The Interactive Effect of Government Financial Support and Firms’ Innovative Efforts on Company Growth: A Focus on Climate-Tech SMEs in Korea

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Abstract: Given the growing importance of climate technology and its early stage of industrial development, the Korean government has supported climate-tech small- and medium-sized enterprises (SMEs) through various policy measures, including credit guarantees. Although the extant literature argues that government financial support plays an important role in the growth of high-tech firms, research has been limited on the impacts of government financial support on company growth in the context of the climate-related industry. Using a sample of 582 climate-tech SMEs in Korea, this study explores the moderating effects of credit guarantees on the relationship between patents and firms’ sales growth as well as their direct effects on growth. This study found that credit guarantees and patent registration have positive effects on the increase in sales volume. Additionally, credit guarantees appear to weaken the relationship between patent registration and the sales growth rate. Based on these findings, we propose that, to develop the climate-technology industry, the voluntary innovation efforts of enterprises should be encouraged and credit guarantees should be provided for SMEs. In terms of managerial interventions, the government should especially avoid providing excessive benefits.

Keywords: climate-tech SMEs; credit guarantee; climate-technology industry; innovative effort; company growth

1. Introduction

The global threat of climate change has forced governments worldwide to work actively on climate issues to achieve sustainable growth. For instance, in 2015, countries participating in UNFCCC COP21 (the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change) submitted a Nationally Determined Contribution to implement the Convention on Climate Change with the goal of stabilizing greenhouse gas (GHG) concentrations, which is necessary for a low-carbon future [1]. Following global efforts, the Korean government has also placed the development of clean future energy on its national agenda and proposed two sub-targets: becoming a globally leading country in this new energy industry and transitioning to a low-carbon, high-efficiency structure [2]. The development of climate technology is considered a crucial measure for the implementation of this policy agenda.

Climate technology refers to technologies to cope with climate change by saving energy as well as resources for GHG mitigation and climate change adaptation [3]. Since the Kyoto Protocol and the Paris Agreement, climate technology has been expected to be the driving force of a sustainable low-carbon economy. However, despite its importance and growth potential, the climate-technology
market in Korea remains in the early developmental stage. The Korean climate industry had an annual average sales of 165,065 billion won (approximately 139 billion US dollars) from 2012 to 2017, with an annual average growth rate of \(-0.03\%\) [3]. Due to the immature market conditions, the existence of technology and patents does not lead directly to increased sales among climate-tech companies.

Furthermore, climate-technology firms face other problems, such as a lack of both market competitiveness and financial aid. According to the 2017 climate industry report of the Green Technology Center Korea (GTC-K), most climate-technology firms were small- and medium-sized enterprises (SMEs) (5820 firms of 6644, 87.6%). Compared to large, established companies, SMEs often have limited access to external research and development (R&D) funding, face difficulties generating economies of scale, and must compete with larger and better funded companies for skilled labor [4,5]. These factors make it more difficult for climate-tech SMEs to attract investment from the private sector because the related market is relatively small and the profitability of climate technology has not been verified.

Given the growing importance of climate technology and its early stage of industrial development, the Korean government supports climate-tech SMEs through various policy measures, including credit guarantees. The government’s policy intervention is helpful for the growth of SMEs seeking financial support in the early stages of industrial development. The extant literature argues that government financial support plays an important role in the growth of high-tech firms [6–8]. Nevertheless, research has been limited on the impacts of government financial support on company growth in the context of the climate-related industry. Paying attention to the impact of technology financing on firm growth, which centers on the technological value held by innovative SMEs, this study focuses on credit guarantees as a form of government financial support for SMEs in the field of climate technology.

In analyzing the impact of credit guarantees on firm growth, we also considered the innovative efforts of climate-tech SMEs. Innovation is often regarded as a key driver of a firm’s performance and growth [9]. The rapid changes in emerging markets allow companies with superior products or technologies to gain competitive advantages. For high-tech SMEs, the innovative effort of the firm, measured by patents, is a factor that stimulates firm growth [10].

In addition to the direct impact of credit guarantees and patents, we examine the moderating role of credit guarantees in the relationship between innovative effort and firm growth. Opponents of government financial support argue that excessive credit guarantees can cause inefficiencies in resource allocations and discourage smaller firms’ growth [6]. Credit guarantees may have indirect negative consequences because the generosity and long duration of government support allow nonviable SMEs to survive, which can limit the development of firms’ innovation efforts. To our knowledge, few studies have examined the moderating effect of financial support in terms of firm growth. To address the research gap, this study explores the moderating effects of credit guarantees on the relationship between patents and firms’ sales growth as well as their direct effects on the growth of climate-tech SMEs in Korea.

The remainder of this article is organized as follows. First, a review of the relevant literature related to credit guarantees, innovative effort, and firm growth is presented. We next describe our data and the measurements of each variable in the empirical context of our study. After presenting the results of the analysis, the final section of the article is dedicated to discussing the implications of the study.

