Government support for SME innovations in the regional industries: The case of government financial support program in South Korea

Soogwan Doh\textsuperscript{a}, Byungkyu Kim\textsuperscript{b, *}

\textsuperscript{a} Department of Public Administration, Catholic University of Daegu, 330 Geumrak-ri, Hayang-eup, Gyeongsan-si, Gyeongsangbuk-do 712–702, South Korea
\textsuperscript{b} Department of Public Administration, Andong National University, 1375 Gyeongdong-ro, Andong-si, Gyeongsangbuk-do 760–749, South Korea

\textbf{ARTICLE INFO}

\textbf{Article history:}
Received 10 June 2012
Received in revised form 14 August 2013
Accepted 4 May 2014
Available online 2 June 2014

\textbf{Keywords:}
Innovation
SMEs
R&D
Regional industries
Patent
Governmental financial support

\textbf{ABSTRACT}

This study explores the impact of governmental support policies on the innovation of SMEs in the regional strategic industries in South Korea. We use the technological development assistance funds as a proxy for governmental support policies for SMEs in the regional industries in Korea. The innovation of SMEs is measured by technological innovation: patent, utility model, trademark, and new design registrations. Before empirically testing the impact of governmental support policies on the innovation of SMEs, this study reviews the literature concerning the innovation and the governmental support policies of SMEs in regional industries. Results from empirical models, which simultaneously control for factors which were thought to affect the innovation of regional SMEs, indicate that a positive relationship exists among the technological development assistance by the Korean government and patent acquisitions and new design registrations of regional SMEs. Networks with universities also have a positive relationship with patent acquisitions and new design registrations of regional SMEs. This study suggests there is an importance to governmental financial aids for regional SME innovations, and there is an importance to the need to build a strong social relationship in today’s networked economy.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Since the middle 1980s, the world economy evolved into a knowledge-based economy driven by rapidly changing technologies and markets (Doh and Acs, 2010). Sustainable economic performance has been, and remains, a central topic for policy agendas around world. Accordingly, a fundamental issue that continually demands the attention of policy makers concerns the drivers of economic performance in this contemporary knowledge-based economy.

Over the years, a variety of arguments have been put forth to address this issue. Each government, irrespective of countries, have been accounting for regional and local factors which affect entrepreneurship. This is because entrepreneurship has been regarded as one of the important drivers of sustainable economic development and growth in this current knowledge-based economy (Acs, 2006; Acs et al., 2004; Baumol, 2002, 2004; Audretsch and Keilbach, 2004; Audretsch and Thurik, 2001; Shane, 2000; Kirzner, 1997; Grossman and Helpman, 1994). In particular, each government puts much importance on the potential contribution of small and medium-sized enterprises (SMEs) toward economic performance, as new technologies reduce the importance of the scale of economies in many kinds of activities (Kramer et al., 2007; OECD, 2004a; Berry, 2002; McIntyre, 2001; Liesch and Knight, 1999). According to OECD (2000), SMEs account for over 95% of firms, 60–70% of employment, and they generate a large share of new jobs in OECD countries. Thus, SMEs play an important role in economic performance in OECD areas, providing the sources for most new jobs and innovations. The performance of SMEs in terms of industrial renewal, job creation, export growth, and productivity thus demands the attention of policy makers. However, many of the traditional problems facing SMEs, such as “lack of financing, difficulties in exploiting technology, constrained managerial capabilities, low productivity, and regulatory burdens,” has become more acute in this new knowledge-based economy (OECD, 2000: 1). Thus, each government has policy initiatives to improve SMEs access to financing and information infrastructures, and to provide SMEs with regulatory, legal and financial frameworks conducive to entrepreneurship, start-up, and growth.

South Korea, an OECD member, has experienced remarkable economic growth since 1970. The most significant factor in the
rapid industrialization was the adoption of an outward-looking strategy in the early 1960s. The strategy promoted economic growth through labor-intensive manufactured exports and government initiatives which played an important role in the growth. However, the export-oriented development strategy of Seoul, the capital city of South Korea, left the rural area relatively underdeveloped by putting emphasis mostly on the industrial sectors. Most industries were located in the urban areas of the northwest and southeast parts of South Korea. Despite government efforts to decrease income disparity between the industrial and agricultural sectors, increasing income disparity was a serious problem in the 1970s and remains a problem still today.

Beginning with DJ Administration’s regime in South Korea, various strategies for balanced regional development have been implemented under various names. In particular, policy initiatives promoting regional industries have been a core of those strategies. Considering the importance of SME innovations, the Korean government has given large amounts of public money (about 957 million US dollars (14.2% of total R&D investment for SMEs) in 2010) to SMEs to promote SME innovations in regional industries, beginning with a public R&D investment of approximately 339 million US dollars (11.8% of total R&D investment for SMEs) in 2005 (OECD, 2011). As a result of the consideration of government, South Korea is regarded as having set a successful model for SME development. According to recent Small and Medium Business Administration (SMBA) of Korea’s internal report, Korean SMEs have developed steadily as a backbone of the national economy and are making important contributions to nation’s economy, creating new job opportunities, the leverage necessary to strong, sustainable and balanced growth within the frame of the global economic system. Fig. 1 describes the status and development of SMEs in South Korea.

To have these SME initiatives implemented, it is necessary to evaluate SME programs based on their relevance and effectiveness. Evaluation of SME programs is essential justifying their costs and to assist in the design of future SME programs (OECD, 2000). However, the SME initiatives of South Korea have been mainly assessed based on each SME’s individual achievements based on reports, not on policy objectives promoting regional industries, such as technology innovation performance (i.e. patent acquisition, new design registration, etc.) of regional SMEs, even though huge amounts of public funds have been invested in promoting regional industries. Making successful governmental intervention effective at realistic costs–benefit ratios (Bennett, 2008) – is difficult, it is needed to evaluate government SME programs for the design of future SME programs.

