The Impact of Government Innovation Subsidies on the Survival of SMEs in Korea

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Abstract

This study analyzed the effect of the government R&D subsidy program on long-term firm survival. In order to estimate the average treatment effect for the treated group, we used the survival analysis and matching method by constituting a comprehensive dataset of more than 90,000 observations.

The analysis results show that the government R&D subsidy has a negative impact on long-term firm survival. In particular, not only the subsidy does not have a statistically significant effect on firm survival in the relatively short-term, the survival probability of the subsidized firms is statistically significantly lower than the non-subsidized firms after six years. These results can be seen as weakening the justification of government R&D support.

There may be problems in the subsidy policy itself and the process of selection of subsidy awardees; however, the more fundamental problem is that the subsidy policy is concluded as the one-time event. Admittedly, it would be difficult for the government to precisely manage the subsidized projects over a long term period. However, in the case of a project in which short-term performance is detected, it would be necessary to provide a step-by-step support to strengthen the firm's competitiveness through further support and continuous development of performance. Of course, mid- and long-term evaluations of subsidy support policy should be performed in parallel with such phased support.

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1. INTRODUCTION

Since Schumpeter (1942) argued that innovation plays a significant role in the survival of a firm, there has been broad consensus that innovation is a crucial factor in maintaining a firm's market competitiveness and ensuring sustainable survival. In other words, innovation enhances a firm's market competitiveness and increases productivity, which ultimately leads to the growth of firm. The growth of innovative firms contributes to the strengthening of national competitiveness by spontaneously driving out non-innovative or inefficient firms from the market.

However, firm innovation is achieved through R&D activities; thus, if its innovation is left autonomously to the market, innovation activities would be performed at a lesser level than the socially optimal level. The neoclassical economic theory sought the cause of such underdevelopment of innovation in the nature of public goods (Nelson, 1959), Cohen and Klepper (1996), Jyrki (2004) and Hall (2002) pointed to the imperfect funding market caused by the uncertainty of R&D or innovation success and information asymmetry. As such, for the purpose of correction of market failures in R&D activities, the government has been intervening to promote innovation activities through various methods such as direct R&D by government agencies, direct subsidies for R&D, tax reduction benefits, and public incentives to R&D cooperation.

Amongst the foregoing, the government funding for R&D (subsidies, tax benefits, and loans) is the most common method to promote private R&D in most OECD countries. For example, in Europe, in order to stimulate private R&D spending, the EU Commission emphasized the relevant efforts of its member states by presenting the "Action Plan for Europe" to each national government of its member states (Czarnitzki and Hussinger, 2004). It is believed that public subsidies encourage innovation in firms, which in turn would lead to the growth of firms and prevention of technological deterioration and ultimately extension of firms' lifespans (Cefis and Marsil, 2005; David et al., 2000; and Saxenian, 1994). In addition, by enhancing the internal R&D of firms, it would be possible to improve firms' absorption capacity and facilitate their R&D cooperation with other organizations, so that firms can improve their survival and growth opportunities through quicker acquisitions of new technologies (Bercovitz and Feldman, 2007; David et al., 2000; and Saxenian, 1994).

The fundamental justification for such government (public) R&D subsidies is that R&D will be under-invested in the private sector despite the positive knowledge spillover. However, in order to support the subsidies' justification, in addition to such theoretical legitimacy of government subsidy support, it would be necessary to verify whether public R&D subsidies were in fact effective in innovation activities. In this regard, the effects of public R&D subsidies have generally been evaluated as "additionality". The concept of "additionality" is defined by Buiseret et al. (1995) as "something which is obtained through public intervention, which wouldn't exist without such intervention, and which is the effect of a public policy of incentives" (Heijs and Herrera, 2004). Early research on the effects of public R&D subsidies focused primarily on whether subsidies stimulated or crowded-out private R&D spending (input additionality). Thereafter, there has been an increasing need to evaluate the impact of subsidies on the technological and economic performances of

firms even if subsidies stimulated additional private investment in R&D (Czarnitzki and Hussinger, 2004; and Hussinger, 2008). This need led to studies on the effects of R&D subsidies on innovation performance of firms (output additionality) and innovation capacity of firms (behavior additionality). In light of the foregoing, this study analyzes the impact of public R&D subsidies beyond the concept of additionality – that is, such subsidies' effects on the survival of firms, which is a long-term and ultimate goal of every firm.

Thus, the ultimate goal of a firm's R&D would be to maintain its competitiveness and achieve sustainable survival in the intense global competition. In this respect, it would be necessary to verify whether government R&D subsidies promote firm innovation and, in the long-term, provide a positive advantage for the survival of firm. However, there is only a limited number of existing researches, which analyze the effects of public subsidy support policies on the survival of firms.

Therefore, this study examines the effects of public subsidies on firm survival as a long-term effect of government innovation supports, which have not attracted much academic attention in the past. In particular, this study aims to analyze the long-term effect of the Technology Innovation R&D Program (TIP), which is the government's key R&D subsidies policy to boost technological innovations of small and medium-sized enterprises (SMEs) in Korea. As explained above, the differentiated aspect of this study from the past research is that this study analyzes the long-term (ten years) effects of public R&D subsidies as opposed to most of existing studies, which focused on short-term or mid-term (typically, one to three years) effects. For the purpose of foregoing empirical analysis, a matching method was employed to construct a counterfactual group (control group) corresponding to the treatment group or the group of subsidized firms. Subsequently, on the basis of the matched group corrected selection bias, the study performed a survival analysis to evaluate the treatment effect of public R&D subsidy on SMEs' survival.

This study is organized as follows. Section 2 provides an overview of the existing literature on the foregoing topic, and Section 3 explains an outline and methods of empirical analysis of this study. The matching process for constructing the control group is described in Section 4, and Section 5 presents the results of the survival analysis. Lastly, Section 6 concludes the study and presents policy recommendations.

2. LITERATURE REVIEW

The argument that government R&D subsidies increase the probability of firm survival is based on the mechanisms that (i) public subsidies promote innovative output; and (ii) these innovations enhance the productivity of firm and ultimately increase the survival probability of firm (Wagner 2002; and Musso and Schiavo 2008). It is also argued that a government subsidy extends a company's lifespan as the subsidy allows the subsidized companies to attain additional commercialization or keep up with technological changes (Cefis and Marsil, 2005; David et al., 2000; and Saxenian, 1994). In the foregoing context, Cefis and Marsil (2005) found through their survival analysis of

Dutch firms that innovation output indicators increase the probability of survival of firms. Esteve-Perez and Manez-Castillejo (2008) also found by using the survival analysis of Spanish manufacturing firms that firms' R&D performances increase the survival probability of firms, and Hall (1987) presented a finding that the R&D intensity increases the viability of firms. These results show that if the government R&D subsidies can enhance the subsidized firm's innovation output or promote firm's R&D spending, it will also increase the subsidized firms' survival probabilities.