2. Literature Review and Hypothesis Development

2.1. Credit Guarantees and Firm Growth

High-tech SMEs are considered critical for economic and employment growth in developed countries. Governments have provided SMEs with various forms of financial support, such as loan guarantees [8,11], R&D tax credits [12], and direct grants [13]. Policy instruments are intended to
enhance the competitiveness of SMEs that could suffer from insufficient investment from private financial institutions in the nascent stages of industrial development.

Climate technology has high upfront capital requirements and requires longer payback periods to investors compared with other existing markets. Private sector investors are often reluctant to adopt the risk of investing in high-tech companies and newly emerging markets [14], which can result in market failure. Thus, public financial support for climate-tech SMEs can function as an effective policy instrument to overcome the market failure caused by information asymmetry.

Credit guarantees are a type of public financial support for technology-based commercialization. The loan guarantee scheme is a widespread practice in more than one hundred countries [7]. Unlike direct subsidies or investments, credit guarantees allow companies to obtain loans by reducing the risk of banks offering the loans [11]. If the company fails to repay a loan, the bank could ask for payment from the guaranteeing agency. In Korea, the Korea Technology Finance Corporation (KOTEC) has been in charge of selecting and implementing credit guarantees for SMEs since 1997. When a company applies for a guarantee, KOTEC issues a guarantee letter to the financial institution (bank) after the appraisal of the SME’s technology, marketability, and business feasibility. Then, banks provide loans for the technology-based commercialization of SMEs based on these guarantees.

Previous studies have shown that public financial support contributes to the actual performance of firms. For example, using firm-level data on Finnish SMEs, Hyytinen and Toivanen (2005) concluded that government funding can alleviate capital market imperfections and increase firm growth [15]. Likewise, even during the recent recession, small business firms receiving loan guarantees showed business growth [11]. Using the firm-level data of Korean SMEs, Noh (2010) illustrated the positive effects of policy loans on firm performance, such as profitability and the growth rate of sales [16]. The effects were distinctive depending on the types of loans and firm characteristics. The magnitude of the effect on growth is greater for prospective young SMEs than for mature firms. Similarly, in the study of credit guarantees, companies that have received guarantees showed an average 7.35% increase in sales growth rates after a year of the guarantees [17]. Kang and Heshmati (2008) also suggested that the frequency of credit guarantees had a positive impact on performance in three ways (growth of sales, increase of employment, and productivity growth) [8]. From this perspective, this study assumes that credit guarantees contribute to the growth of SMEs.

**Hypothesis 1 (H1).** Credit guarantees are positively related to firm growth.

### 2.2. Innovative Effort and Firm Growth

In the knowledge economy, high-tech firms grow and compete through technological innovation. Technological innovation is particularly important in emerging industries because it lowers the entry barriers for firms and provides them with sustainable competitiveness [18]. Innovative efforts can be defined as activities that introduce a new conception of an idea to the market. A firm’s effort to innovate affects growth in at least two ways [19]. First, during the process of innovation, the activity of translating scientific breakthroughs increases firms’ internal capabilities and makes them more perceptive and flexible. Therefore, they can more easily adapt and respond to changes in rapidly developing markets, such as the climate-technology industry. Second, the output of innovative activities such as new products or technologies can fulfill demands in the market and give rise to more sales. Innovative ideas cannot be realized as technological inventions without the R&D process [20].

Since innovation efforts are multifaceted, measures of these efforts vary depending on the focus of the research, such as innovation input (proxied by R&D investment) and innovation output (proxied by patents) [20–22]. This study relies on patents to measure corporate-level innovation efforts. As patents protect new inventions by imposing legal restrictions on the use of new knowledge, patents registered indicate the successful outputs of the innovative efforts that firms want to protect. Patents have linkages with commercialized products because technological inventions with a high potential for commercialization are more likely to be patented than are other inventions [23].
A number of studies have demonstrated that innovative SMEs show more sales growth than less innovative SMEs [19,24,25]. Based on the Fortune Reputation Survey of U.S. firms, Cho and Pucik (2005) concluded that innovativeness improves performance [26]. Furthermore, each innovation effort has different effects on firm performance such as sales and market shares. For instance, R&D has a relatively weaker effect on market sales because of its indirect and time-consuming nature in developing new products compared to patents [27]. Ernst (2001) noted that patents have a positive relationship with the growth of firm sales in his research on the German machine tool industry [23]. Many studies have also found a positive relationship between patents and firm performance in the Korean context [28–30]. Thus, this study proposes the following hypothesis:

**Hypothesis 2 (H2). Innovation output is positively related to firm growth.**

2.3. Moderating Role of Credit Guarantee

As mentioned earlier, government financial support for SMEs is justified to overcome market failure. Credit guarantees are expected to reduce the risk to the lender of providing loans, thereby increasing the willingness to lend to climate-tech SMEs, which contributes to company growth [11,12]. However, the extant literature also suggests that government policies to promote SME financing are negatively associated with firm growth. Government intervention can discourage the development of market-based SME financing, the restructuring of weak SMEs, and the expansion of smaller firms [6].

