DISCUSSION PAPER SERIES

IZA DP No. 7851

The Effect of Credit Guarantees on R&D Investment of SMEs in Korea

Almas Heshmati

December 2013

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

The Effect of Credit Guarantees on R&D Investment of SMEs in Korea

Almas Heshmati
Sogang University
and IZA

Discussion Paper No. 7851
December 2013

IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

IZA Discussion Paper No. 7851
December 2013

ABSTRACT

The Effect of Credit Guarantees on R&D Investment of SMEs in Korea

Korean government has invested significant amount of resources through credit guarantee funds to promote SMEs survival, performance and R&D investment. This study attempts to identify determinants of provision of credit guarantees and estimate their effects on firms R&D expenditures. The relationship between duration of credit and firm's survival and performance is also investigated. Account is made for heterogeneity by various characteristics of firms when looking at credit guarantee and in-house R&D investment relationships. This study results in identification of factors that enhances efficiency of funds and their effects on firms' R&D investment behavior. It enables feedback effects on the public funds selection of firms guaranteed. A number of policy measures are proposed to promote a better balance between public and private investments to reduce the risk of business failure.

JEL Classification: C13, D92, G28, L25, O32, O38

Keywords: Credit Guarantee, SMEs, public funds, R&D investment, firm performance, firm survival, Death Valley

Corresponding author:

Almas Heshmati
Department of Economics, Room K526
Sogang University
35 Baekbeom-ro
Mapo-gu, Seoul 121-742
Korea
E-mail: heshmati@sogang.ac.kr

1. INTRODUCTION

Despite the integral role of SME (Small and Medium Enterprises) in Korean economy, most SMEs were in financially difficult positions with circulation of the cash flow. Accordingly, the Korean government has been investing in funds to boost these SMEs' economic activities. However, the evaluation of governmental funds' performance has not been carried out effectively. In order to manage such funds effectively, comprehensive evaluation procedures are necessary to be performed and the resulting feedback information be provided to better select firms eligible for the future governmental funds. By analyzing the failure factors of firms, we identify factors determining the funds efficiency in the performance and its impacts on survival, performance and R&D investment of the firms.

Most of the previous studies dealing with the evaluation of governmental investments have considered the output performances only. For instance, the report from the SMBA (Small and Medium Business Administration in Korea, 2002) has shown the performance evaluation using an AHP (Analytical Hierarchy Process). With the same methodology, Yurdakula and Tansel (2004) proposed a credit evaluation model for the banks to determine the credibility of the manufacturing firms in an effort to measure their long-term profitability. Frei and Harker (1999) used AHP to measure the performance of the aggregate process of the banking industry. But these studies have not considered the effects of input factors. Some other studies (Banker et. al, 2004; Martinsons et. al, 1999; Milis and Mercken, 2004) have used BSC (Balanced Score Card) in order to evaluate the performance of the investments or projects. Kang et al. (2008) and Oh et al. (2009) used regression analysis and matching methods to evaluate the effects of credit guarantee on survival and performance of firms.

The results of the performance evaluation in the previous studies do not provide enough feedback information to predict the worthy credit recipients in future. In this study we analyze data from 45,749 Korean firms which requested credit guarantees from credit guarantee funds, during the period 2001 to 2004. We analyze the relationship between credit provision and firms R&D investment in several interrelated steps. First this study finds systematic heterogeneity by characteristics of recipients such as industrial sector, technology level, size groups, age, ownership and location of firms. Second, based on longitudinal data from technology-based start-ups we identify factors determining the level of credit guarantee and in-house R&D investment. In particular the emphasis is on the interaction between credit guarantee and in-house R&D investment and their impacts on survival and performance of SMEs. The results is used to suggest policy recommendations for targeting policy measures to promote a better balance between public and private investment components to reduce the need for credit guarantee and risk of business failure.

This study is organized as follows. Section 2 introduces an overview of the public funds invested in SMEs. In Section 3, we propose a research design. In Section 4, the proposed methodology is applied to evaluating credit supply to SME in Korea. Section 5 summarizes the results and provides suggestions for further research.

2. REVIEW OF R&D AND SME POLICIES

2.1 Public and private R&D policy

The development of equilibrium or neo-classical models of fiscal policy has, among other things, brought attention to the role of public investment as a productive input to private production[1]. Within these models, certain types of public investment, broadly referred to as infrastructure, are conjectured to raise the productivity of private capital and labor and so raises private investment. Arrow and Kurz (1970) studied public investment, the rate of return and optimal fiscal policy. Arping et al. (2010) compares credit guarantees versus co-funding in public initiatives to support entrepreneurs. Aschauer (1989a) discusses productivity of public expenditure while Aschauer (1989b) refers to this as the crowding in effect of public investment. In the later study which examines the response of private investment to changes in public investment, he finds quite strong evidence in support of long-run positive impact on private investment. He interprets this as evidence of a productive and complementary role for public investment. David et al. (2000) reviewed the econometric evidence on the complementarity or substitutability of public R&D for private R&D.

A useful framework for understanding how public R&D affects R&D funding decisions in the private sector is provided by an adaptation of a model of firm-level investment behavior. To our knowledge, such a framework was first employed for this purpose by Howe and McFetridge (1976). It postulates that, at each point in time, an array of potential R&D investment projects is available. The firm is assumed to rationally consider the expected cost and benefit streams for each project, in order to calculate its expected rate of return. Under certain conditions, these can be thought of as internal rates of return and therefore used by the firm in question to rank the associated projects in descending order of anticipated yield, thereby forming its marginal rate of return schedule.

The firm faces a marginal cost of capital schedule, which reflects the opportunity cost of investment funds at different levels of R&D investment. As the volume of R&D investment is increased the firm will have to move from financing projects with internally generated funds to

[1] Baxter and King (1993) elaborate with fiscal policy in general equilibrium. The equilibrium approach to fiscal policy is discussed at length in Aschauer (1988) and Barro (1989).

calling upon external (equity and debt) funding. This must be so even were it the case that all of the firm's R&D investment remained financed out of retained earnings; at the margin, expansion of the R&D investment budget would force the firm to turn to external financing for its tangible capital acquisitions.