In the early days of research on the effects of government R&D subsidies, most studies focused on whether subsidies stimulated or crowded-out private R&D input. Thereafter, even if government subsidies promoted additional private R&D investment, there has been an increasing need for evaluation of technical and economic benefits from government subsidy support (Czarnitzki and Hussinger, 2004; and Hussinger, 2008). This need led to studies on the effects of R&D subsidies on innovation performance (output additionality) and innovation capacity (behavioural additionality). However, such studies of additionality focused on the short- or mid-term effects of government R&D subsidies, despite Mansfield's (1995) finding that an average of seven years of basic research is required to commercialize a new product (Czarnitziki et al., 2011; and Einio, 2014). In the foregoing context, this study analyzed the impact of government R&D subsidies on firm survival, which is the long-term goal of firms that is beyond the concept of additionality.

There are relatively many past researches on the effects of R&D subsidies on additionality and determinants of firm survival; however, there are only a few past studies on the impact of R&D subsidies on firm survival. One of the main reasons for such paucity is limited availability of data covering information about firms receiving subsidies and details of long-term tracking of firm survival, which are necessary to analyze the effects of R&D subsidies on the survival of firms.

Smith (2016) and Heim et al. (2016) are a few past studies that directly analyzed the impact of R&D subsidies on firm survival. Smith (2016) analyzed small firms that applied for the US Advanced Technology Program (ATP) in 1998-2000. This dissertation examined the longer-term impact of the ATP program on awardee firms regarding their survival prospects and commercialization outcomes. The results of Smith's dissertation show that receiving an ATP award had a positive and significant causal effect on a firm's lifespan. He used the Heckman selection model to take into account selection bias in the process of selecting a firm to receive the subsidy and the Cox regression for survival analysis.

Heim et al. (2016) estimated the causal impact of restructuring aid granted by the European Commission between 2000 and 2012 on the survival and financial viability of aided 56 firms using the survival analysis (both the parametric model of lognormal model and the semi-parametric model of Cox proportional hazard model). As a result of their analysis, they found that the restructuring aid increased firm's survival time by 8-15 years and decreased the hazard rate of bankruptcy by 58-68 percent.

There are also other studies that analyzed the effects of R&D or innovation on firm survival and this

section will briefly review such studies in order to facilitate the construction of the control variable to be included in the survival analysis.

Cefis and Marsil (2005) conducted a survival analysis of Dutch manufacturing firms that combined the Business Resister database with the Community Innovation Survey (CIS2) using Cox regression. They found that innovative outputs, which measured whether a firm introduced any product or process innovation in a given period by using indicator variables, increased the firms' chances of survival. They also confirmed that firm size is positively correlated with the probability of firm survival.

On the other hand, Zhang and Mohnen (2013) explored a relationship between innovation effort (R&D) or innovation output (share of innovative sales) and firm's duration of survival by examining more than 100,000 Chinese firms that were newly established between 2000 and 2006 and a complementary log-log model with time-varying explanatory variables. The research showed that innovation reduces the risk of bankruptcy, but in the long term, there is an inverse U relationship between R&D or innovation output and the probability of firm survival. In fact, it showed that excessive R&D or innovation of a firm can increase the risk of bankruptcy by increasing the uncertainty of firm.

Korean studies focused mainly on predicting the probability of corporate default or analyzing the determinants of firm survival. There are only a few research on the relationship between R&D and firm survival, and no study has ever analyzed the effects of R&D subsidies on firm survival.[1] The following is a brief description of such researches related to the topic of this study.

First, Lee and Shin (2005) analyzed the survival factors of 1,780 start-up companies that were established in ten years from 1984 using Cox regression with time-varying covariates. The results showed that the growth rate and size of firms have a positive relationship with the survival probability of firms and that firms in industries with high market concentration and low competition intensity are less likely to exit. Also, their analysis found that affiliated firms are more likely to survive than independent firms.

Secondly, Kang (2014) analyzed the effects of corporate intellectual property on survival chances of firms by using the financial data of Korean manufacturing firms from 2000 to 2012 and Cox regression with time-varying covariates. According to the analysis results, the increase in the total number of valid patents of firms leads to a statistically significant decrease in the bankruptcy risk of firms. It also found that the higher R&D intensity (the proportion of R&D expenditure in sales) and the higher market concentration of industry reduce the risk of exit. Notably, he included the interest rate and the unemployment rate as macroeconomic indicators in the survival analysis.

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[1] A search of the ScienceDirect online database and KCI (Korean Citation Index) online database provided by Korea Research Foundation on the 24th of January 2018, using the keywords "Survival Analysis," "R&D subsidy" and "Korea" returned 769 and 310 articles, respectively. We reviewed the titles and abstracts of all selected studies, however, found no research on the relationship between public R&D subsidies and firm survival.

Thirdly, Kim (2008) conducted an in-depth evaluation of TIP. He surveyed companies that applied for the TIP subsidy between 2005 and 2007 and sought to verify the effectiveness of the program. The results showed that the TIP did not have a statistically significant effect on both employment and sales of firms.

3. ANALYSIS METHODOLOGY

3.1. Overview of Analysis

The data used in this analysis is a combination of information[2] of firms receiving the TIP subsidy funded by the Ministry of SMEs and Start-ups (MSS) and financial information (KIS-VALUE) of the firms from 2006 to 2016 provided by NICE Information Service. The TIP was implemented in 1997 by the "Act on the Promotion Technology Innovation of Small and Medium Enterprises" with the following purpose: "The government directly provides some of the R&D costs for SMEs with technology development capability." Table 1 shows the 10-years status of the TIP since its launch in 1997.

TABLE 1. Status of Technological Innovation R&D Program (KRW 100 Million)

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Budget Scale	300	323	450	600	861	990	1,101	1,587	1,422	1,596
No. of Project	683	647	857	1,013	1,313	1,566	1,676	2,312	1,912	2,035
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Budget Scale	1,995	2,355	2,620	2,797	2,206	2,325	2,448	2,470	2,620	2,260
No. of Project	2,135	2,049	1,691	1,526	1,053	1,054	1,082	1,088	1,108	1,030

Source: Park et al. (2014), National Science & Technology Information Service website (http://www.ntis.go.kr)

In 2006, the government support for the TIP subsidy amounted to 159.6 billion won with 2,035 firms as its recipients. The subjects of this analysis are 1,764 firms that were newly selected for the TIP in 2006, and the government support amount concerned is 131 billion won. The subsidized firms conducted R&D from as little as six months to as long as 24 months since 2006.