With regard to the conflicting arguments on the relationship between credit guarantees and firm growth, we expect that government financial support in the form of credit guarantees for SMEs directly contributes to firm growth. At the same time, through the interaction effect with firms’ innovative efforts, financial support is likely to have indirect and negative impacts on the growth of SMEs.

Due to their high default risk and insufficient investment from the capital market, SMEs usually make efficient use of their financial resources [31]. SMEs that receive long-term and large credit guarantees might interpret financial support as success; consequently, the positive impact of innovative efforts on firm growth could decrease. Indeed, given that credit guarantees are based on technological evaluation, the beneficiary companies might aim to survive in the market and put less effort into their innovative work. The dependence on borrowing may prevent SMEs from taking advantage of growth opportunities that may arise [32]. If they rely heavily upon government financial support, then high-tech firms may exert less effort to use assets efficiently and to engage in innovative activities. Obtaining external finance interacts with the management practices of high-tech SMEs, such as R&D projects and human capital [33,34]. Likewise, credit guarantees may weaken the positive relationship between innovative efforts and firm growth. Overall, we expect that credit guarantees will moderate the effect of innovative efforts on firm growth.

**Hypothesis 3 (H3). Credit guarantees moderate the relationship between a firm’s innovative effort and growth.**

Figure 1 shows the research model for the above hypotheses.
3. Methods

3.1. Data

To test our hypotheses, we analyzed climate-tech SMEs in the manufacturing sector. The companies were selected according to the classification of the GTC-K, which defines climate-tech firms as those with Cooperative Patent Classification (CPC) Y-code (Y02, Y04) patents under the European Patent Classification System of the European Patent Office. All CPC Y-code patent data in Korea were provided by the Korea Intellectual Property Office. From 2004 to 2017, 48,023 patents related to climate technology were filed by 8301 firms. Of the climate-tech companies, as classified by the GTCK, observations were narrowed to companies with fewer than 300 workers and limited to those actively operating in the manufacturing sector over a five-year period (2012–2016). SMEs entering or leaving the market during the period and companies that became large firms were removed from our analysis. Accordingly, 582 samples were selected for this study, using the criteria that they were climate-tech companies in the manufacturing industry in the market for the study period (2012–2016) with 300 or fewer employees.

3.2. Variables

Sales growth rate. As a dependent variable of company growth, sales growth was measured as the average rate of growth in sales revenue over the period 2012 to 2016. The measure is frequently used in prior research on SME growth [19,25,35]. The financial data were derived from the Korea Information Service (KIS)-Value Database of NICE (National Information and Credit Evaluation), a private credit rating company.

Patent registration. Based on previous studies [20–22], patent registration is used as a proxy for innovative output. The measurement was observed based on the number of patents registered by the company between 2012 and 2016. The data were taken from KOSTAT (Statistics Korea).

Credit guarantee. To determine government financial support for SMEs, the amount of any credit guarantees from KOTEC was measured. In Korea, credit guarantees are provided through the Korea Credit Guarantee Fund (KCGF), KOTEC, and the Local Credit Guarantee Foundations (LCGFs) [6]. Compared with KCGF and LCGFs, which provide companies with credit guarantee services through a commercial evaluation such as the review of earnings and future cash flows, KOTEC gives credit guarantees to companies based on a technical assessment [8]. KOTEC aims at fostering technology-based firms and promoting technological innovations. Because the climate-related industry has yet to reach commercial maturity [3], it assumes that technology-assessed credit guarantees are more effective for company growth than credit guarantees based on a commercial evaluation of the firm.

Control variables. As in other studies on firm growth [35–37], control variables such as the company age, asset growth rate, and operating profit (OP) rate were included in the analysis. To describe internal corporate attributes, the company age was measured by the number of years that the firm had been in existence from its foundation up to 2016. Given that asset growth was considered an alternative measure of company size [36], the asset growth rate was included to control for unintended effects on the firm’s sales growth rate. The asset growth rate was measured as the average rate of growth in total assets over the period 2012 to 2016. The growth rate depends on operating elements such as the profit margin and asset efficiency [37]. The OP rate was measured as the average rate of growth in total assets over the period 2012 to 2016. The data on the company age, asset growth rate, and OP rate were derived from the KIS-Value Database of NICE.