2.2 Development of SME policy in Korea

There has been considerable change in the orientation of the Korean government policies with respect to SMEs over time. In the 1960s and early 1970s, in the pursuit of rapid economic development, and in the absence of market and other institutions capable of providing support to small and new firms, SMEs were relatively neglected. Public policy was directed to providing credit and other support to those firms, perhaps originally small, but which had managed to succeed in export markets and hence which had grown to be very large. Firms and sectors were assigned ambitious growth quotas. Failure to meet these quotas could result in the loss of access to highly subsidized policy loans or other penalties. SMEs, on the other hand, had access primarily only to credit on the informal market at high interest rates.

When in the 1970s the government's development plan assigned top priority to heavy and chemical industries and exports, SMEs were put in an even more unfavorable position. A SME bank had been set up, but loan repayment rates were quite low, transaction costs very high and hence making little difference for SMEs in general. Even in the late 1960s, however, some seeds were set for the beginnings of an effective SME support system. KCGF was created to facilitate the provision of bank credit to SMEs. A special trading corporation was set up for assisting SMEs in export market. In 1979 the Small and Medium Industry Promotion Corporation was established for the purpose of providing technical assistance and training programs to SMEs.

In the 1980s the shift toward a stronger SME support system and policies aimed at overcoming the earlier neglect of SMEs accelerated. The new constitution stipulated that the protection and promotion of SMEs should be included among the basic responsibilities of the government. A series of laws was passed to turn this broad objective into a body of law. Many specific-purpose credit funds were set up, for example, to help rural industries, to foster venture capital designed to assist small high tech startups, to foster collective or cooperative activities among SMEs, to help older SMEs update their technology, and even to help existing SMEs to relocate some of their operations abroad. An ambitious system for identifying and providing various kinds of support for "promising SMEs" was established, and both commercial banks and rural local banks were required to allocate minimum specified percentages of their loans to SMEs. Such quotas were even forced on nonbank financial

institutions, such as insurance companies. Various tax breaks to SMEs for special purposes were also implemented.

The 1980s and 1990s have also seen a proliferation of technical research centers, institutes, standards centers, productivity centers, and a design and packaging center organized as either government or nonprofit agencies. Although not developed exclusively for use by SMEs, several of these agencies were in fact fairly heavily used by SMEs. Moreover, as the internal capabilities of LSEs increased with accumulated experience and staff additions, LSEs had less need to rely on those external agencies, such as the Korean Overseas Trading Association (KOTRA), which had earlier catered almost exclusively to LSEs. Some of the new centers have also proliferated into networks of either regional general-purpose agencies or national but highly specialized ones.

Nevertheless, because of the large number of programs and agencies, the lack of data on both their benefits and costs, and the likelihood that their effects would appear only in the relatively long run, the proper evaluation of these programs and organizations is quite a challenge. Kim and Nugent (1999), as part of a broader multi-country study, made a qualitative attempt to evaluate the usefulness of these programs in a relatively small sample of mostly exporting SMEs. Four different subsectors were chosen to reflect different environmental conditions. While no attempt was made to obtain cost of program data, the use of each of three different types of SME support was investigated. Lee (2006) analysis the effectiveness of government's occupational skills development strategies for SMEs. The effectiveness of public credit guarantees in the Japanese loan market is investigated by Uesugi et al. (2010).

In addition to the above studies, the issue of SMEs policy constraints is discussed in Nugent and Yhee (2002), Luck (2002) and Laeven (2002). Park et al. (2013) looked into the credit spreads. Ono et al. (2013) investigate whether lending relationships is beneficial or harmful for public credit guarantees. Ghosh and Ghosh (1999) ask whether there was a credit crunch in East Asia. The credit crunch and availability of credit to SMEs is also investigated in Hancock and Wilcox (1998). Domac and Ferri (1998), Dong (1998) and Borensztein and Lee (2002) investigate the impacts of financial crisis and credit crunch on firms under the Asian financial crisis. Kim (1999) asks if credit channel was a key monetary transmission mechanism following the financial crisis. Moon and Sohn (2005) use intelligence approach for effective management of governmental funds for SMEs.

2.3 The credit guarantee system and its development in Korea

Credit guarantee system was first introduced in 1961 in Korea for the purpose of alleviation of the financial difficulties of SMEs. Nowadays, there are two public credit guarantee funds in

Korea, Korea Credit Guarantee fund (KCGF) and Korea Technology Credit Guarantee Fund (KOTEC). They were founded to achieve different policy goals. However, the goal of KOTEC was not executed thoroughly although it was established to foster technology-based firms and to promote technological innovation. The amount of guarantee provided based on technology evaluation has been less than 10% of total amount of guarantee until 2004.

Even though both credit guarantee institutions are established to support SMEs, they have guaranteed relatively small LSEs, especially during the 1997 economic crisis, as well. In 1998, Korean SMEs were severely shocked at economic crisis caused by deficiency of foreign currency. Interest rates soared continuously and many enterprises went bankrupt. Consequently, as a measure to support SMEs who suffered heavily from lack of finance, the amount of credit guarantee increased as well. The balance of guarantee came up to 45.7 trillion won[2], or 6.1% of GDP, in 2003 as shown in Table 1.

[Insert Table 1 about here]

Capital funds for credit guarantee services consist mainly of contributions from the government and financial institutions. From a view of opponents, excessive guarantees hinder growth of the financial market causing inefficiency in resource allocation and negative effects in the long term. Moreover, there are innate factors to provoke moral hazard in the guarantee system. Since the present guarantee rate is too high, 85%, exceeding the international rate, 60-70%, it results in reduced incentives by lenders to investigate applicants thoroughly.