The purpose of this study is to analyze how the selection of TIP in 2006 influenced the survival of firms. In this regard, one must note that the analysis of the effects of government R&D subsidies can be seen as an issue of typical policy evaluation (Hussinger, 2008). In other words, analysing the treatment effect of R&D subsidy is to estimate the causal effects on the firms that received the subsidy and those that did not receive such subsidy. In the estimation of the treatment effect, a simple comparison of the outcomes would result in a biased estimator due to the missing variable or selec-

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[2] MSS provided information on the awardee firms for the in-depth evaluation of TIP (Kim, 2008) conducted by the Korea Development Institute at the request of the Ministry of Strategy and Finance in 2007.

tion bias. The selection bias occurs when the subsidized firms would have had a higher or lower probability of survival than those without subsidies even if the subsidized firms did not receive such subsidies. The main reason for an endogeneity problem in the evaluation of R&D subsidies is that the allocation of the subsidy or the treatment does not occur at random. Therefore, in order to minimize such problem, this study selected an empirical strategy with the use of matching techniques in order to eliminate the unbalanced confusion factors between the treatment group and the control group or to identify the counterfactual group. Subsequently, the survival models were applied to the sample of subsidized firms and the constructed counterfactual group to empirically analyze the impact of public R&D subsidy on SMEs survival.

For the survival analysis, the treatment group and the control group that corrected the selection bias needed to be constructed. The treatment group was linked to the KIS-VALUE data for the composition of control group and utilization of financial information.

The process of building the analysis data is as follows. First, the treatment group merged with the KIS-VALUE data in 2006 by business registration numbers (unique key). Next, the control group was selected using the Propensity Score Matching (PSM) method and the effect of TIP subsidy on the survival of SMEs was estimated using the survival analysis with the matched data.

The survival analysis is a statistical technique to analyze the factors that affect the occurrence of a specific event (in this case, bankruptcy or death) to subjects during a given period and it can take into account censoring data. For the estimation of survival function, this study used the Cox proportional hazards model with time-varying covariates as one of the semi-parametric methods. The event in the survival analysis is the bankruptcy of firms, and the fact of their bankruptcy was confirmed by using the information on the business status of National Tax Service and the business registration numbers of firms. In the matching process, covariates were firm age, firm size, financial information, and whether they are affiliated firms or not among others in 2006. In addition to the covariates used in the matching process, the survival analysis included the characteristics of industry (market concentration), macroeconomic indicators (GDP growth rate), and changes in the financial status of firms as the time-varying covariates. These time-dependent variables were included in the analysis on an annual basis from 2007 to 2016.

3.2. Analysis Methods

Matching techniques constitute a control group from the non-treated firms with the same exogenous characteristics (or covariates) as the treated firms. When treatment assignment depends on a vector of discrete and continuous covariates, the exact matching methods – which require identical values for all covariates of treatment and control groups – suffer from the curse of the dimensionality problem. The Propensity Score Matching (PSM) method defined by Rosenbaum and Rubin (1983) solves this curse of dimensionality in the matching process by reducing all dimensionalities to a one-dimensional score.

They defined the propensity score for the participant $i(i=1,\cdots,N)$ as the conditional probability of assignment to a particular treatment(W_i=1) versus non-treatment(W_i=0) given a vector of observed covariates(x_i).

$$e(X_i) = pr(W_i = 1 | X_i = x_i) \quad (1)$$

The matching between the treatment group and the non-treatment group is made through the estimated propensity score $e(X_i)$ and the Nearest Neighbor Matching (NNM) technique. NNM matches i with j that has the absolute difference of propensity scores among all possible pairs of propensity scores between i: treated participants and j: untreated participants. A neighborhood $C(p_i)$ contains a control participant j as a match for treated participant i.

$$C(p_i) = min_i \| P_i - P_j \| \quad (2)$$

where P_i and P_j are the propensity scores for treated and untreated participants, respectively. If for each i there is only a single j in $C(p_i)$, then the matching is 1-to-1 matching. This study used 1-to-n matching, which consists of multiple control groups, instead of 1-to-1 matching since the non-treatment group used for matching is significantly larger (about 60 times) than the treatment group. Abadie and Imbens (2002) suggested that n=4 usually worked well through data simulation. As per the suggestion of Abadie and Imbens (2002), this study also applied the 1-to-4 matching technique.

The estimation of the impact of TIP subsidy on firm survival depends on the survival analysis. The survival analysis can use the parametric, semi-parametric, and non-parametric approaches to estimate the hazard rate. Although the parametric survival models present the highest efficiency compared to either non-parametric or semi-parametric method (Heim et al. 2016), this study utilized the semi-parametric model (Cox proportional hazards model with time-varying covariates)[3] because the accuracy of parametric survival models depends heavily on the distributional assumptions with regard to the survival time and the population distribution of the model to be estimated is not known.

The Cox proportional hazards model is a semi-parametric method of estimating the coefficient of a model without applying a distributional assumption of the hazard function through a partial likelihood estimation method. The hazard function is the probability of failure or death of the surviving subject at time t in the very small time interval Δt.

The Cox proportional hazards model with time-varying covariates is an extension model of the Cox proportional hazards model to reflect the time-varying effects of some of the covariates. The Cox model with time-varying covariates is necessary when the proportional hazards assumption of Cox model is not satisfied since the relative risk of a covariate is not constant with time.

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[3] Most of past studies on firm survival used the Cox proportional hazards model. (Agarwal and Audretsch 2001; Cefis and Marsil 2005; Strotmann 2007; Zhang and Mohnen 2013; Smith 2016; and Heim et al. 2016).

The Cox proportional hazards model assumes that the hazard function of an individual firm at time t is proportional to the baseline hazard function.

$$h_i(t) = h_0(t) \exp\left(\sum \beta_j x_j\right) \quad (3)$$

where $h_0(t)$ is the baseline hazard function. However, if covariates are varying continuously with time, this model is called the Cox proportional hazards model with time-varying covariates and the hazard function is as (4).

$$h_i(t) = h_0(t) \exp\left(\sum \beta_j x_j + \sum \delta_j z_j(t)\right) \quad (4)$$

where x_j is the time-invariant covariates and z_j is the time-varying covariates. It is also known that the coefficient of the Cox proportional hazards model with time-varying covariates can be estimated by applying the estimation strategy of the Cox proportional hazards model (partial likelihood estimation method).

4. MATCHING PROCESS

The matching procedure that constituted the control group corresponding to the firms that have been supported by the TIP in 2006, which is the treatment group, is as follows. First, the KIS-VALUE data and the treatment group were merged. Then, among the firms that did not receive the TIP subsidy in the combined data, the firms with the same or similar covariates as the covariates of the treated firms were selected as the control group.

Of the 1,764 firms newly subsidized by the TIP in 2006, 324 firms were not included in the 2006 KIS-VALUE database. That is, among 148,597 firms included in the KIS-VALUE in 2006, 1,440 firms received the TIP subsidy. Consequently, 1,440 beneficiaries were viewed as the initial treatment group and the firms that are included in the KIS-VALUE database but did not receive the TIP in 2006 were viewed as a potential control group.

