
<td>343</td>
<td>684</td>
</tr>
</tbody>
</table>

Table 4: Distribution of sample firms by age

<table>
<thead>
<tr>
<th>Age in years</th>
<th>0-3</th>
<th>3-5</th>
<th>5-10</th>
<th>10-15</th>
<th>15-20</th>
<th>20-25</th>
<th>25-30</th>
<th>30-35</th>
<th>&gt;35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awardees</td>
<td>43</td>
<td>52</td>
<td>130</td>
<td>60</td>
<td>32</td>
<td>10</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Non-Awardees</td>
<td>35</td>
<td>64</td>
<td>132</td>
<td>54</td>
<td>27</td>
<td>15</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td>116</td>
<td>262</td>
<td>114</td>
<td>59</td>
<td>25</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 5 shows the variables used in this analysis. The dependent variable, CLSALES, normally defined as sales growth, is the difference between the log of sales in 2008 and the log of sales in 2006. Sales growth can be one of the reasonable metrics of R&D performance and a firm’s competitiveness in the market. As Nagpaul (1995) points out, the concept of research performance is essentially multi-dimensional, so it
cannot be measured by a single universal standard. In assessing the effect of
government R&D subsidies, therefore, measuring sales growth is only the first step in
measuring the performance of the specified program. However, as Lerner (1999)
argues, in reality it is very difficult to identify appropriate measure of R&D program
performance. Thus, he used alternative measures of performance: sales and
employment growth of companies that participated in the R&D program. For the same
reason, I use sales growth as a proxy for a firm’s competitiveness in the market.

I used one control variable, CLEMP, or employment growth between 2006 and
2008 in log terms, as a proxy for firm size. Many researchers have shown the tight
relationship between firm size and innovation, though the direction and magnitude of
the relationship varies among researchers (see, for example, Evans, 1987a; Jang, 2008).
Thus, I controlled the size effect using this variable.

I also used other control variables, LAGE and LAGESQ, which represent the
log of firm age and squared log of firm age respectively. Many researchers have argued
that firm age has a significant impact on the firm growth, so I tried to control the
impact of firm age (see, for example, Stuart, 2000; Kim and Robert, 2009).

In order to analyze the impact of government R&D subsidies on difference in
sales, I used a major binary variable of interest, GRANT. “One” indicates companies
applying to the KTIPS that were selected as awardees in 2006, and “zero” indicates
companies applying in 2006 but denied a grant. Also, I used another variable of interest, LGRANTAMT, which represents the amount of government R&D grants in the form of a natural log, to analyze the impact of the R&D grant amount on sales growth among R&D awardees.

Finally, I used five industrial sector dummy variables: MACHINERY, ELECTRONIC, IT, CHEMISTRY, and OTHER, to determine the effect of subsidy variations across industries. This industrial classification follows the Standard Industrial Classification of the Ministry of Commerce, Industry, and Energy in Korea.

| Table 5: Variables and their description |
|--------------------------------------|--------------------------------------------------|
| Dependent Variable                  | CLSALES                                          |
|                                      | Sales growth between 2006 and 2008               |
| Independent Variable                |                                                  |
| GRANT                               | Government grant (dummy)                        |
| LGRANTAMT                           | Logged amounts of the government grant           |
| CLEMP                               | Employment growth between 2006 and 2008         |
| LAGE                                | Log of firm age                                 |
| LAGESQ                              | Squared log of firm age                         |
| MACHINERY                           | Machinery industry (dummy)                      |
| ELECTRONIC                          | Electric and Electronic industry (dummy)         |
| IT                                  | Information Technology industry (dummy)          |
| CHEMISTRY                           | Fabrics and Chemistry industry (dummy)           |
| OTHER                               | Other industry (dummy)                          |
2. The Analytical Model

The baseline specification for the estimation depends on the relationship between sales growth and employment growth. Sales growth and employment growth are the two most widely used growth indicators; yet, sales growth and employment growth are not interchangeable measures. Rather, they are related (Chandler, 2009). This paper adopts an extended “first-difference” model to relate sales growth and employment growth.