There are few recent studies evaluating the effects of credit guarantee policy on survival and performance of SMEs in Korea. These studies use firm level data from both credit guarantee institutes covering the period 2000-2004. Kang et al. (2008) analyzed the relationship between credit guarantee, the survival and performance of guaranteed firm. Results suggest that credit guarantee frequency enhanced firm performance but the effects of guarantee amount was ambiguous. Thus, credit guarantee satisfied only partially its goals in supporting SMEs. Oh et al. (2009) used matching techniques to compare guaranteed and non-guaranteed firms with respect to different performance indicators. Results suggest that credit guarantee influenced the size and survival rate of firms but not their R&D and investment.

3. DATA AND RESEARCH DESIGN

Our analysis is based on information on 45,749 firms which requested credit guarantees from one or both of two credit guarantee funds during the period from 2000 to 2004. All applicants provided basic information as well as financial data of previous years.

[2] Averagely US $1 = 1,050 won in 2013 sourced by the Bank of Korea

We start exploring our data by looking at descriptive evidence. In Table 2, the age (Age) variable indicates the age of firms since their establishment. Also, we obtain information on whether the firms has received guarantee, the amount (CGamount) received and its frequency (CGnumber). A number of firm characteristics are used in determination of provision of credit guarantee and the amount. These are related to the size of firm or number of employees (Employee), and technology capability such as the CEOs education (CEOedu), firms development cost (Inhouse), new technology based firms (NTBF), and holdings of patents (Patent). The financial variables include total assets (Totassets), intangible share of assets (Intangshare), liability (Dratio), stockholder's equity (Totshequ), net income (Netincome) and income taxes (Tax). In addition interaction of credit guarantee amount and net income is used to capture nonlinearity in the relationship.

[Insert Table 2 about here]

The analysis is conducted in form of two regressions; one is about determinants of credit guarantee and the second is related to determinants of firms' R&D investment. Table 3 shows a large dispersion in credit guarantee amount, in-house R&D investment, assets, net income and taxes. All explanatory variables are positively correlated with each of the two dependent variables. The correlations between the explanatory variables shows that with a few exceptions most of the correlation coefficients are below 0.50 suggesting no serious problem of multicollinearity. The dependent variable amount of credit guarantee is highly correlated with total assets (0.56) and share of equity (0.51). These two variables are main variables explaining variations in the amount of credit guarantee. The second dependent variable, in-house R&D, is highly correlated with its determinants including intangible share of assets (0.30), patents (0.22), total assets (0.45), employment (0.30), and share of equity (0.43).

[Insert Table 3 about here]

4. EMPIRICAL MODEL

In this paper, we analyze the effects of public funds on SMEs R&D investment which proceeds in two steps. First, it is analyzed by identifying what determines the amount of credit guarantee. Second, the effect of credit guarantee on determinants of firms' R&D using net income after and before tax is estimated for the firms which received credit guarantee.

4.1 Determinants of Credit Guarantee amount

In order to identify the determinant of the credit guarantee amount measured in the first part in log form (*lCGamount*), a simple relation accounting for various cohorts and time effects is

specified as follows. The model is estimated by ordinary least squares (OLS) method:

(1)

$$lCGamount = \beta_0 + \beta_{age} age + \beta_{int\,angible}\text{intangshare} + \beta_{patent}\text{D}_{patent} + \beta_{NTBF}\text{D}_{NTBF} + \beta_{age^2} age^2 + \beta_{duplication}\text{D}_{duplication} + \beta_{logtotalasset}\text{ltotassets} + \beta_{deratio}\text{deratio} + \beta_{ceo}\text{ceoedu} + \sum_i \beta_i \text{D}^i_{time} + \sum_i \beta_i \text{D}^i_{size} + \sum_i \beta_i \text{D}^i_{location}\text{location} + \sum_i \beta_i \text{D}^i_{industry} + u_i$$

where $D_{duplication}$ is a dummy variable identifying which firms are provided duplicated credit guarantees. Duplication is defined by the firm applicants receive guarantees from both credit institutes. The intangible asset share is considered in this model. We also estimated firm's technological characteristic by using patent and NTBF dummy variables and considered size, time, location, and industrial sector dummy variables as well. The location is divided into 16 subsections and compared to Seoul as reference location, which stands for location 1. The size has 5 categories is constructed based on the number of employees. The time is classified from 2001 through 2004 using 2001 as a reference year. At last, in the case of industrial sector, we used a list of industry specific three-digit codes as seen in Table 4. In Table 4 several sub-sectors, in total 14, with industrial codes from 242 to 722, represent the relatively new venture industries, and the other data do represent old and conventional industries.

[Insert Table 4 about here]

This equation considers the relationship between the amount of credit guarantee and features of firms. It includes not only financial data but also non-financial data such as age, size, location, possession of patents, period of application and industrial sector in which firms belong to. In case of financial data, fixed assets and sales are introduced since they are used as objective standards. Inclusion of these group effects in the model lead the model to be considered as a fixed effects (least squares dummy variable) model. The larger between groups are accounted for, but the minor within group variations are neglected.