For the successful matching of the treatment and the non-treatment groups, it was necessary to control the appropriate covariates that were expected to affect the selection in the TIP. The covariates considered in the matching process were firm age, logarithm of sales, R&D expenditure, total assets, status of listed and affiliated firms, industry classification (2-digit Korean Standard Industrial Classification 9th), share of intangible assets in total assets, and whether they received the TIP subsidy from 1997 to 2005.[4]

Unfortunately, due to the unavailability of financial information, the number of firms in the treat-

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[4] The covariates controlled by the matching procedure are also used in the survival analysis, with certain exceptions. For a detailed description of each covariate, see Section 5.1.

ment group and the potential control group that were used for the matching procedure is smaller than the number of firms described above. Consequently, the treatment group and the potential control group each included 1,418 and 96,735 firms, respectively. As described in Section 3.1, each treated firm was matched with four non-treated firms in the order in which the propensity scores are most similar. This matching process allowed one non-treated firm to be matched to multiple treated firms. This matching process resulted in the formation of a control group of 5,672 firms matched to the treatment group of 1,418 firms.

Table 1 shows the analysis results of logit model for estimating the propensity score, and Table 2 represents the differences between the covariates of treatment group and non-treatment group or control group pre and post-matching.

TABLE 2. Analysis Results of Logit Model for Estimation of Propensity Score

Variables	Coefficient	Std. Err.
Estab_Year	-0.025***	0.006
Affiliate	-0.316***	0.112
Listed_Firm	-0.332**	0.151
Ln_Sale	-0.161***	0.029
Intangible_Ratio	0.017***	0.002
Ln_Total_Asset	0.045	0.037
Ln_Rnd_Exp	0.165***	0.006
Former_Subsidy	1.113***	0.065
Industry Dummy	○	
_Cons	-4.375***	0.385
Number of Obs.	98,153	
Prob>chi2	0.0000	
Pseudo R2	0.2675	

Note: *** p<0.01, ** p<0.5, * p<0.1

TABLE 3. Mean difference of Covariates Pre and Post-Matching

Variables	Before Matching			After Matching		
	Non-Treatment Group	Treatment Group	Diff.	Control Group	Treatment Group	Diff.
Estab_Year	7.660	6.972	0.688***	7.071	6.972	0.099
Affiliate	0.071	0.077	-0.006	0.083	0.077	0.006
Listed_Firm	0.015	0.042	-0.027***	0.050	0.042	0.008
Ln_Sales	14.450	14.475	-0.025	14.555	14.475	0.080
Intangible_Ratio	2.191	11.113	-8.922***	9.742	11.113	-1.371**
Ln_Total_Asset	14.215	14.572	-0.357***	14.637	14.572	0.065
Ln_Rnd_Exp	1.688	8.317	-6.629***	8.462	8.317	0.145

Former_Subsidy	0.042	0.421	-0.379***	0.366	0.421	-0.055***
Number of Obs.	96735	1418		5672	1418	
Propensity Score	0.013	0.095	-0.082***	0.095	0.095	0.000

Note: Two-sample t test with equal variances, : diff=0

According to Table 2, all covariates of the treatment group and the control group are not statistically different from each other except the Intangible_Ratio and Former_Subsidy variables at post-matching. Although there are differences between the treatment group and the control group in two variables, the magnitude of the difference is significantly reduced compared to pre-matching. In addition, the remaining heterogeneity between the groups is controlled in the survival analysis. Table 3 shows the kernel density estimates of the propensity score distributions of the treatment group and the control group. It also shows that the propensity score distributions of two groups are very similar.

FIGURE 1. Kernel Density Estimates of the Propensity Score Distribution
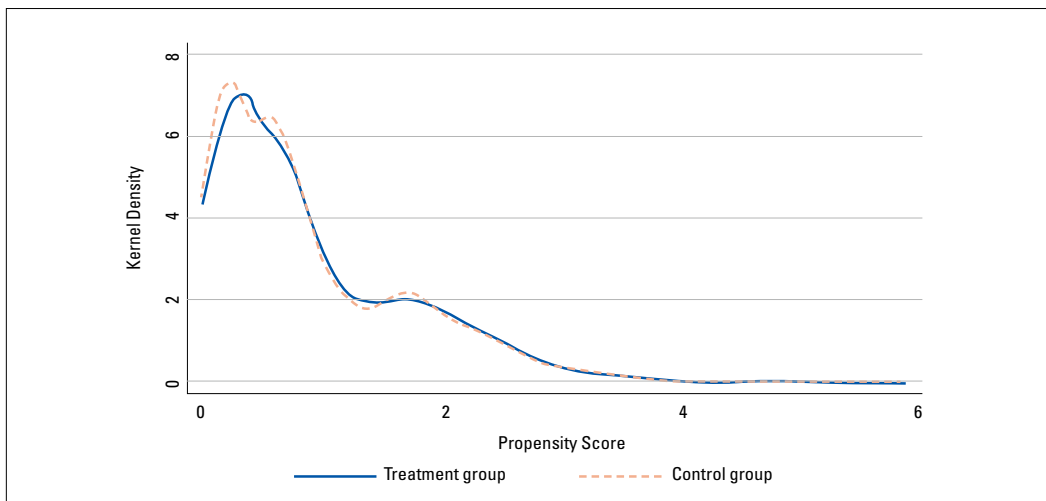
5. EMPIRICAL RESULTS

5.1. Variables and Data Descriptive Statistics

In the empirical analysis, the outcome variable, i.e., the dependent variable, was the survival period of firms. We entered the survival period (month) of 7,090 firms from January 2006 to December 2017 by searching the National Tax Service online database using the business registration numbers.[5] For example, a working firm as of December 2017 had a value of 144 (month). Subsequently,

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[5] https://www.hometax.go.kr/websquare/websquare.wq?w2xPath=/ui/pp/index_pp.xml. Search period: 2018. 1. 31. ~ 2018. 2. 5.

this data were combined with the KIS-VALUE data for 2007-2016 to include time-varying covariates such as financial information.

The survival of firms is influenced by various factors such as the macro- and micro-economic environment, regulations, and firms' financial factors among others The impact of these factors depends on the stage of growth of the firm concerned and surrounding conditions of the industry.

In industrial economics, structural factors such as size and age of firms play a major role in firm survival (Cefis and Marsil, 2005). Therefore, we also considered the size and age of firms as essential control variables. For example, Dunne et al. (1988), Baldwin and Gorecki (1991), Audretsch (1991), Cefis and Marsil (2005), and Yang and Sheu (2006) found that firm age has a positive relationship with firm survival. This analysis used the logarithm of total assets and sales of firm to control the firm size.

Among SMEs, there are affiliated firms belonging to corporate / enterprise groups. It is commonly believed that these affiliated firms are less likely to face risks of bankruptcy because they can obtain financial and technical support from their parent companies. However, it was necessary to conduct an empirical analysis to determine whether affiliated firms actually have a lower risk of exit than independent firms (i.e., non-affiliated standalone firms) because affiliated firms also carry additional risks associated with decisions of their parent companies (i.e., negative effects from poor decision-making or financial status of their parent companies) in addition to their own inherent risks. In this regard, Lee and Shin (2005) who analyzed Korean manufacturing firms found that affiliated companies are more likely to survive than independent firms.