In addition, most previous studies did not consider technological development networks with outside organizations, such as universities, public and private research institutes, and corporations, as an important explanatory variable for regional SME innovations in the viewpoints of innovation systems in South Korea. But, technological development networks can catalyze SME innovations and achievements in regional industries (Eom and Lee, 2010; Link and Scott, 2005; Mowery and Sampat, 2005; Faems et al., 2005; Belderbos et al., 2004; George et al., 2002; Hall and Ziedonis, 2001). Therefore, various technological development networks need to be considered in empirical models for regional SME innovations.

This study is designed to fill this gap in the previous literature on regional SME innovations in South Korea, and is designed to empirically test the impact of government support policy on the regional SME innovations in the regional industries in South Korea. Although literature on the effect of government funding to innovation performance for different sizes of firms in different countries are very extensive already, this study focuses on the SMEs in South Korea in that most previous studies have been intended for managers in large companies. For those who are not too familiar with the South Korea’s science & technology development would have the impression that the economic growth through innovation for South Korea in the last two decades came mainly from the giant companies (so-called Chaebols), like Samsung, LG, Hyundai, etc. The situation of the SMEs in South Korea is largely unknown to many researchers and readers. The contributions of this study are also different from those of previous studies regarding the SMEs in South Korea (i.e. Yi, 2012; Lee et al., 2010; Eom and Lee, 2010; Choi et al., 2009) because this study analyzes the impact of local government support policy funded by central government on the SME innovations using panel data at the firm level. Thus, this study may contribute to the literature on the effect of government support policy on the SME innovations. This study can also give some implications of the effect of the Korean government support policy on the SME innovations to other developing countries.

Specifically, this study explores the impact of government support policies on technology innovation of SMEs in the Gyeongbuk province, South Korea. Gyeongbuk has been promoting regional strategic industry projects with the aim of creating clusters of innovation-oriented regional development in the areas of new materials development, electronic information devices, and oriental biotechnology.

This paper is structured as follows. Section 2 reviews the existing literature on the SME innovations, the relationship between technology development assistance by government and SME innovations and government support for SME innovations, and SME policy initiatives implemented by the Korean government. Section 3 explains the data, variables, and methodologies for the empirical analysis. Section 4 discusses the empirical results with interpretations. Section 5 provides the concluding remarks and implications for future research.

2. Theoretical and conceptual background

2.1. Innovation and SMEs

Innovation occurs in many forms and comprises many different processes (Hansen, 1992). A conventional understanding of the innovation process, which has been shaped largely by scientists, such as Joseph Schumpeter (1942), John Kenneth Galbraith (1956), and Alfred Chandler (1977), was based on the assumption that innovation lies in the domain of large enterprises. Business by SMEs would be outside the domain of innovation because of its own inefficiencies, as well as its deficit of resources and knowledge assets required to generate and commercialize ideas (Acs and Audretsch, 2005). But, the conventional understanding of the innovation has been challenged by a new perspective known as the Entrepreneurship Theory. This new understanding of innovation suggests that entrepreneurial SMEs, as well as large established enterprises, play an important role in innovation (Lee et al., 2010; Maula et al., 2006; Edwards et al., 2005; Laursen and Salter, 2004; Gregory et al., 2002; Link and Bozeman, 1991; Scherer, 1991; Acs and Audretsch, 1988, 1990, 2005; Rothwell, 1992). In other words, SMEs play a

---

1 Dae Jung Kim was the 15th President of South Korea (1998–2001).
2 The DJ government also spent a huge amount of public funds in venture capital and business incubator industries, and it improved access to other types of financing in view of the SME role in regional economic performance.
Thus, Product innovation, by Korea competitive Source patenting et critical 2008; competitiveness, to be expected 2010; Adapted their performance to resources in SME’s and large performance to be assumed (Acs and Audretsch, 1994). Thus, extensive literature has addressed the importance of SMEs in innovation (Lee et al., 2010; Acs and Audretsch, 1990).

According to Hall and Harvie (2003), innovation is critical at the product and process application level. And, productivity can be a measure of the performance of SMEs as innovators. Product innovations are assumed to be the result of a search for technological competitiveness, such as the strategy of market expansion and patenting activity (Vaona and Pianta, 2008). Process innovations are assumed to emerge from a strategy of active price competitiveness dominated by a search for efficiency (Vaona and Pianta, 2008; Antonucci and Pianta, 2002; Pianta, 2001). Thus, SMEs are expected to rely more on innovative dynamics in terms of product innovations, and they critically depend on greater production flexibility in terms of process innovations.

A very large amount of literature explored the relationship between innovation and SMEs based on market concentration and the knowledge-based environment in which firms operate. According to the literature on market concentration, SMEs are more innovative in competitive markets (De Jong and Marsili, 2006; Laforet and Tann, 2006; Wagner and Hansen, 2005), whereas large firms perform better in monopolistic markets and concentrated industries with high entry barriers (Audretsch, 2001; Burke and To, 2001; Audretsch and Mata, 1995; Acs and Audretsch, 1987). Rothwell and Dodgson (1994) argue that the role of SMEs is more relevant where niche markets exist and entry costs are lower.