4.2 Determinants of in-house R&D investment

In this section, in order to estimate the effect of credit guarantee on the determinants of firms' R&D, we investigate the guarantee influence on the firms' R&D investment by considering the predicted credit guarantee amount as another explanatory variable. In particular, two cases of net incomes after tax and before tax are treated for the determinants of firms' own R&D. Here the estimated amount of credit guarantee is included in the set of regressors to analyze the effect of credit guarantee on R&D investment conditional on other control variables as:

(2)

$$
\begin{aligned}
l\ln house = {} & \beta_0 + \beta_{\text{age}} age + \beta_{\text{age}^2} age^2 + \beta_{\text{int}\,angible}\text{intangshare} + \beta_{\text{patent}}\text{D}_{\text{patent}} + \beta_{\text{NTBF}}\text{D}_{\text{NTBF}} \\
& + \beta_{\text{duplication}}\text{D}_{\text{duplication}} + \beta_{\text{logtotalasset}}\text{ltotassets} + \beta_{\text{deratio}}\text{deratio} + \beta_{\text{lnetincome}}\text{lnetincome} \\
& + \beta_{\text{ltotshequ}}\text{ltotshequ} + \beta_{\text{Plcgamount}}\, \hat{plcgamount} + \beta_{\text{Plcgalneti}}\,\hat{\text{plcgalneti}} + \beta_{\text{ceo}}\text{ceoedu} \\
& + \sum_i \beta_i\, \text{D}^{\text{i}}_{\text{time}} + \sum_i \beta_i \text{D}^{\text{i}}_{\text{size}} + \sum_i \beta_i \text{D}^{\text{i}}_{location}\text{location} + \sum_i \beta_{\text{i}} \text{D}^{\text{i}}_{\text{industry}} + u_i
\end{aligned}
$$

where $\hat{plcgamount}$ is the predicted value of credit guarantee amount and $\hat{\text{plcgalneti}}$ is the product of the predicted value of credit guarantee and log net income. The dependent variable, which is the sum of ordinary and development costs, is employed as a proxy indicating the total R&D investment of firms. Other explanatory variables are the same as those are related to credit receipt analysis.

5. EMPIRICAL RESULTS

5.1 Specification and estimation tests

Two models are specified and estimated, a model to identify the determinants of level credit guarantee received by a firm and another determinants of its in-house R&D investment. The former is an explanatory variable affecting the later in which they are estimated recursively.

The credit guarantee model is specified by identifying a number of continuous variables such as total assets and ordinary R&D costs, some characteristics of the firms such as age of firm and its square, share of intangible assets, patents, technology conditions, indebtedness and duplicated sources of credit guarantee receipt. In addition several categorical variables are included in the specification such as the level of education of CEO, year of observation, size of firms, location and industrial classifications. Various F-tests suggest that these variables should be included in the specification of the model. The coefficient of determination R^2 indicate that 54% of the variations in the amount if credit guarantee is explained by this model.

The in-house R&D investment model is explained by total assets, predicted credit guarantee amount, net income, interaction of guarantee amount and net income as continuous variables, and several share variables like intangible share, equity share, indebtedness share, age and its square, patent, technology, frequency and duplication of credit guarantee, as well as education, year, size, location, and industry group category variables. Again various F-tests show that these variables should be included in the specification. The model is estimated by using net income before and after tax. The fits of model suggest that 57% of the variation in R&D investment is explained by the models.

5.2 Credit guarantees

For the analysis of the relationship between credit and firm's performance, we find systematic heterogeneity by characteristics such as industrial sector, technology level, firm size, age, ownership and location of firms. Taking into account the distribution of the firms with respect to their age, we find that most of firms taking credit guarantee are young companies. The cumulative percentages with respect to time are 55.7% for less than 5 years, 82.3% for below 10 years, 93.5% for less than 15 years, and 97.4% for below 20 years, which shows that young firms are main receivers of credit guarantee. We can identify that the firms which have just begun their business have small credit guarantee but the companies with ages of 3 to 5 receive the most credit guarantee fund supplied by KOTEC.

The cumulative distribution of firms receiving credit guarantee by size of firms is also computed. The percentage share is divided into five size classes measured by number of employees. The very small size with less than 20 employees accounts for 69.7% of the sample. The second small size class with less than 50 employees accumulated reached 90.2%. Taking into account for the medium size 3 up to 100 employees, the cumulative distribution reached 96.7%. Accumulation of the remaining large and very large sizes with maximum of 300 and more than 300 employees, respectively, accounts for 99.7% and 100.0% of the cumulative distribution of firms.

Results based on equation (1) showed the factors which determine the credit guarantee amount. R^2 fitness measure of this model is 0.54 and overall, this model gives statistically highly significant parameter estimates. The result in Table 5 shows that credit guarantee amount is a positive function of the size of firms. It is interpreted as smaller firms are given relatively less credit guarantee. Very likely the positive age association is due to improved security or higher asset size. We also examine credit guarantee amount with respect to 16 locations and 15 industrial sectors using this model. On the average almost all locations, receive lower credit guarantee amount than Seoul serving as reference location. Among the industries, basic iron and steel, computers and office machinery, semiconductor and other electronic components and television and radio transmitters receive higher rate of guarantee, while software consultancy lower rate than the manufacture of pharmaceutical as reference industry. Supply of credit guarantee is increasingly negatively related to time. The decline might be attributed to recovery of the industry and reduced needs after the Asian financial crisis.

As shown in Table 5, the negative but significant age coefficient indicates that the younger firms receive more credit guarantee amounts. However, it is found from the positive coefficient of the age squared that, accounting for initial 4 years of positive relationship, the

relation between age and credit guarantee is non-linear and characterized as U-shaped relationship. Looking at the frequency of number of firms receiving credit guarantee by age of firm shows a positive relationship before 4 years and a negative relationship thereafter. The credit guarantee measured in form of sum value show very similar patterns. This result coincides with the expectation that credit guarantees are preferentially distributed to the new entrants or growing firms. It is consistent with objectives of the guarantee system as well.

As firms possess more intangible assets and new technologies with patents, they are found to receive more credit guarantees. The technology dummy shows that lenders consider technology as an important standard and preference is given to technology-based firms in evaluation of applications. All three technology related explanatory variables, intangible assets, patent and NTBF, are highly correlated in their impacts on credit guarantee amount. A duplication of receipt of guarantee from two sources as expected reduced the demand and supply of credit from each source. Total assets as security and operational capacity has a positive relationship with the guarantee amount received, as well has the ordinary R&D investment cost. Surprisingly the degree of indebtedness despite its negative effect has no significant effect. We also find that firms with higher CEO's education level receive more amount of credit guarantee. The rate is increasing in the level of education. Finally, this model yields highly significant negative values with respect to time, positive with respect to size and mixed considering location and industry dummies.