The level of technology or innovation of firm also affects the chance of firm survival. Hall (1987), Pérez et al. (2004), Audretsch (1991), and Esteve-Perez and Manez-Castillejo (2008) found that firm's R&D activities reduce the bankruptcy risk. Cefis and Marsil (2005) and Zhang and Mohnen (2013) also confirmed that the innovation performance of firm increases the probability of firm survival. In this regard, this study used the ratio of intangible assets to total assets and the logarithm of R&D expenditure to control technology capacity and innovation activities of firms.[6] We also included total liabilities to capital stocks to reflect the relationship between the debt ratio and default risk. The logarithm of the sales and R&D expenditure and the debt ratio are time-varying covariates, and these three indicators had different values for each year when financial data were available.

The industry and macroeconomic environment also affects the survival of firm. Zhang and Mohnen

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[6] The expenditures related to R&D in the financial data of firms are divided into the ordinary R&D cost, development cost as assets, and manufacturing cost. Hence, to aggregate the accurate total R&D expenditure of firms, is balance sheet, income statement and manufacturing statement need to be confirmed. In particular, the development cost, which is an intangible asset, need to be calculated through intangible assets at the beginning and end of period and amortization. However, most SMEs tend to treat the R&D expenditure as an expense rather than an intangible asset, and it is challenging to identify changes in intangible assets by linking continuous financial data in most of small firms. Therefore, in this study, the R&D expenditure of firms is defined as the sum of the ordinary R&D cost included in the income statement and the research and ordinary development costs included in the manufacturing statement.

(2013) used the ratio of product innovators in the industry to take into account the innovation characteristics of each industry and Delmar and Shane (2004) also included the intensity of competition in the industry. Moreover, Lee and Shin (2005) and Kang (2014) showed that the bankruptcy risk of start-up firms decreases as the degree of market competition is lower, that is, the degree of market concentration of the industry is high. In contrast, Audrestch and Mahmood (1994) argued that market concentration has a statistically significant negative relationship with the survival of startups. Carling et al. (2007) and Bonfim (2009) also found that macroeconomic indicators such as the GDP growth rate and interest rates are significant factors in predicting corporate defaults. This study utilized the market concentration ratio of the top four companies as a control variable for the industry characteristics and the GDP growth rate as a macroeconomic indicator.

The independent variable in this study is the dummy variable indicating whether the firm received the TIP subsidy in 2006, and the dependent variable is the survival period of firm expressed in months. An additional consideration is that information about the date of firm's closure and the annual financial data were obtained from different databases, so that information about time-varying covariates may not exist for all periods in which the relevant firm survives. In other words, even though the firm has not closed, because information about companies is missing from the KIS-VALUE database after 2006, additional information may not be available outside of 2006. To overcome these limitations, this study performed further data modifications as follows.

First, there was a certain modification process for companies that were closed before December 2017. If there was no financial information at the time of closing, the most recent financial information available for the relevant firm was used as a time-varying covariate at the time of closing. For example, if the financial information of a firm closed in 2010 was only available until 2008, the 2008 financial data was reflected in the analysis as the firm's latest financial information at the time of closing.

Next, there were two ways to modify surviving firms. The first method was to apply the recent financial information available to the time of final phase of survival for the purpose of revision. For example, if the surviving firm's financial data was only available until 2015, we entered 144 months (the period from 2006 to 2017) in the row containing the 2015 time-varying covariates. The second method was to treat a firm that did not have available financial information as a censored case for the time periods in which there was no financial information available even though it was confirmed that the firm survived until December 2017. In such case, the final survival period of the firm was modified from 144 months to 120 months. This study chose to apply the second method.[7]

The final panel data combined with the financial data for 2007-2016 had 54,531 observations. Table

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[7] The results of the analysis are the same regardless of whether the final survival period of the surviving firm is 144 months or the firm without financial information is treated as a censored case. However, the coefficient estimates and statistical significance of the industrial and macroeconomic variables change only slightly. Compared with model 3 in Table 7, the coefficient estimates of GDP_growth changes statistically significantly at the significance level of 5%.

3 shows the definitions and types of the variables used in the analysis and whether each variable was included in the matching process and survival analysis.

TABLE 4. Definition of Variables

Variables	Definition	Type	Logit Model	Survival Analysis
Subsidy	1 if the firm received the TIP subsidy in 2006	C	D.V.	○
Estab_Year	Age of firms (2006 - year of establishment)	C	○	○
Affiliate	1 if affiliated firms	C	○	○
Listed_Firm	1 if the firm is listed on KOSPI or KOSDAQ	C	○	○
Former_Subsidy	1 if the firm received the TIP subsidy before 2006	C	○	○
Ln_Total_Asset	Logarithm of total assets in 2006	C	○	○
Intangible_Ratio	Ratio of intangible assets to total assets in 2006 (%)	C	○	○
Ln_Sale	Logarithm of sales in 2006 - Use only 2006 data for logit analysis	T	○	○
Ln_Rnd_Exp	Logarithm of the annual R&D expenditure - Use only 2006 data for logit analysis	T	○	○
Debt_Ratio	Debt ratio (Total liabilities / Capital stock) * 100	T	○	○
CR4	Market concentration ratio (sales) of the largest four companies in industry according to the KSIC (Korean Standard Industrial Classification, ver.9) (%)	T	○	○
GDP_Growth	Annual GDP growth rate	T	○	○

Note: C is a time-constant covariates and T is time-varying covariates

TABLE 5. Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
Subsidy	54,531	0.197	0.397	0	1
Estab_Year	54,531	7.472	6.150	0	62
Affiliate	54,531	0.091	0.288	0	1
Listed_Firm	54,531	0.054	0.226	0	1
Ln_Total_Asset	54,531	14.814	1.426	8.869	22.400
Intangible_Ratio	54,531	8.620	16.132	0	99.764
Ln_Sale	54,531	15.273	1.598	2.303	21.635
Ln_Rnd_Exp	54,531	8.640	5.559	0	18.625
Debt_Ratio	54,531	913.610	1,681.822	0.059	96,758.62
CR4	54,531	25.169	18.275	2.600	96.980
GDP_Growth	54,531	3.625	1.596	0.700	6.500

5.2. Analysis Results

The purpose of this study is to analyze the effects of government R&D subsidies on the survival of firms. Hence, the primary concerns were the period until the closing of firms and the probability of firm survival. As explained above, firms that closed down before December 2017 had a monthly period from 2006 to the closing date as the survival duration and firms that survived until December 2017 were assigned 144 months.

Table 5 describes the summary statistics of survival time. Figure 2 shows the Kaplan-Meier survival estimates (the ratio of surviving firms) for the subsidized and non-subsidized groups.