In terms of the knowledge-based environment in which firms operate, SMEs appear to be better at capturing the benefits of networking for innovation (Edwards et al., 2005; Rogers, 2004), and at exploiting external economies deriving from a more innovative environment by the benefit of proximity to the R&D centers of large firms and universities (Eom and Lee, 2010; Link and Scott, 2005; Mowery and Sampat, 2005; Faems et al., 2005; Belderbos et al., 2006). SMEs are expected to rely more on market power in terms of product innovations, and they may invest more in new machinery and search for larger markets in terms of process innovations (Vaona and Pianta, 2008).

---

4 Especially, SME’s performance and sustainability are more important in South Korea because a large chaebol (conglomerate) overwhelms most economic markets.

5 SME performance can be defined as the organization’s ability to attain its goals by using resources in an efficient and effective manner (Daft, 1991). As a result of innovation, productivity is an important outcome.

---
the administrative costs and burdens of SMEs to promote the SME innovation.

Third, many government support measures exist to help SME innovation link with, and engage in, joint activities with other actors, because the creation of networks in innovation is important in this knowledge-based economy. In this knowledge-based economy, innovation is a social process (Doh and Acs, 2010). It is no longer achieved by isolated individuals and it is conceived as an interactive process involving both formal and informal relationships among various actors connecting through social networks (Hidalgo and Albors, 2008; Landry et al., 2002; Pyka, 2002; Kline and Rosenberg, 1986). Technological networks (collaboration and partnership) between actors in markets are important sources of innovation. Thus, governments have tried to promote alliances and build networks among SME cross sectors and cross borders. In particular, governments improve SME access to information about networking opportunities, increase the participation of SMEs in research and innovation networks, support the emergence and maintenance of innovative clusters for strengthening cooperation among firms, and identify and promote the best practice policies which support the innovation of SMEs through cluster development (Wilson, 2007).

Fourth, SMEs are a special risk group because of vulnerability, insufficient funds of their own, dependence on only a few clients, and a lack of collateral and/or credit history. Bankers in markets also offer higher interest rates reflecting the cost of risk and management and have no lending services provided for SMEs. Thus, governments provide SMEs with financial incentives and assistance to help the innovation of SMEs. However, innovative SMEs must be market-driven because the over-dependence of SMEs on public support and finance will not help SME sustainability. In other words, too much public financial support, without market co-investments, can hinder SME innovation by creating possible market distortion.

Finally, governments reinforce, for SME innovation, legal frameworks to protect intellectual properties, and discourage monopolies and unfair trade practices. In terms of intellectual property rights, SMEs lack a good working understanding of the system and consequently under exploit current forms of intellectual property protection. So, the reinforcement of legal frameworks by governments is critical in the innovation of SMEs (Wilson, 2007).

While government support is often based on overcoming market failures in the availability or use of SME support, successful government intervention is difficult to make effective at realistic costs–benefit ratios (Bennett, 2008). Thus, it is not possible to suggest that any one kind of government support is absolutely better than any other kind of government support for SME innovation.

The purpose of this study was to explain the role of government financial support in the innovation of SMEs in regional industries in South Korea, because potential impacts on the innovation of regional SMEs from current, large amounts of public financial aid or funds in regional industries are needed for estimations. A particular emphasis was placed on the contribution of government financial support for SME innovation. Thus, the next section briefly describes the government financial support for regional SMEs in South Korea focusing on technological development assistance funds.

2.3. Government financial support for SME innovation in South Korea: technological development assistance funds

SMEs play a particularly important role in the Korean economy, because of their numbers and because of the large share of the workforce involved in them (Nugent and Yhee, 2002). Specifically, the number of SMEs is about 3122 thousands (99.9%) and the number of SME employees is about 12,263 thousands (86.8%) in 2010. Table 1 shows status and trends of Korean SMEs from 2005 to 2010.
Considering the importance of SMEs in the Korean economy, the Korean governmental authorities have, for many years, carried out a variety of programs to support these enterprises. In particular, the Korean government has implemented various strategies for a balanced regional development to decrease income disparity between the industrial and agricultural sectors since DJ Administration’s regime and policy initiatives promoting regional industries. As a means of promoting regional industries, the Korean government has invested huge amounts of public funds conducive to SME innovation on the assumption that innovative SMEs may strengthen their competitiveness in markets and make a considerable impact on local competitiveness. This, in turn, promotes regional economic growth. Since the Korean government has provided financial support for SME innovation in regional industries, the design and implementation of such programs have received the increasing attention of regional SMEs. Table 2 illustrates the total R&D investment and public R&D investment for SMEs from 2005 to 2010 in South Korea.

The Korean governmental financial support for SME innovation has focused on technological innovation. Technology is considered a necessary condition for the growth of the economy (Guan et al., 2006). Technological development is often linked with economic progress and social benefits (DTI, 2000). Although SMEs need to acquire technological skills and introduce new and effective technologies into their firms to promote their innovations, they are reluctant to (or cannot) do so because many SMEs do not have enough financial resources required to invest in or develop such technologies (Lee et al., 2010). The profit technology brings to SMEs is not guaranteed, and even, many SMEs do not have a sufficient technical infrastructure to support and develop the next stage in advanced technology. This limits the success of SMEs (Thomas, 2007). Governmental intervention, such as technological development assistance policies for SMEs, i.e., ‘Technology Development Assistance Fund’ (TDAF), in South Korea is required to overcome the constraints that SMEs cannot resolve themselves. Fig. 2 describes the financial support policy system for SMEs in South Korea.

According to Fig. 2, the part shown in dotted line is the flow of TDAF in regional industries. Korean central government provides the TDAF to local governments and they have offered financial support for technological innovations of regional SMEs in Korea. The TDAF has been targeted by central government for its use for SME innovations in regional strategic industries.