[Insert Table 5 about here]

5.3 Internal R&D investment

The second model employing equation 2 is estimated by using net incomes before and after taxes, respectively. The results from both model specifications are listed in Table 6. Each model with R^2 of 0.57 shows relatively good fit. This model aimed to find the differences in internal R&D investment using net income before and after taxes but the estimation results are almost the same from the two models.

The dependent variable here is summation of firm's ordinary and development costs. In addition we investigated whether the predicted credit guarantee amount obtained from equation (1) had effect on firms' own R&D investment or not. Results suggest that in firms' R&D investment, public credit guarantee frequency and amount and duplicated guarantees have positive influence. However, none are statistically significantly different from zero effect. The net income seems to have strong and positive effects. The amount of credit guarantee in conjunction with net income has positive effect on R&D investment. That is, the credit guarantee encourages firms to invest in R&D actively.

It is found that younger or recently established firms are more prawn to R&D investment and the relationship is characterized as an inverted U-shaped with respect to firm's age. These results indicate that there exists an incentive effect of credit guarantee on firms' R&D investments. Also, in the case that firms have more patents and they are selected as a new technology based firm, they invest more in R&D. The effect of patents is strongest among the explanatory variables. However, looking at the duplication of funds, receiving funds from KOTEC twice is found not to result in an increased R&D investment. The fact that the total share of equity has a negative and insignificant relation with the R&D investment is that credit guarantee fund generally goes into technology investment.

Debt ratio denotes the ratio of the total liabilities to the total assets, and a higher such indicates smaller R&D investment. The number of times receiving credit guarantee fund as well as the amount of the fund do not have a significant influence. In addition, surprisingly as the net income of the firms increases, the firms' R&D investment is reduced. The interactive variable (lcgalneti), which is the product of logarithm value of the credit guarantee amount and that of the net income of firms, is shown to have a positive relation with the R&D investment of firms.

The level of CEOs education in an increasing form has positive impact on firms R&D investment. In looking at the development of R&D investment over time we note that only the last year, 2004, is higher compared with the first year, 2001. Results suggest a positive and increasing relationship between size of firms measured as number of employees and firms R&D investment activity. We observe significant heterogeneity in R&D behavior in regards with location of firms. Seoul as reference location seems to have a higher propensity to investment compared to most of other locations. The industrial sectors are also different in their R&D investment. The computer system design, manufacture of television industries and radio and manufacture of computer and office machinery show a high rate of R&D, while manufacture of iron and basic steel low R&D rate.

[Insert Table 6 about here]

5.4 Death Valley and Survival of SMEs

New technology-based firms have a crucial role to the economic development in Korea. However, these firms suffer from a 'liability of newness', and most emerging technology firms struggle to survive. Especially these firms' problems are directly or indirectly related to their financing needs and sources. In general the new technology based start-ups of Korea are supported by public funds provided through the two national credit guarantee funds. The evidence show that the amount of public financing reduces as time elapses and in parallel private financing increase. The development include gap between the two sources where the

difference between the ending point of public financing and the starting point of private financing is referred to as 'Death Valley'. Therefore, as the difference gets deeper and wider, the start-ups go through serious financial problems threatening their survival.

A look at the distributional relationship between credit guarantee amounts received by firms and their total R&D investment shows that the credit guarantee and R&D investment lines cross at around 3 years age resulting into a Death Valley gap around 2-4 years of age. At this point we can find evidence of Death Valley among young firms with age below five years.

Previous research has shown that survival and performance of SME is highly affected by access to credit guarantee. Few of these studies based on current data are reviewed below. These studies have good coverage on the exploitation of the information containing the data on survival of firms and use advanced methodology. Thus, instead of conducting survival analysis we briefly resent their main findings.

Kang et al. (2008) studied the effect of credit guarantee policy on survival and performance of SMEs by using regression analysis method. The analysis shows that the size and age play a decisive role in survival and performance of firms. In addition to size and age the firms are also differentiated by industrial sector they participate in. High survival likelihood of old firms establishes that management experience was the critical factor in the aftermath of the Asian financial crisis. Larger firms are also found superior in performance. This is explained by the fact that large firms accumulated growth potential by investment in R&D and innovative restructuring, while SMEs suffered from shortage of finances and loss of competitiveness.

Oh et al. (2009) is another study that evaluates credit guarantee policy by adopting propensity score matching methodology. The authors evaluate the effect of the guarantee policy in terms of growth in size of the firm, R&D, investment, productivity, and survival of firms in the post crisis period, by comparing guaranteed with non-guaranteed firms. The results suggest that credit guarantees influenced significantly firms' ability to maintain their size and it increased their survival rate. However, it did not increase their R&D, investment, growth and productivity. Due to the adverse selection problem, firms with lower productivity were receiving guarantees which made the process of creative destruction less effective in manufacturing. The policy was also criticized for its lack of effective selection mechanism and interference in the market mechanism with disturbing impacts on the restructuring plan leading to overcapacity among SMEs.

In a third study Oh et al. (2009) conduct a comparative analysis of plant dynamics in the Korean manufacturing. The analysis is performed by size classes and sources of TFP growth are decomposed into entry, exit, and survival effects of plants. Additional survival analyses investigate internal and external determinants of the survival of plants. The results from chain

based productivity analysis indicate that the exit of SMEs with higher productivity is becoming problematic in the post-Asian crisis period. The improvements in large-scale establishments after the crisis appeared to occur in high-technology industrial sectors; while SMEs in low-technology industries are suffering from a sluggish market selection process.