TABLE 6. Summary Statistics of Survival Time

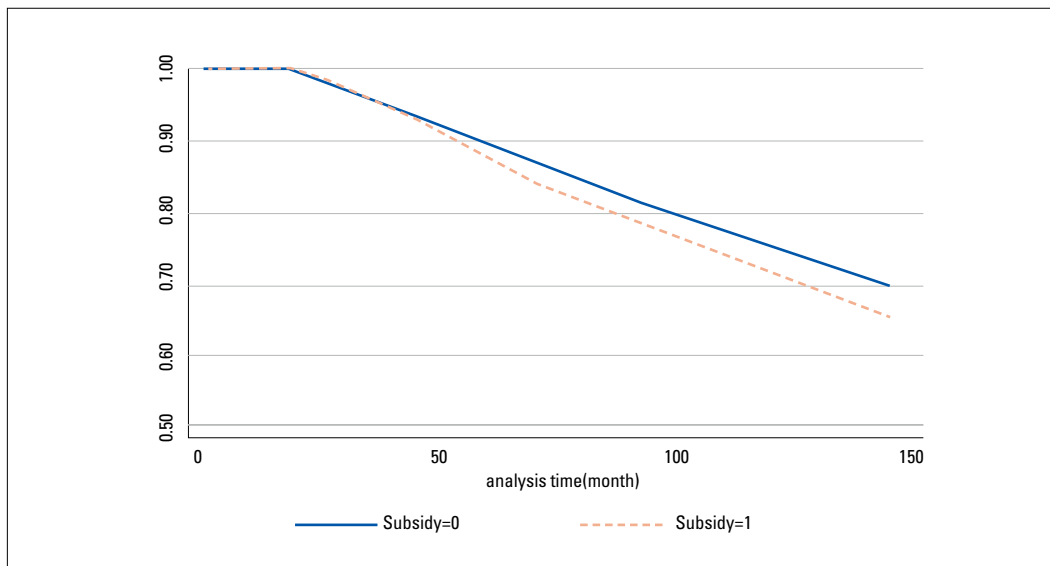| Survival Time (month)	Mean	Min	Q1	Median	Max
Total	114.58	12	117	144	144
Subsidy=0	114.93	12	120	144	144
Subsidy=1	113.17	15	103	144	144

FIGURE 2. Kaplan-Meier Survival Estimates

Table 5 and Figure 2 show that the mean survival time of the non-subsidized group is slightly longer and also the non-subsidized group is more likely to survive. And according to Table 6, the null hypothesis that the survival functions of the two groups are equal is rejected as a result of the log-rank test.

TABLE 7. Results of Log-Rank Test for Equality of Survivor Functions

Subsidy	Events Observed	Events Expected
0	1,530	1,586.73
1	446	389.27
Total	1,976	1,976
chi2(1) = 10.34, Pr>chi = 0.0013		

The Kaplan-Meier analysis assumes that the characteristics of the groups to be compared are controlled to be the same. Although this study controlled the difference between the characteristics of the subsidy recipients and non-recipients using the matching method, there was a residual confounding factor because it was not a perfect or exact matching. In a long-term analysis over ten years, it would be necessary to consider time-varying variables to reflect the financial status of the firms and the changes in the industry and macroeconomic environment. Hence, this study used the Cox proportional hazard model with time-varying covariates.

Model 1 in Table 7 is the result of Cox regression that took into account only time-invariant covariates, and Model 2 additionally includes time-varying covariates that represent the changes in the firms' financial status. Model 3 is the analysis result of the full model including the intensity of market competition and economic growth rate on an annual basis.

TABLE 8. Results of Survival Analysis

Variable	Model 1		Model 2		Model 3	
	Coeff.	Haz. Ratio	Coeff.	Haz. Ratio	Coeff.	Haz. Ratio
Subsidy	0.150*** (0.054)	1.162*** (0.063)	0.186*** (0.054)	1.204*** (0.065)	0.183*** (0.054)	1.201*** (0.065)
Estab_Year	-0.039*** (0.006)	0.962*** (0.005)	-0.043*** (0.006)	0.958*** (0.005)	-0.042*** (0.006)	0.959*** (0.005)
Listed_Firm	0.223** (0.112)	1.250** (0.140)	0.147 (0.113)	1.158 (0.131)	0.138 (0.113)	1.148 (0.129)
Affiliate	0.204** (0.090)	1.226** (0.111)	0.180** (0.090)	1.198** (0.108)	0.175* (0.090)	1.192* (0.108)
Intangible_Ratio	0.012*** (0.001)	1.012*** (0.001)	0.007** (0.001)	1.007*** (0.001)	0.007*** (0.001)	1.007*** (0.001)
Ln_Total_Asset	-0.067*** (0.019)	0.935*** (0.018)	0.174*** (0.021)	1.190*** (0.026)	0.165*** (0.022)	1.180*** (0.025)
Ln_Sale			-0.003*** (0.000)	0.997*** (0.000)	-0.003*** (0.000)	0.997*** (0.000)
Ln_Rnd_Exp			-0.0004*** (0.0000)	0.9996*** (0.0000)	-0.0004*** (0.0000)	0.9996*** (0.0000)
Debt_Ratio			-0.000 (0.000)	1.000 (0.000)	-0.000 (0.000)	1.000 (0.000)
CR4					0.00004*** (0.00001)	1.00004*** (0.00001)

					0.0007 (0.0004)	1.0007 (0.0004)
GDP_Growth						
Number of Obs.	54,531		54,531		54,531	
Prob>chi2	0.000		0.000		0.000	

According to the results of Table 7, there is a positive relationship between firm age and firm survival, and these results are the same as those of Dunne et al. (1988), Baldwin and Gorecki (1991), Audretsch (1991), Cefis and Marsil (2005), and Yang and Sheu (2006). However, in contrast to the results of Lee and Shin (2005), the survivability of affiliates was lower than independent firms. This result shows that the magnitude of the additional risk arising from the parent company's business situation or decision making is higher than the benefits from parent company's support.

The study also found that the R&D investment and sales of firms, which are considered as time-varying covariates, have a positive relationship with firm survival. This finding is consistent with the analysis results of Hall (1987), Pérez et al. (2004), Audretsch (1991), and Esteve-Perez and Manez-Castillejo (2008) that firm's R&D lowers the risk of bankruptcy. However, it was also found that the debt ratio among the time-varying covariates does not have a statistically significant impact on firm survival.

Another finding of the study was that the analysis results of the market concentration of the top four firms by industry show that the degree of market concentration of the industry or the market share of the large incumbent firms and the probability of firm survival have a negative relationship statistically. This result is the same as the result of study of Audrestch and Mahmood (1994), but it is opposite to the results of studies of Lee and Shin (2005) and Kang (2014). It was also found that the macroeconomic indicator does not have a statistically significant effect on firm survival.