In particular, the local governments (13 metropolitan cities and provinces) in Korea have invested in technological innovations of regional SMEs in their regional strategic industries to promote balanced regional development. This is why the TDAF was selected for the study.

Government industrial policy can be divided into two categories: an application of national (central) industrial policies to the local (regional) level, and local industrial policies for their own regional economic prosperity. The TDAF of South Korea is a part of national industrial policies which are distributed from the Department of Knowledge and Economy to the local (or provincial) government level. In other words, the policies included in the former category are implemented by local level government agencies representing central government. The objective of technological development assistance funds of government for SMEs is enhancing the performance of SMEs through technological innovation and contributing to the regional development through capacity (or competences) strength.

The goals of local industrial policies, including technology development assistance funds, are reducing the gap (disparity) in economies across regions and increasing GRDP by vitalizing local corporations, especially small and medium enterprises. Especially, the Korean government has concentrated on investments to expand local infrastructures, growth of self-sufficient corporations through SMEs’ technological development support, and strengthening industrial competitiveness at a local level since 1999. With the authority and funds given from the national government, a local government agency can initiate local industrial policies which are classified into six parts: technological development assistance, infrastructure building support, human resource development, corporation support services, networking, and local business community development. According to the Department of Knowledge and Economy’s report, technological development assistance, among six parts of local industrial policies, occupied 23.3% of the total investments, and the amount was at about 182 million US dollars in 2008.

In this study, we focused on the technological development assistance policies implemented at the firm level. Cho et al. (2005) argued that government investments in the technological development of SMEs brought more efficiency than inefficiency originating from crowding out effects by compensating for market failure. Government financial assistance for technological development increased proportion of success in technological development (Lee and Kim, 2007). Thus, government financial assistance funds promote the innovation of SMEs. Many countries have also evolved extensive infrastructures to support the development of technological capability among SMEs. The performance of SMEs is a function of intangible assets, skills and the ability of SMEs to develop.
new capabilities over time (Prencipe, 1995; Lundvall, 1992). What we have discovered in previous studies especially for developing regions like Africa is that the SMEs requires capabilities to translate inventions into innovation (albeit most of the innovations are incremental in nature) and so also convert government financial intervention into significant developments. SMEs just like firms of all sizes require technology capabilities (production, maintenance and innovation) to generate incremental as well as other innovations. Thus, it is important to support the development of technological capability of SMEs as well as to support innovation.

As a part of local industrial policy, local technology development assistance funds aim to strengthen the competitiveness of local corporations and the economy by supporting common technology, core technology and fundamental technological developments. The common technological development is that which has potential in securing a competitive advantage in a global market in the short term. The core technology implies an interdisciplinary that enhances the capacity of local strategic industries and produces at a higher value. The fundamental technological development implies to the origin and how it is related to many corporations. The significance of local technological development assistance policies through financial support (or funds) is that SMEs in local areas can get support to enhance their technological competence and produce a better performance. According to the recent internal documentation provided by the Department of Knowledge and Economy of Korea, 396 local SMEs out of 521 received the new technological development support from 2003 to 2006, through local technological development assistance policies in nine provincial areas. In 2009, the Department of Knowledge and Economy of Korea reported growth in sales and employment in SMEs, and cost savings through local technological development assistance policies as a direct achievement. It was also reported that the change of mind about technological improvement and innovation in local SMEs, which were located in a blind spot, was an indirect achievement.

Even though there are direct and indirect achievements to government support policies for SMEs as reported by the central government of Korea, there is still much debate on assessing the innovativeness of SMEs. Thus, potential impacts on the innovation of regional SMEs from current, large amounts of public financial aid and/or funds in regional industries is still needed to be analyzed. In spite of the increasing interest in potential impacts of government financial support on regional SME innovations, most previous studies have not focused on the innovation of regional SMEs in Korea. Accordingly, this study examined the relationship between governmental financial assistance and the innovation of regional SMEs, building upon and considering the limitations of previous research. Specifically, this study researched about how governmental, technological development assistance funds influenced the innovation of SMEs in the regional strategic industries of Korea.

3. Research strategy

To further explore the points discussed above – i.e. that SME innovation is positively influenced by government financial assistance – this study first tested the general hypothesis of a positive relationship between government financial assistance and the innovation of regional SMEs at the firm level. That is, in addition to investigating the relationship between government financial assistance and factors derived from technological innovation approaches and knowledge capital theory, we examined government financial assistance as a driver of regional SME innovations. Accordingly, we explored the relationship between government financial assistance and regional SME innovations based on various empirical models.

---

7 The results of local technology development support policies from 2004 to 2006 showed 558 patent applications, 104 patent registrations, and seventy-six research papers listed in Science Citation Index.

8 For the same period, the total number of enterprises receiving technological development assistance funds was 1258 (both local and central).
3.1. Empirical model

To examine the impact of governmental financial assistance on regional SME innovations, this study used multiple regression equations, providing us with a straightforward approach for measuring the impact on the technological innovation of regional SMEs. Based on previous studies, government financial support for SMEs is represented by the technological development assistance funds (TDAF) in South Korea. Thus, the fund is used as a main explanatory variable in this study. As main dependent variables, this study uses the technological innovation of SMEs in regional strategic industries.