On the other hand, many studies have shown that firm age is one of the important determinants of sales growth (Jang 2008; Huynh and Petrunia, 2009; Park et al., 2009). In line with Huynh and Petrunia (2009), I use a quadratic function of the log form of age. Therefore, the baseline specification for the estimation is:

$$\Delta \log(Sales)_{it} = \delta_0 + \delta_1 \Delta \log(Employment)_{it} + \delta_2 \log(age) + \delta_3 [\log(age)]^2 + u_{it} \quad (1)$$

where subscripts $i$ and $t$ are the firm and time indexes, respectively. The term $u_{it}$ means an idiosyncratic error.

---

5 As Huynh and Petrunia (2009) argue, an alternative specification uses age dummies with little difference in the fundamental findings.
To investigate the relationship between sales growth and the government R&D subsidies, the amount of the subsidies, and the industrial diversification, the sales growth function in equation (1) is extended to include variable for a grant dummy, grant amount, and sector dummies.

\[
\Delta \log(\text{Sales})_{it} = \beta_0 + \beta_1 \Delta \log(\text{Employment})_{it} + \beta_2 \log(\text{age}) + \beta_3 [\log(\text{age})]^2 + \beta_4 \text{Grant} + \beta_5 \text{Electronic} + \beta_6 \text{IT} + \beta_7 \text{Chemistry} + \beta_8 \text{Other} + u_{it} \quad (2)
\]

\[
\Delta \log(\text{Sales})_{it} = \beta_0 + \beta_1 \Delta \log(\text{Employment})_{it} + \beta_2 \log(\text{age}) + \beta_3 [\log(\text{age})]^2 + \beta_4 \log(\text{Grantamt}) + \beta_5 \text{Electronic} + \beta_6 \text{IT} + \beta_7 \text{Chemistry} + \beta_8 \text{Other} + u_{it} \quad (3)
\]

\[
\Delta \log(\text{Sales})_{it} = \beta_0 + \beta_1 \Delta \log(\text{Employment})_{it} + \beta_2 \log(\text{age}) + \beta_3 [\log(\text{age})]^2 + \beta_4 \text{Electronic} + \beta_5 \text{IT} + \beta_6 \text{Chemistry} + \beta_7 \text{Other} + u_{it} \quad (4)
\]

The equation (2) is used to test the hypothesis 1. The equations (3) and (4) are applied to the government R&D awardees to test hypothesis 2 and 2a.
V. Results and Discussion of the Analysis

1. Overall effect of government R&D subsidies

First, I tested for the presence of heteroskedasticity, because, while the sample size is large enough to test the models, the dataset used in this study represents only 15.4% (684 out of 4,451) of the original dataset. The test result showed the presence of heteroskedasticity in the models.\(^6\) So, in this study, I test all models using heteroskedasticity-robust standard errors, which makes the model valid whether or not the errors have constant variance.

Table 6 presents the overall effect of government R&D subsidies on SMEs’ sales growth. The regression result indicates that government R&D subsidies have no statistically significant effect on SMEs’ sales growth. But, this result may be influenced by the endogeneity between sales and employment growth. In order to check for endogeneity, I ran an Instrumental Variables (IV) regression, using the level of 2006 employment as an instrument for the employment growth. This variable functioned well as an instrument, but did not change the results; the variable of interest,\(^6\)

---

\(^6\) The Breusch-Pagan/ Cook-Weisberg test for heteroskedasticity of the overall regression model does not reject the null hypothesis of constant variance, with a p-value of 0.7997.
grant, is positive but still statistically insignificant.\textsuperscript{7} Thus, endogeneity is not a crucial issue for the regression model.

Table 6: Overall regression of sales growth

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient (Robust Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (Machinery)</td>
<td>0.404 (0.065) ***</td>
</tr>
<tr>
<td>Employment Growth between 2006 and 2008</td>
<td>0.342 (0.058) ***</td>
</tr>
<tr>
<td>Log (Age)</td>
<td>-0.167 (0.049) ***</td>
</tr>
<tr>
<td>([\text{Log (Age)}]^2)</td>
<td>0.034 (0.013) ***</td>
</tr>
<tr>
<td>R&amp;D Grant dummy</td>
<td>0.017 (0.038)</td>
</tr>
<tr>
<td>Electronic sector dummy</td>
<td>-0.042 (0.053)</td>
</tr>
<tr>
<td>Fabrics &amp; Chemistry sector dummy</td>
<td>-0.068 (0.046)</td>
</tr>
<tr>
<td>IT sector dummy</td>
<td>-0.122 (0.062) **</td>
</tr>
<tr>
<td>Other sector dummy</td>
<td>-0.004 (0.112)</td>
</tr>
</tbody>
</table>