In light of the foregoing, this section of the study will examine the results of the subsidy variable, which is the focus of this study. The firms with the TIP subsidy in 2006 have a higher risk of exit or lower likelihood of survival than those who did not receive the subsidy. The TIP subsidy statistically significantly increases the hazard rate of bankruptcy by 20.4%, ceteris paribus. This result is different from the general expectation that the government R&D subsidy would increase the subsidized firm's innovation capacity and firm survival, as described in the introduction. In the foregoing context, we present three possible causes for explaining this result.[8]

First, as a result of the analysis, it was found that the TIP subsidy has a negative impact on firm survival over the long term. If the subsidy resulted in a crowding-out effect, which reduces the firm's own R&D spending, and the firm spending less efforts on the subsidized project compared to its projects funded with its own money, the government R&D subsidy may have reduced the firm's

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[8] The three possible causes explain the general cause of the long-term negative effects of subsidies on the survival of firms, which does not preclude the possibility of negative consequences due to factors not controlled by analysis models. Hence, we present the limitation of this study in Section 5.

R&D performance and detrimentally affected the firms' long-term survival.

Second, there may be a problem in the selection process of the subsidy's awardees. This problem can be divided into data problems in the analysis process and problems of authorities in the selection process. Regarding the analytical procedure, even though subsidized and non-subsidized firms were almost similarly matched to each other through the matching technique, there may be a difference in the characteristics between the two groups by unobserved factors. In other words, uncontrolled factors such as CEO's risk-taking propensity and financial status before 2006 may have affected firm survival. Next, the authorities may have failed to select firms that would have achieved excellent innovation performance in the selection process of the awardees. This means that the government agency selected excellent firms on the face of documents but may have failed to confirm the actual R&D capacity of such firms.

Third, in evaluating certain government support policies, ten years may be too long. This analysis assumed that the characteristics of the treated firms and the matched control firms are identical except for the characteristics controlled by the survival analysis. For these reasons, uncontrolled characteristics such as a receipt of additional government support may have distorted the analysis results in combination with a long period of ten years. Therefore, we performed an additional analysis by constructing the mid-term data of four and six years each after the receipt of government subsidy.[9]

TABLE 9. Results of Survival Analysis at Short- and Mid-Term

Variables	4 years		6 years	
	Coeff.	Haz. Ratio	Coeff.	Haz. Ratio
Subsidy	0.044 (0.106)	1.044 (0.111)	0.245*** (0.075)	1.278*** (0.096)
Estab_Year	-0.030*** (0.010)	0.971*** (0.010)	-0.035*** (0.008)	0.966*** (0.008)
Listed_Firm	-0.372 (0.259)	0.689 (0.178)	0.135 (0.155)	1.144 (0.177)
Affiliate	0.256 (0.169)	1.292 (0.218)	0.112 (0.123)	1.118 (0.137)
Intangible_Ratio	0.008*** (0.002)	1.008*** (0.002)	0.007*** (0.001)	1.007*** (0.001)
Ln_Total_Asset	0.277*** (0.044)	1.319*** (0.059)	0.255*** (0.031)	1.291*** (0.040)
Ln_Sale	-0.009*** (0.001)	0.991*** (0.001)	-0.007*** (0.0004)	0.993*** (0.0004)
Ln_Rnd_Exp	-0.001*** (0.0002)	0.999*** (0.0002)	-0.001*** (0.0001)	0.999*** (0.0001)

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[9] The four year period covers the data from 2006 to December 2009, and the six year period covers the data from 2006 to December 2011.

Debt_Ratio	-0.000 (0.000)	1.000 (0.000)	0.000* (0.000)	1.000* (0.000)
CR4	0.0002*** (0.0001)	1.0002*** (0.0001)	0.0002*** (0.00003)	1.0002*** (0.00003)
GDP_Growth	0.051** (0.026)	1.052** (0.027)	-0.004*** (0.001)	0.996*** (0.001)
Number of Obs.	18,669		28,152	
Prob>chi2	0.000		0.000	

Note: ( ) standard error, * p<0.1; ** p<0.05; *** p<0.01

According to the analysis results of four and six years in Table 8, the analysis of the 4-year period shows that the subsidy variables do not have a statistically significant effect on firm survival. On the other hand, in the analysis of the 6-year period, the hazard rate of bankruptcy of the subsidized firms is statistically significantly higher than that of non-subsidized firms by 27.8%. These results represent that the TIP subsidy does not have a significant effect on firm survival even in the relatively short-term period (4-years), and also significantly decreases the survival probability of subsidized firms in mid-term of six years.

6. CONCLUSION

This study analyzed the effect of the government R&D subsidy program on long-term firm survival as a measure to overcome the limitations of existing studies evaluating the short-term effects of subsidies on SMEs. In order to estimate the average treatment effect for the treated group that received the TIP subsidy in 2006, we used the survival analysis and matching method by constituting a comprehensive dataset of more than 90,000 observations.

The analysis result shows that the government R&D subsidy has a negative impact on long-term firm survival. In particular, not only the TIP subsidy does not have a statistically significant effect on firm survival in the relatively short term period (4-years), the survival probability of the subsidized firms is statistically significantly lower than the non-subsidized firms in the mid-term period of six years. These results can be seen as weakening the justification of government R&D subsidy support that promotes innovation in firms and enhances the competitiveness of firms through such innovations. Given that there is no difference in firm survival in a relatively short term period, it is highly likely that the government R&D subsidy did not produce superior innovation that enhances the competitiveness of firms.[10]

Dimons and Pugh (2016) reviewed past studies for the meta-regression analysis of the effectiveness of R&D subsidies and they reported that more than two-thirds of the reviewed researches found that the R&D subsidies have had a positive effect on R&D output such as patents and R&D

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[10] Kim (2008) suggested that even in the short term (2 years), the TIP subsidy does not have a statistically significant effect on both employment and sales of firms.

sales. Although our study does not provide a detailed evaluation of the impact of subsidies on R&D investment, innovation performance, and innovation capacity of firms, the results of our survival analysis show that even if the government R&D subsidy improves the output indicators such as patents or R&D expenditures, these innovation outputs may not enhance the competitiveness of the subsidized firms.

As mentioned earlier, there may be problems in the government's subsidy policy and the process of selection of awardees. However, the more fundamental problem is that the subsidy policy is concluded as the one-time event. In particular, it is common to evaluate the effectiveness of subsidy through visible short-term outcomes such as patents and the authorities are more focused on finding other new projects every year.

Admittedly, it is difficult for the government to precisely manage the subsidized projects over a long term. However, in the case of a project in which short-term performance is detected, it would be necessary to provide a step-by-step support to strengthen the firm's competitiveness through further support and continuous development of performance. Of course, mid- and long-term evaluations of subsidy support policy should be provided in parallel with such phased support.

This study has a limitation – even though its empirical analysis is more advanced than the past studies by using the panel data and matching method. In particular, this study did not reflect whether the firms received additional government R&D subsidy after 2006. Although this limitation is inevitable due to inherent limitations in the data, if the firms that did not receive the TIP subsidy in 2006 are more likely to receive other subsidies after 2006 than the subsidized firms, we may have overestimated the survival probability of non-subsidized firms. Therefore, we hope to analyze the model that will complement the limitation of this study in the future.