As measures of the innovation of SMEs, this study uses the number of patents, utility models, trademark registrations, and new design registrations of each SME. There are several important limitations to using the number of patents as an indicator of SME innovation, such as the difference between innovation and inventions (Edwards and Gordon, 1984), the inability of capturing all of the innovations actually made (Acs and Audretsch, 2005), the uncertainty in the propensity to register patents across firms and across industries (Scherer, 1983), variations in the value and cost of individual patents within and across industries (Mansfield, 1984), and misleading comparisons both within and between industries (Cohen and Levin, 1989). The reliability of the patent data as a measure of innovation has been challenged, although new and superior patent data sources, such as the new computerized measures for patented inventions by the US Patent and Trademark Office and patent offices in Europe, have been introduced (Acs and Audretsch, 2005). Acs et al. (2002) showed that patented inventions provide a fairly reliable, though not perfect, measure of innovation activity. Thus, this study used patents as a measure of SME innovation.

Considering important limitations to using only the number of patents as an indicator of SME innovation, this study also used utility models, trademark registrations, and new design registrations of each SME as a measure of SME innovation. A utility model is an intellectual property right to inventions and is very similar to the patent. But it usually has less stringent patentability requirements and a shorter term (often 6–15 years) than those of patent.

Moreover, factors causing SME innovation, like firm age; firm size; R&D resources; technology development networks with universities, public research organizations, private research organizations, and private enterprises; and the relationships of SME with conglomerates are set as control variables. This study examined how these main explanatory and control variables have impacted technological SME innovations in regional strategic industry.

Hansen (1992) suggested that both firm size and firm age tend to be inversely related to innovative output. Firm size does matter in identifying the determinants of both product and process innovations (Lee et al., 2010; Vaona and Planta, 2008; Audretsch and Vivarelli, 1996). Thus, firm age and size are needed to be considered in the empirical models of the technological innovation of regional SMEs.

R&D resources can be converted to new commercially successful products and processes (Hansen, 1992; Von Hipple, 1978; Allen and Fusfeld, 1975). The presence of R&D enhances innovation (Bergek and Bruzelius, 2010; Kleer, 2010; Choi et al., 2009; Clarysse et al., 2009; Love and Ashcroft, 1999). R&D resources, such as R&D personnel and R&D expenditure, have been regarded as the infrastructure for SME technological innovation. Thus, R&D investment in SMEs does matter in identifying the determinants of the technological innovations of regional SMEs.

SME networks with other organizations for technological development, in particular, have been regarded as important factors for SME innovation in today’s knowledge-based economy (Eom and Lee, 2010; Edwards et al., 2005; Faems et al., 2005; Link and Scott, 2005; Mowery and Sampat, 2005; Belderbos et al., 2004; George et al., 2002; Hall and Ziedonis, 2001). In this knowledge-based economy, innovation is a social process (Doh and Acs, 2010). It is no longer achieved by isolated individuals and is conceived as an interactive process involving both formal and informal relationships among various actors interacting through networks (Hidalgo and Alborns, 2008; Pyka, 2002; Landry et al., 2002; Kline and Rosenberg, 1986). Moreover, technological networks (collaboration and partnership) between actors in markets are important sources of innovation. In particular, SMEs use external means of innovation more than large firms, as they consider alliances as ways to extend their technological competences (Lee et al., 2010; Edwards et al., 2005).

SMEs and large conglomerates interact with and influence each other on a substantial level (Lee et al., 2010; Narula, 2004; Mangematin et al., 2003). Many SMEs become subcontracting firms for the conglomerates, and some of them are located in the areas nearby where the conglomerates are operating. In particular, the relationship between the SMEs and conglomerates can be characterized as more vertical than horizontal, and such a strong network-based relationship between the SMEs and conglomerates can reduce the first stage of investment risks of SMEs in business activities and technological innovation (Park and Kim, 2011). Emale (2011) showed that SMEs actually benefit from large firms or conglomerates in a number of ways, including technology transfer, finance, and product development. Growing use of networking by SMEs reflects a possible catch-up of large firms (Lee et al., 2010). Thus, the nature and level of subcontracting is a key consideration that determines the level of participation of local SMEs in the process of technological innovation.

To examine the impact of the technological development assistance funds by the Korean government on regional SME innovations, we used a pooled regression equation type with time-lag, providing us with a straightforward approach to measuring the impact on SME innovations in terms of four basic equations. Pooled regression works similar to regular regression, except an extra intercept or ‘dummy’ is added for each firm. This is basically an Ordinary Least Squares (OLS) model with dummy variables to control for time differences, assuming constant slopes (coefficients) for independent variables and constant variance across times. In this study, year dummy variables are included in each empirical model.

\[
\text{Patent}_{i,t+2} = \alpha_0^p + \beta_1^p \text{Fund}_{i,2007} + \sum_{j=2005}^{2007} \beta_j^p YD_{i,j} + \epsilon_{\text{patent}}
\]

(1)

\[
\text{Utility}_{i,t+2} = \alpha_0^u + \beta_1^u \text{Fund}_{i,2007} + \sum_{j=2005}^{2007} \beta_j^u YD_{i,j} + \epsilon_{\text{utility}}
\]

(2)

\[
\text{Trademark}_{i,t+1} = \alpha_0^t + \beta_1^t \text{Fund}_{i,2008} + \sum_{j=2005}^{2008} \beta_j^t YD_{i,j} + \epsilon_{\text{trademark}}
\]

(3)

\[
\text{Design}_{i,t+1} = \alpha_0^d + \beta_1^d \text{Fund}_{i,2008} + \sum_{j=2005}^{2008} \beta_j^d YD_{i,j} + \epsilon_{\text{design}}
\]

(4)

Social capital theorists argue that innovation is no longer explained by the sole combinations of tangible forms of capital, such as physical, financial, etc., but instead by combinations of intangible forms of capital, such as social capital in the knowledge economy (Doh and Acs, 2010; Landry et al., 2002). Thus, it can be said that basic R&D, combinations of tangible forms of capital (i.e. physical capital) in conjunction with intangible forms of capital (i.e. social capital), and technological networks (collaboration and partnership) between actors in markets are important sources of innovation.
3.2. Data and variables

This study used micro panel data and survey data for the empirical analysis at the firm level. The data on regional SMEs in the Gyeongbuk province was mainly collected by questionnaire. In the Gyeongbuk province in Korea, there are four strategic industries: electronic information devices, parts made of advanced materials, bio-oriental medicine, and culture tourism industries. These regional strategic industries are core industries and therefore they are very important industries in today’s Korean economy. This is one of the reasons why we selected the Gyeongbuk province as the scope and range of our study. The other reason is that we could not access the database on other provinces and cities because of data unavailability.