\(F\)-statistic \hspace{1em} 6.72***  
\(R^2\) \hspace{1em} 0.155  
Number of observations \hspace{1em} 684

A two-tailed test, *** Significant at 99%; ** Significant at 95%; * Significant at 90%

However, the result for start-up companies is more encouraging.\textsuperscript{8} Table 7 indicates that in the case of young companies, whose age is not more than 3 years, the

\textsuperscript{7} The IV (2SLS) estimation shows that the level of 2006 employment functions well as an instrument, but the coefficient of the variable of interest, grant, still shows statistical insignificance with a p-value of 0.841. Additionally, a difference-in-Sargan (C-statistic) test performed using the same instrument does not show endogeneity.

\textsuperscript{8} In Korea, under the SMEs Establishment Promotion Act, “start-up companies” whose ages are not more than 3 years are eligible for various tax exemptions and involvement in other government programs.
government R&D grants have a positive and significant effect on the awardees.

Moreover, the magnitude of the grant effect on sales growth is more than 15 times greater than the effect on SMEs overall. And yet, this result is vulnerable, considering the low explanatory power of the $R^2$ and $F$-statistic.

Table 7: Regression result for sales growth of young firms

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient (Robust Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (Machinery)</td>
<td>0.335 (0.165) **</td>
</tr>
<tr>
<td>Employment Growth between 2006 and 2008</td>
<td>0.281 (0.187)</td>
</tr>
<tr>
<td>R&amp;D Grant dummy</td>
<td>0.292 (0.167) *</td>
</tr>
<tr>
<td>Electronic sector dummy</td>
<td>-0.092 (0.221)</td>
</tr>
<tr>
<td>Fabrics &amp; Chemistry sector dummy</td>
<td>-0.072 (0.168)</td>
</tr>
<tr>
<td>IT sector dummy</td>
<td>-0.158 (0.231)</td>
</tr>
<tr>
<td>Other sector dummy</td>
<td>-0.034 (0.344)</td>
</tr>
</tbody>
</table>

| $F$-statistic                           | 0.94                                |
| $R^2$                                   | 0.081                               |
| Number of observations                  | 78                                 |

A two-tailed test, *** Significant at 99%; ** Significant at 95%; * Significant at 90%

On the other hand, the regression results in Table 6 indicate that both employment growth and firm age play a role as key determinants of SMEs’ sales growth. The employment growth shows a positive significant effect on the sales growth. The coefficient of the employment growth implies a one percent increase in the employment growth leads to a 0.342 percent increase in the sales growth, holding
other variables constant. Although this elasticity is at odds with the result of previous studies which indicate a negative relationship between firm growth including sales growth and firm size (Evans 1987a, 1987b), it suggests the existence of strong correlation between sales growth and employment growth shown in the previous studies.

The firm age also shows a significant result. The impact of age on sales growth is non-monotonic because estimates on the linear and the quadratic term have the opposite sign. The negative coefficient on the linear term means that sales growth should fall with age in the early years of a firm’s life, while the positive coefficient on the quadratic term suggests sales growth eventually levels off and increases with age. The switch from a negative to a positive sales growth-age relationship occurs at the age of 11.7, holding all other variables constant. This quadratic curve implies that there can be a kind of “valley of death” that SMEs need to overcome in order to continue to grow, as researchers have argued (Osawa and Miyazaki, 2006).

Estimates of effects of R&D by major sector are mixed (Table 6). The machinery and IT sectors show a significant result, though average sales growth in the

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9 I extended specification of the regression to the cubic form of age, but the cubic term did not show statistically significant result (the p-value is 0.219). So, I followed the quadratic specification on the firm age as Huynh and Petrunia argue (2009).

10 Osawa and Miyazaki (2006) consider the “valley of death” as the period between product launch and when the business becomes successful.
IT sector is lower than in the machinery sector. The other sectors show no significant result.