Additionally, we considered whether the firms received Inno-Biz certification from 2012 to 2016. The Korean government supports high-tech companies through certification programs. Inno-Biz certifications are awarded to high-tech SMEs based on a company assessment following the Oslo Manual, the first international standard for high-tech firms [38]. The certification program is implemented to reduce uncertainty caused by the information asymmetry between SMEs and investors. In the Korean context, the Inno-Biz certification program can be related to firm growth. We consider a dummy
variable with the value of 1 if the companies were certified as an Inno-Biz between 2012 and 2016. The data were taken from KOTEC. Table 1 shows the operational definitions for the variables used in this study.

| Variable               | Description/Measure                                           |
|------------------------|---------------------------------------------------------------|
| Sales growth rate      | (Annual sales in 2016 − annual sales in 2012; %)             |
| Patent registration    | The number of patents registered by the company between 2012 and 2016 |
| Credit guarantee       | The amount of the credit guarantees from KOTEC; Korean won    |
| Inno-Biz               | Certified as an Inno-Biz company between 2012 and 2016; dummy (yes = 1) |
| Company age            | The number of years the firm has been in existence from its foundation to 2016 |
| Asset growth rate      | (Total assets in 2016 − total assets in 2012)/total assets in 2012; % |
| OP growth rate         | (OPs in 2016 − OPs in 2012)/OPs in 2012; %                   |

3.3. Analytical Strategy

Before performing a statistical analysis, the data were transformed to satisfy the normal distribution [39,40]. Considering the skewness of the data, square-root transformations were made for the sales growth rate, company age, asset growth rate and OP growth rate, and a logarithm was taken for patent registration and credit guarantees. To compensate mathematically for the possibility that the minimum value is a negative number, the absolute value of the minimum value plus one was added before the transformation [39].

After the data transformations, a hierarchical regression analysis was employed to test the hypotheses. To reduce multicollinearity, the independent variables (i.e., credit guarantees and patent registrations) were mean-centered prior to the computation of the interaction term [41]. The data were analyzed using SPSS 20.0 and the PROCESS macro for SPSS [42]. Within the PROCESS macro, ‘Model 1’ was used to statistically assess the significance of the moderating effect. To test the research hypotheses, the following multiplicative interaction model was performed.

\[
\text{SalesGR} = \beta_0 + \beta_1\text{CG} + \beta_2\text{PR} + \beta_3\text{CG*PR} + \epsilon
\] (1)

where \(\beta_0\) is the intercept of the regression line and \(\epsilon\) is the error in the estimation. The sales growth rate (SalesGR) was entered as the outcome variable; credit guarantees (CG), as moderator; and patent registration (PR), as independent variable. Equation (2) represents the specified interaction model including controls.

\[
\text{SalesGR} = \beta_0 + \beta_1\text{CG} + \beta_2\text{PR} + \beta_3\text{CG*PR} + \beta_4\text{Inno-Biz} + \beta_5\text{ComAge} + \beta_6\text{AssetGR} + \beta_7\text{OPGR} + \epsilon
\] (2)

4. Results

Table 2 shows the descriptive statistics for the sample. The annual sales slightly increased from 2012 to 2016, with a mean sales growth rate of 6.4% during the period. The average number of patents registered during the period was 9.9. The mean amount of credit guarantees was 1.3 billion won for the sample, including 186 companies that did not receive credit guarantees. From 2012 to 2016, 320 firms received Inno-Biz certification. The average company age of the sample was 15.7 years. The average rates of growth in total assets and OPs over the period 2012 to 2016 were 13.1% and 10.2%, respectively.

Table 3 provides the correlations of the variables. No variable showed a high correlation, which ensured that the multicollinearity issues were not critical in the sample. The sales growth rate, the dependent variable, is significantly correlated with the other variables, except for the Inno-Biz certification. The pattern and direction of the correlations between the variables were mostly as expected, which supported the theoretical relationships in the model.
Table 2. Descriptive Statistics.

|                          | Mean  | SD   | Min.  | Max   |
|--------------------------|-------|------|-------|-------|
| Sales growth rate        | 6.41  | 17.04| −71.55| 128.86|
| Patent registration      | 9.9   | 15.12| 0     | 153   |
| Credit guarantees        | 1,376,008,326 | 2,492,226,992 | 0 | 23,860,000,000 |
| Inno-Biz                 | 0.55  | 0.498| 0     | 1     |
| Company age              | 15.66 | 9.16 | 0     | 60    |
| Asset growth rate        | 13.12 | 17.04| −32.49| 130.51|
| OP growth rate           | 10.26 | 39.50| −81.32| 395.93|

Table 3. Correlations.

|                      | 1     | 2     | 3     | 4     | 5     | 6     |
|----------------------|-------|-------|-------|-------|-------|-------|
| 1. Sales growth rate | 1     |       |       |       |       |       |
| 2. Patent registration | 0.102 * | 1     |       |       |       |       |
| 3. Credit guarantees | 0.099 * | 0.023 | 1     |       |       |       |
| 4. Inno-Biz          | 0.045 | 0.114 ** | 0.430 ** | 1     |       |       |
| 5. Company age       | −0.176 ** | 0.061 | 0.036 | 0.236 ** | 1     |       |
| 6. Asset growth rate | 0.600 ** | 0.037 | 0.048 | 0.025 | −0.161 ** | 1     |
| 7. OP growth rate    | 0.537 ** | 0.025 | 0.041 | 0.015 | −0.079 | 0.411 ** |

* p < 0.05; ** p < 0.01.