Local authority of the Gyeongbuk province has offered financial support with the TDAF for technological innovations of regional SMEs in the three strategic industries excepting for culture tourism industry since 1999. We collected survey data by ourselves and a person in charge of work on the TDAF in the Gyeongbuk province helped us to collect the data. The person provided us a lot of information on the TDAF in the Gyeongbuk province. Regarding the data on technological innovations (i.e. patent, utility model, trademark, new design registrations) of regional SMEs in the Gyeongbuk province, the responses of 47 regional SMEs were identified from the Korea Intellectual Property Rights Information Service website and then followed up by survey. Also, most firms provided sensitive data on their characteristics and business for 6 consecutive years because the TDAF manager tried to his best to enlighten regional SMEs about our research background.

Specifically, other data on regional SMEs was from the Ministry of Knowledge Economy, the NICE credit information service website, and out survey. As previously mentioned, firm age, firm size, R&D personnel, networks for technology innovation, and relationships with conglomerates are related with the technological innovation of regional SMEs. Thus, this study considered these factors in an analytical model of the technological innovation of regional SMEs.

First, as an indicator of governmental financial support for regional SME technological innovations, this study used the TDAF for regional SMEs provided by the Korean government in the Gyeongbuk province from 2004 to 2009. The Korean government started to support regional SMEs with the technological development assistance fund in 2003. Because of data availability, this study used the technological development assistance fund (TDAF) data provided by the Ministry of Knowledge Economy of South Korea from 2004 to 2009. The technological development assistance fund (TDAF) was measured as the total amount of TDAF from 2004 to 2009.

Second, indicators for the control variables were drawn from a variety of sources, as described in this paper. The authors of this study also conducted a survey of regional SMEs which are from the technological development assistance fund from August 1st to September 2nd, 2010, to collect data on other indicators which were not covered by the Ministry of Knowledge Economy of South Korea.

In these models, Patent represents the number of patent registrations, Utility represents the number of utility model registrations, Trademark represents the number of trademark registrations, Design represents the number of new design registrations, \( \alpha \) represents the constant, \( \beta \) represents the coefficient of each variable, Fund represents the technology development assistance fund, \( \mathbf{X} \) represents the control variables vector, and \( YD \) represents the year dummy variable vector. Subscript \( i \) represents particular SMEs, \( t \) represents year, and \( \varepsilon \) is the random error term.

4. Results and discussions

4.1. Descriptive statistics

Before exploring the relationship between government financial support and the technology innovation of regional SMEs using pooled regression analysis, descriptive statistics regarding the firm-level characteristics of each SME will be discussed. Table 4 presents descriptive statistics regarding characteristics of all SMEs per year. Table 4 shows increasing mean total amount of technological development assistance funds for each SME from 2004 (about $19,000) to 2009 (about $117,000). The number of patent registrations was the highest among the number of patents, utility models, and new design registrations. The mean number of patent registrations was the highest among the number of patents, utility models, and new design registrations. The mean number of patent registrations was the highest among the number of patents, utility models, and new design registrations. The mean number of patent registrations was the highest among the number of patents, utility models, and new design registrations.

4.2. Regression results

As previously mentioned, we followed convention and used patent, utility model, trademark, and new design registrations as the overall measure of regional SME innovations in the Gyeongbuk province of South Korea. The number of patent registration, the number of utility model registrations, the number of trademark registrations, and the number of new design registrations were included in the model. The results from the four equations and the four related variations modeling technological innovation are shown in Table 5.

According to Table 5, indicators of SME’s technological innovations, such as patents and new design registrations, are positively related to the main explanatory variable (the total amount of fund,
Table 3
A brief description of variables and data sources.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Brief description</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variables</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Technological innovation of SMEs | • Patent registrations
    • Utility model registrations
    • Trademark registrations
    • New design registrations | The number of patents per year
    The number of utility models per year
    The number of trademark registrations per year
    The number of new design registrations per year | Korea Intellectual Property Rights Information Service website (www.kips.or.kr) |
| Independent variables            |                                                                                   |                                                                                                                                          |
| Total amount of funds            | Total amount of technology development assistance funds for each SME per year      | Ministry of Knowledge Economy website (www.mke.go.kr)                                                                                     |
| Firm age                         | How long the firm has been in business (from the date of founding) (unit: year)  | Survey (2010)                                                                                                                          |
| Firm size                        | Natural log value of total gross per employee (unit: US$) per year                 | Survey (2010), financial statement of each SME                                                                                           |
| R&D personnel                    | The number of researchers in R&D                                                | Survey (2010), Financial Statement of Each SME                                                                                          |
| R&D expenditures                 | Annual R&D expenditure for each SME (unit: US$)                                  |                                                                                                                                          |
| Networks for technological       | The number of technological development networks with universities                |                                                                                                                                          |
| development                       | The number of technological development networks with public research organizations |                                                                                                                                          |
| Relationship with conglomerates  | Subcontractors 1 = Subcontractors with conglomerates 0 = Other                    |                                                                                                                                          |
| Year dummy                       |                                                                                   |                                                                                                                                          |
|                                  | Year 2005 1 = year 2005; 0 = other                                              |                                                                                                                                          |
|                                  | Year 2006 1 = year 2006; 0 = other                                              |                                                                                                                                          |
|                                  | Year 2007 1 = year 2007; 0 = other                                              |                                                                                                                                          |
|                                  | Year 2008 1 = year 2008; 0 = other                                              |                                                                                                                                          |
|                                  | Year 2009 1 = year 2009; 0 = other                                              |                                                                                                                                          |