2. Variations of subsidy effect with the amount of subsidies granted

Table 8 presents the model estimates of the effect of the amount of the government R&D subsidies on the sales growth of awardees. The results show that the amount of the subsidy has no significant effect on awardees’ sales growth.

Table 8: Impact of R&D subsidy amount on sales growth of R&D awardees

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient (Robust Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (Machinery)</td>
<td>0.305 (0.644)</td>
</tr>
<tr>
<td>Employment Growth between 2006 and 2008</td>
<td>0.300 (0.077) ***</td>
</tr>
<tr>
<td>Log (Age)</td>
<td>-0.205 (0.062) ***</td>
</tr>
<tr>
<td>Log (Age)^2</td>
<td>0.038 (0.017) **</td>
</tr>
<tr>
<td>R&amp;D Grant Amount – log of amount</td>
<td>0.017 (0.057)</td>
</tr>
<tr>
<td>Electronic sector dummy</td>
<td>-0.039 (0.073)</td>
</tr>
<tr>
<td>Fabrics &amp; Chemistry sector dummy</td>
<td>-0.085 (0.064)</td>
</tr>
<tr>
<td>IT sector dummy</td>
<td>-0.178 (0.087) **</td>
</tr>
<tr>
<td>Other sector dummy</td>
<td>-0.158 (0.146)</td>
</tr>
</tbody>
</table>

\[ F \text{-statistic} = 4.66^{***} \]
\[ R^2 = 0.180 \]

Number of observations 341

A two-tailed test, *** Significant at 99%; ** Significant at 95%; * Significant at 90%
Also, the employment growth, age, and sector dummies of R&D awardees show the same pattern as the previous model. But, the switch from a negative to a positive sales growth-age relationship occurs at the age of 14.8 – 3 years beyond the result in Table 6.

3. Variations of subsidy effect with industrial diversification

Table 9 presents the effect of the government R&D subsidies on the sales of awardees in various industrial sectors. The results show the same pattern as the previous models. The machinery and IT sector show a significant result; the machinery sector shows higher average sales growth than the IT sector. Other sectors show no significant results. The employment growth and age effect also show the same significant impact on awardees’ sales growth.
Table 9: Regression result for sales growth of R&D awardees

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient (Robust Standard Error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant (Machinery)</td>
<td>0.491 (0.086) ***</td>
</tr>
<tr>
<td>Employment Growth between 2006 and 2008</td>
<td>0.300 (0.077) ***</td>
</tr>
<tr>
<td>Log (Age)</td>
<td>-0.204 (0.062) ***</td>
</tr>
<tr>
<td>( [\text{Log (Age)}]^2 )</td>
<td>0.038 (0.017) **</td>
</tr>
<tr>
<td>Electronic sector dummy</td>
<td>-0.039 (0.073)</td>
</tr>
<tr>
<td>Fabrics &amp; Chemistry sector dummy</td>
<td>-0.085 (0.064)</td>
</tr>
<tr>
<td>IT sector dummy</td>
<td>-0.180 (0.087) **</td>
</tr>
<tr>
<td>Other sector dummy</td>
<td>-0.162 (0.147)</td>
</tr>
</tbody>
</table>

\( F \)-statistics 5.16***

\( R^2 \) 0.180

Number of observations 341

A two-tailed test, *** Significant at 99%; ** Significant at 95%; * Significant at 90%

4. Discussion of the results

Most of all, while conducting this study, I recognized a strong need for better data to monitor the success of the program. Even the government R&D awardees’ track records were not well established. Among 1,779 awardees, only 341 awardees’ records (19%) were available. The missing data might cause a number of significant biases in the regression results. One is the presence of heteroskedasticity in the model. Another is the omitted variables bias that I could not avoid because of the narrow spectrum of the data. A test for omitted variables also shows that the overall regression
model has omitted variables. In addition, as many researchers argue (Meuleman and Maeseneire, 2008; Jang and Chang, 2008; Park et al., 2009), other external financing, industrial networking, R&D intensity, and other factors also have a strong correlation with SMEs’ performance and competitiveness. So, to better estimate the impact of government R&D subsidies, variables like these should have been used in the regression models. Perhaps because these variables were not included, the analysis does not clearly support the hypotheses that the Korean SMEs are seeing a return from the government R&D grants in terms of economic growth or competitiveness in the market.