Table 4 presents the regression results. First, all of the control variables were included in Model 1, accounting for approximately 47% of the variance in the sales growth rate. The results show that the company age (β = −0.090, p < 0.01) was negatively associated with the dependent variable, while the asset growth (β = 0.441, p < 0.01) and OP growth rates (β = 0.348, p < 0.01) were positively associated with the sales growth rate. Then, Model 2 included the credit guarantees and patent registrations, which explained an additional 9% of the variance in the sales growth rate. Model 2 shows that the credit guarantees (β = 0.059, p < 0.10) and patent registrations (β = 0.089, p < 0.01) are positively related to the sales growth rate, thus supporting H1 and H2.

Table 4. Results of the Hierarchical Regression on the Sales Growth Rate.

|                  | Model 1 |       | Model 2 |       | Model 3 |       |
|------------------|---------|-------|---------|-------|---------|-------|
|                  | β       | SD    | β       | SD    | β       | SD    |
| Inno-Biz         | 0.050   | 0.063 | 0.016   | 0.070 | 0.020   | 0.070 |
| Company age      | −0.090 *** | 0.027 | −0.089 *** | 0.027 | −0.087 *** | 0.027 |
| Asset growth rate | 0.441 ** | 0.029 | 0.437 *** | 0.029 | 0.437 *** | 0.029 |
| OP growth rate   | 0.348 *** | 0.018 | 0.346 *** | 0.018 | 0.348 *** | 0.018 |
| Credit guarantees (CG) | 0.059 * | 0.003 | 0.058 * | 0.003 | 0.058 * | 0.003 |
| Patent registration (PR) | 0.080 *** | 0.030 | 0.080 *** | 0.030 | 0.080 *** | 0.030 |
| CG × PR          | -       | -     | −0.060 ** | 0.003 |         |       |

|                  |       |       |       |
| F-value          | 1270.66 *** | 870.87 *** | 760.27 *** |
| R²               | 0.469 | 0.478 | 0.482 |
| ΔR²              | 0.009 | 0.004 |       |

n = 582; * p < 0.10, ** p < 0.05, *** p < 0.01.

In Model 3, the interaction term of the credit guarantees and patent registrations was added to test H3. Model 3 explained an additional 4% of the variance in the sales growth rate, confirming the moderating effect of the credit guarantees on the association between the patent registrations and sales growth rate (β = −0.060, p < 0.01). Thus, H3, which predicted that credit guarantees moderate the relationship between patent registrations and sales growth rates, is supported.
To explore the interaction pattern, simple slopes of the patent registrations on the sales growth rates depending on the levels of the credit guarantees were tested for the low (−1 SD below the mean) and high (+1 SD above the mean) credit guarantee subgroups. Figure 2 shows that the slope of the relationship between the patent registrations and the sales growth rates was greater in the companies with high than it was in the companies with low levels of credit guarantees.

![Figure 2. Two-way Interaction Effect of Credit Guarantees and Patent Registration on the Sales Growth Rate.](image)

The significance of the simple slope was examined using the PROCESS macro for SPSS (Model 1), which determines the conditional effect of the patent registrations on the sales growth rates at certain credit guarantee values, which represents the moderator [42]. Table 5 shows that, for both the moderate (mean) and high (+1 SD) values of the credit guarantee subgroups, the upper bound of the bias-corrected confidence interval exceeds 0, suggesting that the indirect effect is not significant. However, for the subgroup with low levels of credit guarantees (−1 SD), the upper bounds of the confidence intervals are comfortably below 0, and the effect of the patent registrations on the sales growth rates was significant, as can be seen in Table 5 (b = 0.159, t = 3.16, p < 0.05).

| Credit Guarantees | B   | SE  | t-Value | LLCI  | ULCI  |
|-------------------|-----|-----|---------|-------|-------|
| −1 SD             | 0.159 | 0.050 | 30.16 ** | 0.060 | 0.258 |
| Mean              | 0.041 | 0.035 | 10.18 | −0.028 | 0.110 |
| +1 SD             | 0.029 | 0.039 | 0.73 | −0.048 | 0.105 |