Kaplan Meier survival curve in Oh et al. (2009) show that export, R&D investment, and multi-plant production enhance the survival rates of plants. However, export activities have the strongest effect followed by R&D. Cox regression of plant's survival analysis suggests that both internal and external variables affect the survival of plants. GDP growth, R&D, export, multi-plant, and number of employees have a positive association with the survival of the plants. The sectoral growth implies that during the boom period, the entry rate and competition would increase, negatively affecting the survival rates of plants. The TFP level shows that the TFP level was not a very important factor for the survival of SMEs, but high productivity level was a very important factor for the survival of LSEs.

The above discussion leads us to conclude that financial support for SMEs must be designed counter-cyclically, i.e., the amount of credit provision must gradually decrease in keeping with the progress of recovery from the crisis and economic boom. The support policy targeting SMEs must focus more on improved selection mechanism of firms requiring support. The objective must be to enhance productivity, not merely as a broader support measures. In allocation of scarce credit resources, preference must be given to firms with higher productivity rates in order to improve their survival rates. This will eventually enhance the productivity growth of the entire industry. In order to assist in the survival of SMEs, the government support must be such that it stimulates SMEs to initially begin with moderate size in order to avoid external risks and be able to compete in the market primarily with their internal resources ability. Policies promoting R&D and the export activities of firms can also assist to improve the survival rate of SMEs.

6. SUMMARY AND CONCLUSIONS

In recent years, various kinds of public funds have been committed to SMEs in Korea, but their effects have not been evaluated effectively. In order to ensure effective management of such funds, evaluation of the effects and the feedback information from the previously invested public funds need to be utilized in the future selection of worthy recipient firms.

In this paper we used a large firm level data to study how credit guarantee amount is determined and how it affects firms' R&D investment. In analysis of the relationship between duration of credit and firm's survival and performance, we segment in several characteristics of firms such as industrial sector, technology level, firm size, age, financial status, ownership,

location and industrial sector. Finally we look into elasticity of credit fund and R&D investment of firms with respect to several firm characteristics.

Through this exercise, we found the factors determining the level of credit guarantee and in-house R&D, which include development and R&D investment costs, and their interaction, especially the tradeoff between the two and how they form the Death Valley. The results we obtain are from a sample of firms which requested credit guarantees form one or two credit guarantee funds during the period 2001 to 2004. The impact of credit guarantees on R&D of SMEs in Korea is analyzed at covering the economic recovery period of post the Asian economic crisis.

Estimation of model with determinants of credit guarantee amount led us to identification of several such determinants. The age of firms show to have a negative effect at a decreasing rate as older firm use international sources of finances and have well established relation with the financial market. High levels of total assets and intangible share are positively associated with the amount credit guarantee. Number of patents, NTBF and education of the CEO also impacted positively the amount. We find positive relationship between size of firm and credit guarantee suggesting the small firms to have limited access to R&D investment finances. It must be explained by their small size and lack of organization and research capacity.

In order to measure the effect of credit guarantees on research, the relationship between credit guarantee and R&D investment of firms is analyzed. The amount and frequency of credit guarantee provisions have positive effects on R&D expenditures of SMEs but it is not statistically significant. The distribution of receiving firms show that about 55% of firms have operated less than five years and 82% of firms less than ten years. Also 83% of firms belong to new technology based firm category. Based on these we find that the credit guarantee support is concentrated on younger firms. The ratio of credit guarantee amounts to total assets is positively correlated with R&D investment. The statistics clearly shows that the amount of credit guarantee and R&D cost is gradually increasing during the early years of firm's operation. The amounts peak at the 3rd year for the credit guarantee and at the 5th year for in-house R&D cost, respectively. Therefore, it seems clear that a large amount of resources are spent for the R&D during the first 5 years of establishment of firms. However, the shape of credit guarantee and R&D investment indicates that credit guarantee amount decreases steeply. The data show that age is a crucial factor to the level and relationship between credit guarantee and R&D investment of firms.

The emergence of new technology-based firms affects economic development positively. However, new organizations in general and new technology-based firms in particular, suffer from a ‘liability of newness’, and most emerging technology firms struggle to survive.

Especially these problems are affected by the financing source. In general the new technology based start-ups are supported by public funds. However, the amount of financing reduces as time elapses and private financing increase. The difference between the ending point of public financing and the starting point of private financing gets deeper and wider, as the start-ups face financial problems. This shows evidence of Death Valley among young firms.

As revealed in other studies patent, assets, employees and total stock share of equity play a decisive role in provision of credit guarantee and its amount as well as the R&D investment of firms. The amount of guarantee and R&D investment differ over time, across industries, and locations. This result is in favor of government policy which aimed at balancing the economic development. Therefore, the total amount and distribution of credit guarantee allocated to firms should be aligned with politics targeting to balance the development and firm dynamics at the national level.

Acknowledgement

The author would like to thank representative of the Korea Technology Credit Guarantee Fund (KOTEC) for providing the data.

REFERENCES

Arping, S., Lóránth, G. & Morrison, A.D. (2010). Public initiatives to support entrepreneurs: Credit guarantees versus co-funding. Journal of Financial Stability, 6(1), 26-35.

Arrow, K.J. & Kurz, M. (1970). Public Investment, the Rate of Return and Optimal Fiscal Policy. The John Hopkins Press, Baltimore.

Aschauer, D.A. (1988). The equilibrium approach to fiscal policy. Journal of Money, Credit and Banking, 20, 41-62.

Aschauer, D.A. (1989a). Is public expenditure productive? Journal of Monetary Economics, 23, 177-200.

Aschauer, D.A. (1989b). Does public capital crowd out private capital? Journal of Monetary Economics, 24, 171-188.

Banker, R.D., Chang H., Janakiraman, S.N. & Konstans, C. (2004). A balanced scorecard analysis of performance metrics. European Journal of Operational Research, 154, 423–436.

Barro, R.J. (1989). The neo-classical approach to fiscal policy. In: Barro, R.J., Ed., Modern Business Cycle Theory. Harvard University Press, Cambridge.