* This survey was conducted by the authors of this study from August 1st to September 2nd, 2010.

TDAF). In other words, the positive and statistically significant coefficient of technological development assistance funds at the 95% level in Table 5 points to a positive relationship to technological innovation of regional SMEs. As the total amount of technology development assistance funds increase, the number of patents and new design registrations will also increase, as we originally expected. However, the total amount of TDAF is not associated to the utility model and trademark registrations. The coefficients of

Table 4
Descriptive statistics.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cases 2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent</td>
<td>47</td>
<td>0.2</td>
<td>0.3</td>
<td>0.4</td>
<td>0.8</td>
<td>1.1</td>
</tr>
<tr>
<td>registrations</td>
<td>(0.48)</td>
<td>(1.00)</td>
<td>(0.58)</td>
<td>(1.42)</td>
<td>(1.97)</td>
<td>(4.12)</td>
</tr>
<tr>
<td>Utility model registrations</td>
<td>47</td>
<td>0.085</td>
<td>0.10</td>
<td>0.06</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>Trademark registrations</td>
<td>47</td>
<td>0.085</td>
<td>0.12</td>
<td>0.06</td>
<td>0.085</td>
<td>0.19</td>
</tr>
<tr>
<td>New design registrations</td>
<td>47</td>
<td>0.085</td>
<td>0.085</td>
<td>0.085</td>
<td>0.34</td>
<td>0.46</td>
</tr>
<tr>
<td>Total amount of funds (TDAF)</td>
<td>47</td>
<td>19.2</td>
<td>34.1</td>
<td>91.2</td>
<td>88.1</td>
<td>60.3</td>
</tr>
<tr>
<td>(unit: US$)</td>
<td>(66.71)</td>
<td>(76.54)</td>
<td>(162.77)</td>
<td>(156.99)</td>
<td>(132.01)</td>
<td>(329.90)</td>
</tr>
<tr>
<td>Firm age</td>
<td>47</td>
<td>6.23</td>
<td>7.23</td>
<td>8.23</td>
<td>9.23</td>
<td>10.23</td>
</tr>
<tr>
<td>R&amp;D personnel</td>
<td>47</td>
<td>3.0</td>
<td>3.6</td>
<td>4.4</td>
<td>5.5</td>
<td>6.3</td>
</tr>
<tr>
<td>R&amp;D expenditures</td>
<td>47</td>
<td>84.9</td>
<td>139.8</td>
<td>169</td>
<td>248.7</td>
<td>277.2</td>
</tr>
<tr>
<td>Networks with universities</td>
<td>47</td>
<td>0.3</td>
<td>0.4</td>
<td>0.5</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Networks with public research organizations</td>
<td>47</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Networks with private research organizations</td>
<td>47</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Networks with private enterprises</td>
<td>47</td>
<td>0.3</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Relationship with conglomerates</td>
<td>47</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Note: S.D. means “standard deviation.”
the total amount of TDAF in the regression results on the utility model and trademark registrations are not statistically significant. These results suggest that changes in the patent and new design registrations of regional SMEs appear to be caused by the government financial support.

Also the estimates of the coefficients of the “control variables” provide interesting indications. Firm size measured as the total gross per employee is positively related to patent registrations of regional SMEs and the relationship is statistically significant at the 95% level. This result reflects the fact that the number of patent registrations of larger firms (when measured the total gross per employee) are on average higher than those characterizing smaller firms among regional SMEs.

On the one hand, the number of R&D personnel (researchers) is positively related to the utility model acquisitions of regional SMEs, and the relationship is statistically significant at the 95% level. However, the number of R&D personnel is negatively related to the trademark registrations. On the other hand, annual R&D expenditures of each SME are positively related to patent registrations of regional SMEs. And, the relationship is statistically significant at the 95% level. Also, there is a positive impact of R&D expenditures on new design registrations of regional SMEs. This means that the regional SMEs that have a high R&D expenditure tend to find that the impact of R&D expenditure is positive and even might promote their new design registrations. But, the impacts of R&D expenditures on utility model and trademark registration are not statistically significant. Thus, the impacts of the R&D infrastructure are inconsistent in this study and are in line with that of previous studies suggesting that there is still much debate on assessing the innovativeness of SMEs because of their material or resource factor disadvantages (Lee et al., 2010; Audretsch and Vivarelli, 1996).

We also looked at the relationships between SME networks with four different entities and technological innovations of regional SMEs. Among SME networks with four different entities, SME networking with universities is positively related to patent acquisitions, trademark registrations, and new design registrations of regional SMEs. This result implies that SME networks with universities promote and contribute to technological innovation of SMEs in terms of patent, trademark, and new design registrations. The results on the impacts of SME networking with universities in this study are in line with those of many previous studies (i.e. Eom and Lee, 2010; Santoro and Chakrabarti, 2002; Schartinger et al., 2002; Meyer-Krahmer and Schmoch, 1998; Geisler, 1995).