**p < 0.05.

As seen in Figure 1 and Table 5, in the low credit guarantee subgroup, the sales growth rates are higher as the patent registrations increase; on the other hand, the slope of the sales growth rates is not associated with the patent registrations for the low credit guarantee subgroup. These results indicate buffering interactions in which the moderator, credit guarantees, weakens the relationship between the predictor (patent registrations) and the outcome (sales growth rates). Thus, as predicted in H3, government financial support dampens the effect of the company’s innovative effort on its growth.
5. Discussion

Given the growing importance of climate technology and its early stage of industrial development, the Korean government has attempted to develop the climate-technology market and industry through policy financing and continuous R&D investment. In particular, through credit guarantees, the government has made an effort to address the problems that climate-tech SMEs face in their growth stage. Nevertheless, little research has paid attention to whether government financial support and credit guarantees contribute to firm growth in the context of the climate-related industry. To fill this gap, this study explores the impact of credit guarantees and patents on firm growth and the moderating role of credit guarantees on the relationship between firms’ innovative efforts and their growth in the context of climate-tech SMEs in Korea.

This study found that credit guarantees and patent registrations increase sales volume. Additionally, the interaction effect between credit guarantees and patent registrations differed between the subgroups. While the positive effect of patent registrations on company growth was significant in the SMEs with low credit guarantees, patent registrations had no significant effect on company growth in the SMEs with high credit guarantees. Thus, the relationship between patent registrations and company growth is moderated by credit guarantees.

The findings reveal that government financial support contributes to the increase in sales volume. The significant relationship between credit guarantees and company growth is consistent with that found in previous studies e.g., [8,11,16,43]. The result indicates that government financial support in the form of credit guarantees is effective for company growth under immature market conditions. Beyond the positive effects of government financial support on new high-tech firms such as start-ups, which have been extensively examined in the extant literature [8,11,16], the present study confirms that government financial support contributes to the growth of the firms struggling to survive in the early stage of industrial development, such as those in the climate-technology market.

Additionally, consistent with previous studies e.g., [19,23,24], this study found that innovative efforts appeared to be significantly predictive of firm growth. The positive relationship reaffirms that innovative efforts are essential for climate-tech SMEs who wish to enhance their market competitiveness and pursue sustainable growth. Given the positive effects of credit guarantees and innovative efforts, facilitating innovative efforts associated with government financial support can result in potent consequences for firm growth. In particular, as technology-intensive companies have a structure that enables them to increase sales through innovation, credit guarantees based on technological potential are an appropriate policy financing tool for the growth of SMEs in the climate industry.

We also found that credit guarantees weaken the relationship between patent registration and the sales growth rate. This finding is consistent with the results of previous research on high-tech firm growth [32,44]. It demonstrates empirically that, in the context of Korean climate-tech SMEs, excessive dependence on government financial support can dampen the positive effect of innovative efforts on company growth. The buffering interactions implied that government intervention can have side effects that provoke moral hazards. Government financial support could prevent less innovative companies from being kicked out of the market [6]. Companies with high credit guarantees may feel a reduced need to innovate in the promotion of corporate growth because credit guarantees represent a reduced difficulty of financing, even if they do not increase market competitiveness through the development of new technologies or products.

The present study extends our understanding of the outcomes of government financial support. The extant literature suggests that public financial support for SMEs is an effective policy instrument to address the market failure caused by information asymmetry; however, government intervention can also generate negative consequences by hindering the restructuring of weak SMEs [6,45,46]. In terms of the effects of credit guarantees, we found evidence of both positive and negative consequences for company growth. Thus, despite the positive effects of credit guarantees on firm growth in the climate-tech industry, such policies indirectly have negative side effects. Future research should investigate the intervening processes that transform public financial support into firm growth.
The findings clearly indicate that, for the development of the climate-technology industry, the voluntary innovation efforts of enterprises should be encouraged while credit guarantees for SMEs should be provided. For global carbon reduction efforts to succeed, the current technological level of the climate industry requires further development, which should be linked to financial statements and thereby to the issuance of credit guarantees. In particular, in the early stages of market growth, the government’s institutional support for GHG reduction gives climate-technology companies strong opportunities to grow. If a company relies solely on government support, the size of the industry can grow in the early developmental stage, but its technological competitiveness will inevitably fall behind its potential, in contrast to its expected growth and performance. Therefore, in terms of managerial interventions, the government should especially avoid providing excessive benefits, such as long-term and large credit guarantees. To prevent the reduction in the positive effects of credit guarantees, it is important to help prospective enterprises sustain a willingness to innovate. Monitoring the beneficiaries of financial support aligned with a credit guarantee limit would decrease the waste of public resources and the risk of moral hazard.

Despite these theoretical and practical implications, this study has limitations while it offers suggestions for further research on climate-tech companies and industry. First, the availability of data is highly limited. We have 582 samples, but the data used were from corporations’ databases. Therefore, we could not test a time-series panel model, which would have strengthened our research analysis. Second, further investigation on the peculiarities of the climate-tech industry is needed to determine detailed policy implications. Our data do not allow us to compare the climate-tech industry with other industries.