Borensztein, E. & Lee, J. (2002). Financial crisis and credit crunch in Korea: evidence from firm-level data. Journal of Monetary Economics, 49, 853-875.

Baxter, M. & King, R.G. (1993). Fiscal policy in general equilibrium. American Economic Review, 83, 315-334.

David, P.A., Hall. B. & Toole, A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. Research Policy, 29, 497–529

Domac, I. & Ferri, G. (1998). The Impact of Financial Shocks: Evidence from Korea. The World Bank. Working Paper.

Dong, Y.K. (1998). Credit crunch and shocks to firms: Korean experience under the Asian financial crisis, Emerging Markets Review, 198-210.

Frei, F.X. & Harker, P.T. (1999). Measuring aggregate process performance using AHP1. European Journal of Operational Research, 116(2), 436–442.

Ghosh, S.R. & Ghosh, A.R. (1999). East Asia in the Aftermath: Was there a Crunch? IMF. WP/99/38.

Hancock, D. & Wilcox, J.A. (1998). The ‘credit crunch’ and the availability of credit to small business. Journal of Bank Finance, 22, 983-1014.

Howe, J.D. & McFetridge, D.G. (1976). The determinants of R&D expenditures. Canadian Journal of Economics, 9, 57–71.

Kang, J.W., Heshmati A. & Choi, G.G. (2008). Effect of Credit Guarantee Policy on Survival and Performance of SMEs in Republic of Korea, Small Business Economics, 31, 445-

462.

Kim, H.E. (1999). Was the Credit Channel a Key Monetary Transmission Mechanism following the Recent Financial Crisis in the Republic of Korea? The World Bank Policy Research Working Paper 2103.

Kim, L. & Nugent, J.B. (1999). Korean SMEs and Their Support Systems, in Brian Levy, Albert Berry and Jeffrey B. Nugent (eds.), Fulfilling the Export Potential of Small and Medium Firms, Boston: Kluwer. Small and Medium Enterprises in Korea: Achievements.

Laeven, L. (2002). Financial constraints on investments and credit policy in Korea, Journal of Asian Economics, 13(2), 251-269.

Lee, K.W. (2006). Effectiveness of government's occupational skills development strategies for small- and medium-scale enterprises: A case study of Korea. International Journal of Educational Development, 26, 278–294.

Luc, L. (2002). Financial constraints on investments and credit policy in Korea. Journal of Asian Economics, 13, 251-269.

Martinsons, M., Davison R. & Tse, D. (1999). The balanced scorecard: A foundation for the strategic management of information systems. Decision Support Systems, 25, 71–88.

Milis, K. & Mercken, R. (2004). The use of the balanced scorecard for the evaluation of Information and Communication Technology projects, International Journal of Project Management, 22, 87–97.

Moon, T.H. & Sohn, S.Y. (2005). Intelligent approach for effective management of governmental funds for small and medium enterprises. Expert Systems with Applications, 29, 566–572.

Nugent, J.B. & Yhee, S.J. (2002). Small and Medium Enterprises in Korea: Achievements: Constraints and Policy Issues. Small Business Economics, 18, 85–119.

Oh, I., Lee. D.J., Heshmati A. & Choi, G.G. (2009). Evaluation of Credit Guarantee Policy using Propensity Score Matching, Small Business Economics, 33(3), 335-351.

Oh, I., Heshmati, A., Baek, C. & Lee, J.D. (2009). Comparative Analysis of Firm Dynamics by Size: The Korean Manufacturing, Japanese Economic Review, 60(4), 512-538.

Oh, I., Lee, J.D. & Heshmati, A. (2008). Total Factor Productivity in Korean Manufacturing Industries, Global Economic Review, 37(1), 23-50.

Ono, A., Uesugi I. & Yasuda, Y. (2013). Are lending relationships beneficial or harmful for public credit guarantees? Evidence from Japan's Emergency Credit Guarantee Program, Journal of Financial Stability, 9(2), 151-167.

Park, K.L., Ahn, C.M., Kim, D.H. & Kim, S.K. (2013). An empirical study of credit spreads in an emerging market: The case of Korea, Pacific-Basin Finance Journal, 21(1), 952-966.

Uesugi, I., Sakai, K. & Yamashiro, G.M. (2010). The Effectiveness of Public Credit Guarantees in the Japanese Loan Market, Journal of the Japanese and International Economies, 24(4), 457-480.

Yurdakula, M. & Tansel, Y. (2004). AHP approach in the credit evaluation of the manufacturing firms in Turkey. International Journal of Production Economics, 88, 269–289.

Table 1. Development of credit guarantee amount over time and by fund (billion won).

	1997	1998	1999	2000	2001	2002	2003
KCGF	11,329	21,454	19,621	22,592	31,268	32,514	32,734
KOTEC	5,724	11,340	11,306	12,498	16,161	16,523	16,746
Total	17,053	32,794	30,927	35,090	47,429	49,037	49,480

Note: Korea Credit Guarantee Fund (KCGF) and Korea Technology Credit Guarantee Fund (KOTEC)

Table 2. Definition of variables.

Variable	Description
Year	2001-2004
CGamount	The amount of credit guarantee
Inhouse	Develop costs + ordinary cost
Age	Age of firms
IntangShare	Intangible assets
Patent	Holding patent or not
NTBF	New tech based firm or not
TotAssets	Total assets
Employee	The number of employees
DEratio	Total Liabilities /total assets
NetIncome	Net income
Tax	Income taxes
TotShEqu	Total stockholders' equity
CGnumber	Number of credit guarantee
CGamount	The amount of credit guarantee
CgaNeti	CGamount x NetIncome
CEOedu	CEO education (high value has more school career)

Table 3. Descriptive statistics, 2001-2004, 45,749 observations.