However, the scarcity of relevant statistics and restricted data access to the R&D projects suggests at least one precious policy implication: the Korean government should establish an R&D subsidy tracking system in which the government-affiliated agents like the KEIT or other external organizations act as watchdogs to record the progress of the R&D project for as long as 10 years or more after the projects are finished in order to estimate the long-run impact of the government R&D subsidies, especially considering the result of the age effect on SMEs’ sales growth. In addition, the R&D tracking system should include important information other than sales and employment growth, for example, the number of

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11 The Ramsey RESET test for the overall regression model of this study rejects the hypothesis that the model has no omitted variables, with a p-value of 0.0013.
researchers and patents registered, and external financing. Such a tracking system would eventually help to let people know if the government R&D programs work and improve the transparency of government R&D spending.

Second, this study does not cover long-term sales growth. Even if we accept the regression result despite the weakness of the model itself, the interpretation of the subsidy effect is limited only to a short-term period. However, the regression result suggesting the existence of a long-range “valley of death” should be taken into account. It implies that if the government sets up a long-term strategy for SMEs’ R&D programs, the result can turn out to be positive. In this regard, the Korean government should benchmark other R&D programs like the United States’ Small Business Innovation Research (SBIR) program, which has a long-run scheme for supporting SMEs’ R&D activities and three phases in its process of providing the government R&D grants.\footnote{According to the U.S. Small Business Administration, the SBIR program was established by the Small Business Innovation Act in 1982. The SBIR program was designed to encourage small business to develop new processes and products and to provide quality research in support of the many missions of the U.S. government. The program mandated that all federal agencies spending more than $100 million annually on external research set aside 1.25% of these funds for awards to small businesses. Its structure includes 3 phases in its process. Promising projects are awarded Phase I awards ($100,000 or smaller), which are intended to allow firms to determine the feasibility of their ideas. Approximately one-half of the Phase I awardees are then selected for the more substantial Phase II grants (at most $750,000). In Phase III, the awardees are expected to match external finances based on the market values.}

Third, based on the regression results showing that government R&D subsides may have a greater effect on start-up companies, and the fact that such companies find
it harder to fund their R&D projects than more established companies, the Korean government should focus a larger portion of subsidies on start-up companies. Some of that implies the government needs to limit subsidies for older companies.

Fourth, the regression results indicate that the machinery sector, where the Korean government has traditionally concentrated its R&D support, still shows higher average sales growth in response to R&D subsidies than the IT sector. This suggests that, despite the fact that the government has steeply increased its IT-related subsidies in recent decade in order to be the IT-leading nation, it should now expand the R&D subsidies in the IT sector.13

13 Also, the regression results suggest that Korea may get better value by investing more in the machinery sector. Maybe the aim of a leading IT nation is not the best policy for the Korean people.
VI. Conclusions

This paper empirically investigates the impact of the government R&D subsidies on SMEs. It finds, first, that government R&D subsidies awarded in 2006 show no statistically significant impact on SMEs’ sales growth between 2006 and 2008. However, the R&D subsidies for younger companies, whose ages are not more than 3 years, may make some contribution to sales growth, but this is less certain given the limited explanatory power of the model. Second, the employment growth has a significant positive impact on SMEs’ sales growth. Moreover, the age effect implies the existence of the “valley of death” that SMEs need to overcome in order to grow continuously. Third, the amount of government R&D subsidies also has no significant impact on the sales growth of subsidy awardees. Lastly, R&D subsidies have different impacts on sales growth across industries: the machinery sector shows a significantly higher average sales growth in response to an R&D grant than the information technology sector.

These findings do not clearly support the initial idea that the Korean people are seeing a return government R&D subsidies in terms of economic growth. This is at least partially because the data used in this study are so limited that I can neither cover long-run effects of the subsidies, nor consider other important factors of
competitiveness such as the number of patents, other external financing, and R&D
intensity. Yet the findings that young companies may benefit from the subsidies and
the effect of the subsidies varies according to sector suggest some important policy
implications regarding where the government should focus its resources. The study
also suggests that the Korean government should act immediately to build a better
R&D data system that can track the history and performance of R&D awardees.
References


http://gcoe.ier.hit-u.ac.jp/CAED/papers/id090_Huynh_Petrunia.pdf


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