Although the findings of this study require empirical confirmation from future studies, this study broadens our understanding of the effects of credit guarantees on the growth of climate-tech SMEs. The present research points to the significance of credit guarantees because they generate direct positive outcomes and indirect negative outcomes for company growth. This study aims to inspire future research to explore in greater depth how government financial support can promote the growth of climate-tech firms.

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**References**

1. United Nations (UN). Paris Agreement. 2015. Available online: https://unfccc.int/process-and-meetings/theparis-agreement/the-paris-agreement (accessed on 16 August 2020).
2. The Government of the Republic of Korea. 100 Policy Tasks Five-Year Plan of the Moon Jae-in Administration. 2017. Available online: https://english1.president.go.kr/dn/5af107425f0d (accessed on 30 September 2020).
3. Green Technology Center Korea. Statistics on Climate Change Industry in 2012~2018; KOR: Seoul, Korea, 2019.
4. Hall, B.H. The Financing of Innovative Firms. In *Review of Economics and Institutions*; University of Perugia Electronic Press: Perugia, Italy, 2010; Volume 1, Available online: http://www.rei.unipg.it/rei/article/view/4 (accessed on 30 September 2020).
5. Belitz, H.; Lejpras, A. Financing Patterns of Innovative SMEs and the Perception of Innovation Barriers in Germany. *Discussion Papers*; DIW Berlin German Institute for Economic Research: Berlin, Germany, 2014; pp. 1–26. Available online: https://d-nb.info/1153063239/34 (accessed on 30 September 2020).
6. Jones, R.S.; Kim, M.K. Promoting the Financing of SMEs and Start-Ups in Korea. In *OECD Economics Department Working Papers*; OECD Publishing: Paris, France, 2014; Volume 1162, pp. 1–37. Available online: https://www.oecd-ilibrary.org/economics/promoting-the-financing-of-smes-and-start-ups-in-korea_5px054bd1vh-en (accessed on 30 September 2020).
7. Beck, T.; Klapper, L.F.; Mendoza, J.C. The typology of partial credit guarantee funds around the world. *J. Financ. Stab.* 2010, 6, 10–25. [CrossRef]

8. Kang, J.; Heshmati, A.; Choi, G.G. Effect of Credit Guarantee Policy on Survival and Performance of SMEs in the Republic of Korea. *Small Bus. Econ.* 2008, 31, 445–462. [CrossRef]

9. Hölzl, W. Is the R&D behavior of fast-growing SMEs different? Evidence from CIS III data for 16 countries. *Small Bus. Econ.* 2009, 33, 59–75.

10. Audretsch, D.; Klomp, L.; Santarelli, E.; Thurik, A. Gibrat’s law: Are the services different? *Rev. Ind. Organ.* 2004, 24, 301–324. [CrossRef]

11. Bradshaw, T.K. The Contribution of Small Business Loan Guarantees to Economic Development. *Econ. Dev. Q.* 2002, 16, 360–369. [CrossRef]

12. Cowling, M. You can lead a firm to R&D but can you make it innovate? UK evidence from SMEs. *Small Bus. Econ.* 2016, 46, 565–577.

13. Cannone, G.; Ughetto, E. Funding innovation at regional level: An analysis of a public policy intervention in the Piedmont region. *Reg. Stud.* 2014, 48, 270–283. [CrossRef]

14. World Bank Group. *Building Competitive Green Industries: The Climate and Clean Technology Opportunity for Developing Countries*; World Bank: Washington, DC, USA, 2014.

15. Hyytinen, A.; Toivanen, O. Do financial constraints hold back innovation and growth? Evidence on the role of public policy. *Res. Policy* 2005, 34, 1385–1403. [CrossRef]

16. Noh, Y. The Role and Performance of Policy Loan on the SMEs in Korea: Firm-Level Evidence. *Korean Small Bus. Rev.* 2010, 32, 153–175.

17. Kim, J.R.; Kim, S.B.; Nam, J.H. The Performance Measurement of Credit Guarantee and Methods of Improvement of Its System. *Korea Rev. Appl. Econ.* 2014, 16, 33–64.

18. Porter, M.E. *Competitive Advantage. Creating and Sustaining Superior Performance*; The Free Press: New York, NY, USA, 1985.

19. Gerorski, P.; Machin, S. Do Innovating Firms Outperform Non-Innovators? *Bus. Strategy Rev.* 1992, 3, 79. [CrossRef]

20. Griliches, Z. Patent Statistics as Economic Indicators: A Survey. *J. Econ. Lit.* 1990, 28, 1661–1707.

21. Schoenecker, T.; Swanson, L. Indicators of firm technological capability: Validity and performance implications. *IEEE Trans. Eng. Manag.* 2002, 49, 36–44. [CrossRef]

22. Cin, B.C.; Kim, Y.J.; Vonortas, N.S. The impact of public R&D subsidy on small firm productivity: Evidence from Korean SMEs. *Small Bus. Econ.* 2017, 48, 345–360.