Variable	Mean	Std. Dev.
Credit Guarantee amount	337.6999	835.3139
In-house R&D investment	84.7303	426.2624
Age	6.6930	5.3147
Intangible share	0.0372	0.1077
Patent	0.2998	0.4582
NTBF	0.8270	0.3781
Total assets	2383.0000	7599.0000
Employee	22.4300	39.4544
Debt-Equity ratio	0.5571	0.2740
Net income	57.3947	818.2582
Tax	74.2279	941.4965
Total Share Equity	816.3480	2836.0000

Table 4. Three-digit classification of industries

Industrial code	Industry
242	Manufacture of Pharmaceuticals, Medicinal Chemicals and Botanical Products
300	Manufacture of Computers and Office Machinery
321	Manufacture of Semiconductor and Other Electronic Components
322	Manufacture of Television and Radio Transmitters and Apparatuses for Line Telephony and Line Telegraphy
331	Manufacture of Medical Appliances and Instruments
721	Computer System Design and Consultancy
722	Software Consultancy and Supply
241	Manufacture of Basic Chemicals
243	Manufacture of Other Chemical Products
244	Manufacture of Man-Made Fibers
252	Manufacture of Plastic Products
271	Manufacture of Basic Iron and Steel
291	Manufacture of General Purpose Machinery
343	Manufacture of Parts and Accessories for Motor Vehicles and Engine

Table 5. Parameter estimates from Model 1 of determinants of credit guarantee amount.

Variable	Parameter Estimate	Standard Error	t-value	Pr > |t|
Intercept	2.5682***	0.0210	122.61	0.0001
Age	-0.0100***	0.0017	-5.94	0.0001
Age^2	0.0002***	0.0001	4.00	0.0001
Intangible share of assets	0.1581***	0.0400	3.95	0.0001
Patent	0.1426***	0.0094	15.10	0.0001
NTBF	0.1287***	0.0110	11.71	0.0001
Duplication	-0.1230***	0.0079	-15.60	0.0001
Log Total Assets	0.3542***	0.0032	111.22	0.0001
Log Ordinary R&D cost	0.0394***	0.0033	11.89	0.0001
Debt/Equity ratio	-0.0084	0.0156	-0.53	0.5932
CEO edu2	0.0867***	0.0083	10.51	0.0001
CEO edu3	0.2071***	0.0149	13.87	0.0001
T2002	-0.0417***	0.0099	-4.20	0.0001
T2003	-0.1072***	0.0097	-11.10	0.0001
T2004	-0.2393***	0.0119	-20.04	0.0001
size2	0.3501***	0.0107	32.76	0.0001
size3	0.6715***	0.0173	38.78	0.0001
size4	0.9683***	0.0249	38.92	0.0001
size5	1.2186***	0.0671	18.16	0.0001
R^2	0.5358			
RMSE	0.7950			
Observation	45749			

The model included dummy variables for 17 locations and 15 industrial sectors. Robust standard erroes.

Table 6. Parameter estimates from Model 2 for determinants of own R&D.

Variable	Using net income AFTER tax				Using net income BEFORE tax			
	Parameter Estimate	Std. Error	t-value	pPr > |t|	Parameter Estimate	Std. Error	t-value	Pr > |t|
Intercept	-1.5368***	0.0609	-25.23	0.0001	-1.5448***	0.0609	-25.37	0.0001
Age	0.0278***	0.0031	9.06	0.0001	0.0283***	0.0031	9.22	0.0001
Age^2	-0.0010***	0.0001	-9.67	0.0001	-0.0010***	0.0001	-9.81	0.0001
Patent	0.8027***	0.0167	48.05	0.0001	0.8025***	0.0167	48.04	0.0001
NTBF	0.0909***	0.0196	4.64	0.0001	0.0888***	0.0196	4.53	0.0001
Duplication	0.0145	0.0141	1.03	0.3048	0.0158	0.0141	1.12	0.2628
Intangible Share	8.4243***	0.0722	116.74	0.0001	8.4108***	0.0722	116.46	0.0001
Log TotShEqu	-0.0205	0.0107	-1.91	0.0559	-0.0176	0.0107	-1.64	0.1017
Log Total Assets	0.3240***	0.0130	24.98	0.0001	0.3235***	0.0130	24.95	0.0001
Debt/Equ ratio	-0.7124***	0.0437	-16.31	0.0001	-0.7044***	0.0437	-16.11	0.0001
CGnumber	0.0063	0.0092	0.68	0.4963	0.0061	0.0093	0.66	0.5065
Log CGamount	0.0170	0.0127	1.34	0.1809	0.0183	0.0127	1.44	0.1492
Log netincome	-0.1598***	0.0164	-9.73	0.0001	-0.1609***	0.0162	-9.94	0.0001
Log cga x logneti	0.0240***	0.0028	8.45	0.0001	0.0234***	0.0028	8.40	0.0001
CEO edu2	0.1540***	0.0147	10.47	0.0001	0.1538***	0.0147	10.46	0.0001
CEO edu3	0.5959***	0.0266	22.40	0.0001	0.5936***	0.0266	22.31	0.0001
T2002	-0.0022	0.0176	-0.12	0.9013	-0.0018	0.0176	-0.10	0.9192
T2003	0.0103	0.0172	0.60	0.5500	0.0111	0.0172	0.65	0.5178
T2004	0.1223***	0.0213	5.74	0.0001	0.1231***	0.0213	5.77	0.0001
size2	0.3099***	0.0192	16.14	0.0001	0.3111***	0.0192	16.20	0.0001
size3	0.6651***	0.0316	21.03	0.0001	0.6674***	0.0316	21.10	0.0001
size4	0.9104***	0.0458	19.90	0.0001	0.9116***	0.0458	19.91	0.0001
size5	1.4668***	0.1206	12.16	0.0001	1.4698***	0.1206	12.18	0.0001
R^2		0.5722				0.5723		
RMSE		1.4122				1.4121		
Observations		45749				45749		

The models included dummy variables for 17 locations and 15 industrial sectors. Robust standard errors.