REFERENCES

Abadie, A., and Imbens, G.W. (2002). Simple and bias-corrected matching estimators (Technical report). Department of Economics, University of California, Berkeley. Retrieved August 8, 2008, from http://ideas.repec.org/p/nbr/nberte/0283.html

Agarwal, R. and Audretsch, D.B. (2001), Does entry size matter? The impact of the life cycle and technology on firm survival, *The Journal of Industrial Economic*, 49, 21-43.

Audretsch, D.B. (1991), New Firm Survival and the Technological Regime, *Review of Economics and Statistics*, 73(3), 441-450.

Audretsch, D.B. and Mahmood, T. (1994), The rate of hazard confronting new firms and plants in U.S. manufacturing, *Review of Industrial Organization*, 9, 41-56.

Baldwin, J.R. and Gorecki, P.K. (1991), Firm entry and exit in the Canadian manufacturing sector: 1970-1982, *Canadian Journal of Economics*, 24, 300-323.

Bercovitz, J., and Feldman, M. (2007), Fishing upstream: Firm innovation strategy and university research alliances, *Research Policy*, 36(7), 930-948.

Bonfim, D. (2009), Credit Risk Drivers: Evaluating the Contribution of Firm Level Information and of Macroeconomic Dynamics, *Journal of Banking & Finance*, 33, 281-299.

Buiseret, T., Cameron, H. and Georgiou, L. (1995), What Differences Does it Make? Additionality in the Public Support of R&D in Large Firms, *International Journal of Technology Management*, 10(4-6), 587-600.

Carling, K., Jacobson, T., Lindé, J., and Roszbach, K. (2007), Corporate Credit Risk Modelling and the Macroeconomy, *Journal of Banking & Finance*, 31, 845-868.

Cefis, E. and Marsil, O. (2005), A matter of life and death: Innovation and firm survival, *Industrial and Corporate Change*, 14(6), 1167-1192.

Cohen, W.M. and Klepper, S. (1996), A Reprise of Size and R&D, *The Economic Journal*, 106(437), pp.925-951.

Czarnitzki, D. and Hussinger, K. (2004), The Link Between R&D Subsidies, R&D Spending and Technological Performance, *ZEW Discussion Paper*, No. 04-56.

Czarnitziki, D., Hanel, P., and Rosa, J. (2011). Evaluating the impact of R&D tax credits on innovation: A microeconometric study on Canadian firms. *Research Policy*, 40(2), 217-229.

David, P., Hall, B., and Toole, A. (2000), Is public R&D a complement or a substitute for private R&D? A review of the econometric evidence, *Research Policy*, 29(4-5), 497-529.

Delmar, F. and Shane, S. (2004), Legitimating first: organizing activities and the survival of new ventures, *Journal of Business Venturing*, 19(3), 385-410.

Dimos, C. and Pugh, G. (2016), The effectiveness of R&D subsidies: A meta-regression analysis of the evaluation literature, *Research Policy*, 45, 797-815.

Duune, T., Roberts, M.J. and Samuelson, L. (1988), Patterns of firm entry and exit in the U.S. manufacturing industries, *RAND Journal of economics*, 19, 495-515.

Einio, E. (2014). R&D subsidies and company performance: Evidence from the geographic variation in government funding based on the ERDF population-density rule. *The Review of Economics and Statistics*, 96(4), 710-728.

Esteve-Perez, S., and Manez-Castillejo, J. (2008). The resource-based theory of the firm and firm survival. *Small Business Economics*, 30(3), 231-249.

Hall, B.H. (1987), The relationship between firm size and firm growth in the US manufacturing sector, *The Journal of Industrial Economics*, 35, 583-606.

Hall, B.H. (2002), The financing of research and development, *Oxford Review of Economic Policy*, 18(1), 35-51.

Heijs, J. and Herrera, L. (2004), The distribution of R&D subsidies and its effect on the final outcome of innovation policy, *IAIF Working Paper* No. 46.

Heim, S., Hüschelrath, K., Schmidt-Dengler, P. and Strazzeri, M. (2016), The impact of state aid on the survival and financial viability of aided firms, Retrieved from http://ftp.zew.de/pub/zew-docs/dp/dp16035.pdf

Hussinger, K. (2008), R&D and subsidies at the firm level: An application of parametric and semiparametric two-step selection models. *Journal of Applied Econometrics*, 23(6), 729-747.

Jyrki, A.Y. (2004), Impact of public R&D financing on private R&D: Does financial constraint matter?, *ETLA: Keskusteluaiheita Discussion papers*, No.943.

Kang, G.N. (2014), Studies on Intellectual Property and Economic Development (in Korean), Korea Institute of Intellectual Property

Kim, K.W. (2008), In-depth Evaluation of Budgetary Program: Innovation Development Program for SMEs (in Korea), Korea Development Institute.

Lee, B.K. and Shin, K.C. (2005), The Determinants of New Firms Survival: An Empirical Analysis Using Hazard Model (in Korean), *KUKJE KYUNGJE YONGU*, 11(1), 131-154.

Mansfield, E. (1995). Academic research underlying industrial innovations: Sources, characteristics, and financing. *The Review of Economics and Statistics*, 77(1), 55-65.

Musso, P., and Schiavo, S. (2008). The impact of financial constraints on firm survival and growth. *Journal of Evolutionary Economics*, 18(2), 135-149.

Nelson, R. (1959), The Simple Economics of Basic Scientific Research, *Journal of Political Economy*, 67, 297-306.

Park, S.J., Koh, Y.U., Bae, Y.I. and Oh, M.H. (2014), The Study on Employment Impact Assessment of Technology Innovation R&D Program on SMEs (in Korean), Korea Labor Institute.

Pérez, S., Llopis, A. and Llopis, J. (2004), The Determinants of Survival of Spanish Manufacturing Firms, *Review of Industrial Organization*, 25(3), 251-273.

Rosenbaum, P.R. and Rubin, D.B. (1983), The central role of the propensity score in observational studies for causal effects, Biometrika, 70, 41-55.

Saxenian, A. (1994), Regional advantage: Culture and competition in Silicon Valley and Route 128, Cambridge, MA: Harvard University Press.

Schumpeter, J.A. (1942), Capitalism, Socialism, and Democracy, New York: Harper.

Smith, D.P. (2016), The longer term effects of federal subsidies on firm commercialization and survival: Evidence from the advanced technology program, Doctoral dissertation, University of North Carolina.

Strotmann, H. (2007), Entrepreneurial survival, *Small Business Economics*, 28(1), 87-104.

Wagner, J. (2002), The Causal Effects of Exports on Firm Size and Labor Productivity: First Evidence from a Matching Approach. *Economics Letters*, 77(2), 287-292.

Yang, C.Y. and Sheu, H.J. (2006), Managerial Ownership Structure and IPO Survivability, *Journal of Management and Governance*, 10(1), 59-75.

Zhang, M.Q. and Mohnen, P. (2013), Innovation and Survival of New Firms in Chinese Manufacturing: 2000-2006, *MERIT Working Paper* 057.