23. Ernst, H. Patent applications and subsequent changes of performance: Evidence from time-series cross-section analyses on the firm level. *Res. Policy* 2001, 30, 143–157. [CrossRef]

24. Yasuda, T. Firm growth, size, age and behavior in Japanese manufacturing. *Small Bus. Econ.* 2005, 24, 1–15.

25. Freel, M.S. Do Small Innovating Firms Outperform Non-Innovators? *Small Bus. Econ.* 2000, 14, 195. [CrossRef]

26. Cho, H.J.; Pucik, V. Relationship between Innovativeness, Quality, Growth, Profitability, and Market Value. *Strateg. Manag. J.* 2005, 26, 555–575. [CrossRef]

27. Guarascio, D.; Tamagni, F. Persistence of innovation and patterns of firm growth. *Res. Policy* 2019, 48, 1493–1512. [CrossRef]

28. Lee, K.H.; Yoon, B.S. The Effects of Patents on Firm Value: Venture vs. non-Venture. *J. Technol. Innov.* 2006, 14, 67–99.

29. Park, S.Y.; Park, H.W.; Cho, M.H. The Relationship between Technology Innovation and Firm Performance of Korean Companies based on Patent Analysis. *J. Korea Technol. Innov. Soc.* 2006, 9, 1–25.

30. Ahn, Y.S. An Empirical Analysis about the Effect on Performance of Firm’s Patent Competency: Focusing on the High Performance Venture Firms in Korea. *Knowl. Manag. Res.* 2010, 11, 83–96.

31. Müller, E.; Zimmermann, V. The importance of equity finance for R&D activity. *Small Bus. Econ.* 2009, 33, 303–318.

32. Fagiolo, G.; Luzzi, A. Do liquidity constrains matter in explaining firm size and growth? Some evidence from the Italian manufacturing industry. *Ind. Corp. Chang.* 2006, 15, 1–39. [CrossRef]

33. Colombo, M.; Grilli, L. Funding gaps? Access to bank loans by high-tech startups. *Small Bus. Econ.* 2007, 29, 25–46. [CrossRef]
34. Heshmati, A. The effect of credit guarantees on SMEs' R&D investments in Korea, Asian J. Technol. Innov. 2015, 23, 407–421.
35. Nunes, P.M.; Serrasqueiro, Z.; Leitao, J. Is there a linear relationship between R&D intensity and growth? Empirical evidence of non-high-tech vs. high-tech SMEs. Res. Policy 2012, 41, 36–53.
36. Falk, M. Quantile estimates of the impact of R&D intensity on firm performance. Small Bus. Econ. 2010, 39, 19–37.
37. Fonseka, M.M.; Ramos, C.G.; Tian, G.L. The Most Appropriate Sustainable Growth Rate Model for Managers and Researchers. J. Appl. Bus. Res. 2012, 28, 481–500. [CrossRef]
38. Oh, S.; Shim, D.; Lee, D. Evaluation of complementarity effect of innovation policies: Venture certification and Inno-biz certification in Korea. Singap. Econ. Rev. 2020, 65, 385–402. [CrossRef]
39. Tukey, J.W. Exploratory Data Analysis; Addison Wesley Publishing Company: Boston, MA, USA, 1977.
40. Peck, R.; Olsen, C.; Devore, J.L. Introduction to Statistics and Data Analysis; Cengage Learning: Belmont, CA, USA, 2008.
41. Aiken, L.S.; West, S.G. Multiple Regression: Testing and Interpreting Interactions; Sage: Newbury Park, CA, USA, 1991.
42. Hayes, A.F. Introduction to Mediation, Moderation, and Conditional Path Analysis; Guilford Press: New York, NY, USA, 2013.
43. Brault, J.; Signore, S. The Real Effects of EU Loan Guarantee Schemes for SMEs: A Pan-European Assessment; EIF Working Paper, No. 2019/56; European Investment Fund (EIF): Luxembourg, 2019.
44. Elston, J.; Audretsch, D. Financing the entrepreneurial decision: An empirical approach using experimental data on risk attitudes. Small Bus. Econ. 2011, 36, 209–222. [CrossRef]
45. Tsuruta, D. SME policies as a barrier to growth of SMEs. Small Bus. Econ. 2020, 54, 1067–1106.
46. Dvoulety, O.; Cadil, J.; Mirošník, K. Do Firms Supported by Credit Guarantee Schemes Report Better Financial Results 2 Years After the End of Intervention? BE J. Econ. Anal. Policy 2019, 19, 1–20. [CrossRef]

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