Finally, SME relationship with conglomerates is not related to the indicators of technological innovations. This is not in line with many previous studies (i.e. Edwards et al., 2005; Faems et al., 2005; Link and Scott, 2005; Mowery and Sampat, 2005; Belderbos et al., 2004; George et al., 2002; Hall and Ziedonis, 2001). It is difficult to explain why the SME relationship with conglomerates is not statistically significant. But it can be said that the results might be caused by the fact that this study used different data and time period from those of previous studies.

All in all the findings of the estimates presented in Table 5 convey four major messages. The first one is that governmental financial support for technological innovations is important driver in the patent and new design registrations of regional SMEs. The second finding is that the SME network with university is an effective strategy other than networks with the other organizations. The third message is that R&D resources of regional SMEs, such as R&D expenditures, are also important factors in the technological innovations of SMEs. The final one is that we need to adopt more sophisticated innovation models to analyze the impact of the governmental financial support on utility model and trademark registrations of regional SMEs. In other words technological innovation models in the regional strategic industries seem to require the adoption of a more systemic approach to technological innovations measured as utility model and trademark registrations.

5. Conclusion and implications for future research

This study explored the impact of government financial support on the technological innovations of regional SMEs in the Gyeongbuk province, South Korea. The research presented here provided supportive evidence and raised theoretical and empirical questions for linking government financial support for the technological innovations of regional SMEs beyond such issues raised in other approaches. The findings suggested that government financial support plays an important role in generating the technological innovations of regional SMEs. In other words, results from pooled regression models indicated that there is a positive relationship between technology development assistance funds of Korean
government and the patent acquisitions of regional SMEs. Results also showed that there is a positive relationship between technological development assistance funds and new design registrations of regional SMEs. In other words, the regional SMEs with more public funds for technological development have a higher number of new design registrations. In terms of networks for technological development, SME’s networks with universities have an influence on regional SME’s patents acquisitions and new design registrations. But we need to consider that all the findings of the estimates presented in this study are valid only in the case of Gyeongbuk province. To make generalizations about the impact of government financial support on technological innovations of regional SMEs, we need to consider the analysis based on SME database in 13 metropolitan cities and provinces, South Korea in the future research.

As comparing our findings with the recent literature on technological innovations of firms in South Korea (i.e. Yi, 2012; Lee et al., 2010; Eom and Lee, 2010; Choi et al., 2009), one of the major contributions of this study was in linking technological development assistance of central and local governments to technological innovation of regional SMEs in regional strategic industries. Another major contribution of the study was in exploring the impact of the technological networks of SMEs with outside organizations, such as universities, on the technological innovation of regional SMEs.

Overall, the following suggestions are presented, which are based on the results of this study. First, technological development assistance plans should be divided by the stage of technological development, and the assistance plan should be differentiated so as to best use the necessity of the stage of technology, because innovation occurs in many forms and comprises many different stages or processes.

In addition, regional SME technological innovation performances, which are supported by the technological development financial support, can be mainly drawn from universities. Hence, it is necessary to divide a technological phase that is the object of technological development into two phases: an original technology and a product development technology. In case of the original technology, for the first step, SME’s technological development networks with universities can play a leading role in the original technological innovations. In addition, there should be modifications on the assistance systems to allow the product development technological assistance only for SME innovations which had already developed original technology.

Finally, regional SMEs should secure fundamental R&D resources for the qualification of government financial support policies in order to maximize the effects of the policies because the number of R&D researchers and expenditures of regional SMEs have a close relationship with the technological innovation of regional SMEs in regional strategic industries.

As one of limitations, this study could not consider adopting the net present value approach. Since the model includes financial data, i.e. government funding, R&D expenditures, for 6 consecutive years plus 2 lag years. This may be quite a considerably long period of time. Thus, future study needs to consider adopting the net present value of each variables. Another limitation is that this study fails to adopt more sophisticated innovation models to analyze the impact of the governmental financial support on utility model and trademark registrations of regional SMEs. Thus, the R² values are just too small for utility model and trademark registrations. Thus, it is necessary to adopt a more systemic approach to technological innovations measured as utility model and trademark registrations in the future research. The third limitation is that the dependent variables used in this study are zero in many cases. In this case, it is possible that there is a high level of error of the regression model. Thus, if possible, it is necessary to use a panel data with a long time period and lots of cases at the firm level in regional strategic industries, South Korea in the future study. To support the research findings and conclusion, this study tried to interview with practitioners and got some useful opinions on the impact of governmental financial support on the technological innovations in the regional strategic industries. According to the interviews with government financial support practitioners and members of regional SMEs in Gyeongbuk province, the technology development assistance funds of government for regional SMEs, is very useful for technological innovations of regional SMEs, especially, for patent acquisitions of regional SMEs. In addition, they said that the SMEs’ networks with university are very effective strategy other than networks with the other organizations on technological innovations of regional SMEs. But, they brought up a problem that the entry barrier to get the TDAP is so high. Thus, local government needs to introduce a more sophisticated system to lower the barrier to entry.

For future consideration, more research is also needed on the issue of the regional strategic industry areas, such as biotechnology, information and communication technology, chemical technology, new material development technology, etc. In addition, more research on regional SME social networks with other organizations is needed to explore the role of SME networks in technological innovation, because innovation is a process involving social interaction in this knowledge-based economy. Innovation is an interactive process involving both formal and informal relationships between firms and organizations involving various actors interacting within networks. Thus, the relationship between governmental financial support and technological innovation of SMEs in regional industries is clarified.

References


