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Study on the Complementarity Effect according to the Overlapped, Repetitive and Sequential Support in Innovation Policy

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Abstract

Study on the Complementarity Effect according to the Overlapped, Repetitive, and Sequential Support in Innovation Policy

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Innovation activity is an important factor in firms' growth, and the government has implemented various policies that support the firms' innovation activity. There are various rationales for public policy implementations that encourage firms' innovation activity; first, there is the presence of innovation spillover. If innovation activity is only dependent on the private sector, it causes a lower level of innovation than the social optimum. To solve this problem, the public sector, particularly the government, needs to support firms' innovation activity. The other problem is asymmetric information in the loan market, known as the "Lemon market" problem. Due to asymmetric information in the loan market, the marginal costs of capital increases. This makes outside investors reduce their investments in firms' innovation activities. Because of the spillover effect and "Lemon market" problem, firms can fail to manage their innovation activity. Therefore, the

government should intervene in the market, and resolve these asymmetric information problems and the uncertainty of the capital market. With government intervention, firms can continue focusing their efforts on innovation activities and increasing their capacities.

Alongside the implementation of various government policies, discussions regarding evaluations of public policy have been consistently undertaken in economics, because it is very important to evaluate whether public policies have played a proper role there. These studies on the evaluation of public policy not only include evaluations of a single policy, but also the discussion about which policies can play more effective roles in certain situations. However, all policies have direct or indirect connections with each other, so they cannot be discriminative or exclusive. Consequently, in order to evaluate one policy correctly, its interactions with other policies also require consideration. However, studies on the interactions in innovation policies—that is, studies on cases where many policies have been simultaneously implemented—are insufficient. These interactions and their complementarity effects are quite important factors in real situations, but have not been discussed sufficiently in innovation policy. This paper is focused on these interactions and the complementarity effects of innovation policy. For the analysis, a theoretical framework about interaction and complementarity effects will be suggested based on previous economic concepts. Along with the suggested theoretical framework, various analyses will be conducted in this paper, and various policy implications will be deduced.

Various methodologies for estimating impact assessments of public policy have been

discussed in previous economic studies. Among these methods, a matching estimator is used in this paper, because it is the most suitable method for estimating the complementarity effect. In particular, in this paper, the multivariate matching estimator considering the propensity score has been applied to reduce the selection bias that can occur in impact assessment studies.

The main results of this paper are the following: The complementarity effect of overlapped support in innovation policy is positive when heterogeneous policies are overlapped; however, in the case of overlapping homogeneous policies, the complementarity effect is negative. Therefore, policy makers have to consider policies that have been given to the firm before supporting any new policies, and it is desirable that supporting homogeneous policies to the same firms is avoided. Second, in the analysis of the effects of repetitive support, firms receiving repetitive support perform better than firms that do not receiving such support. “Repetitive support” is when the same policies are supported continuously; however, as the number of repetition increases, the marginal effect may stagnate or diminish. That is to say, in public policy, the continuity of support plays an important role in the growth of firms, but excessive repetition can be inefficient in a firms' growth. Therefore, when policy makers select the firms to receive support, they need to consider these characteristics of innovation policy. Finally, the complementarity effect of sequential support in innovation policy is analyzed. “Sequential support” means that different policies are supported sequentially. In this case, the firms that receive sequential support are superior to firms that receive single support,

in terms of their financing and capacity for innovation. This result means that if different policies are well mixed, their effect can be larger than that of a single policy. Therefore, when the policy makers choose the firms that receive policy support, they need to consider the path dependency of the policies of each firm.

Compared with previous studies, this paper has some uniqueness in the following way: First, deviating from the view of previous studies that focused on the evaluation of a single policy, this paper has considered interactions and the complementarity effect of innovation policy through "policy mix," an economic term. Based on these concepts, this paper suggests an analysis framework for the analysis of interactions and the complementarity effect of innovation policy. Second, by examining the various methodologies for the evaluation of government support, the most suitable method for estimating the complementarity effect has been developed in this paper. Finally, through various application analyses in the case of overlapped support, repetitive support, and sequential support, this paper suggests varied policy implication to the policy makers.

Keywords: Innovation policy, Policy mix, Complementarity effect, Matching, Overlapped support, Repetitive support, Sequential support

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Chapter 1. Introduction

1.1 Overall introduction

Innovation activities play a key role for the firms' growth and development. In this respect, most firms perform innovation activities through internal and external resources. David, Hall, and Toole (2000) indicates that firms tend to invest when the marginal benefit should be larger than the marginal cost. However, due to the asymmetric information of capital market, the marginal cost of the capital becomes higher and the investment incentive of external investors shrinks. According to Himmelberg and Petersen (1994), these phenomenon are intensified in high-technology industry. In company with the asymmetric information of capital market, the spillover effect of innovation output also reduce the external investment.

In this context, many countries are concerned with the development of policies to enhance the innovation activity of the firms. Lerner (1999) mentioned some rationales of public policy for enhancing the firms' innovation. First, as Griliches (1992) and Jaffe (1996) mentioned, there is the presence of innovation spillover. Therefore, if innovation activity is only dependent on the private sector, it causes a lower level of innovation than the social optimum. The other problem is asymmetric information in the loan market, known as the "Lemon market" problem (Akerlof, 1970). Because of the spillover effect and "Lemon market" problem, firms can fail to manage their innovation activity. Therefore, the government should intervene in the market, and resolve these asymmetric

information problems and the uncertainty of the capital market. With government intervention, firms can continue focusing their efforts on innovation activities and increasing their capacities.

Alongside the implementation of various government policies, discussions regarding evaluations of public policy have been consistently undertaken in economics, because it is very important to evaluate whether public policies have played a proper role there. These studies on the evaluation of public policy not only include evaluations of a single policy, but also the discussion about which policies can play more effective roles in certain situations. However, all policies have direct or indirect connections with each other, so they cannot be discriminative or exclusive. Consequently, in order to evaluate one policy correctly, its interactions with other policies also require consideration.

1.2 Motivation and research purpose

As mentioned above, government implements a variety of policies to solve the market failure, and it is very important to evaluate whether public policies have played a proper role there. These studies on the evaluation of public policy not only include evaluations of a single policy, but also the discussion about which policies can play more effective roles in certain situations. However, all policies have direct or indirect connections with each other, so they cannot be discriminative or exclusive. Consequently, in order to evaluate one policy correctly, its interactions with other policies also require consideration. However, studies on the interactions in innovation policies—that is, studies on cases

where many policies have been simultaneously implemented—are insufficient. These interactions and their complementarity effects are quite important factors in real situations, but have not been discussed sufficiently in innovation policy. In this approach, as discussed by Witt (2003), the concept of public policy was regarded as selecting standardized policies from a toolbox of policy instruments with a fragmented vision, which were actually not related to each other. Rather, it would be more proper to approach with an understanding that each policy instrument, their legitimacy, purpose, executive method, and influence in certain periods and spaces are related, and that they have interactions and complementary effects rather than independence. Ringeling (2005) suggested that an appraisal of the effectiveness of a single policy is meaningless, as the effectiveness of a single policy arises from the result of interactions between various different policies. That is, as Morlacchi and Martin (2009) mentioned, the study on the innovation policy is the “something of a crossroads”.

Therefore, the search of the complementarity which is occurred by interaction of policies is very important, and through these discussion, true effect of policies can be estimated. Figure 1. shows a theoretical framework which is suggested in this paper.

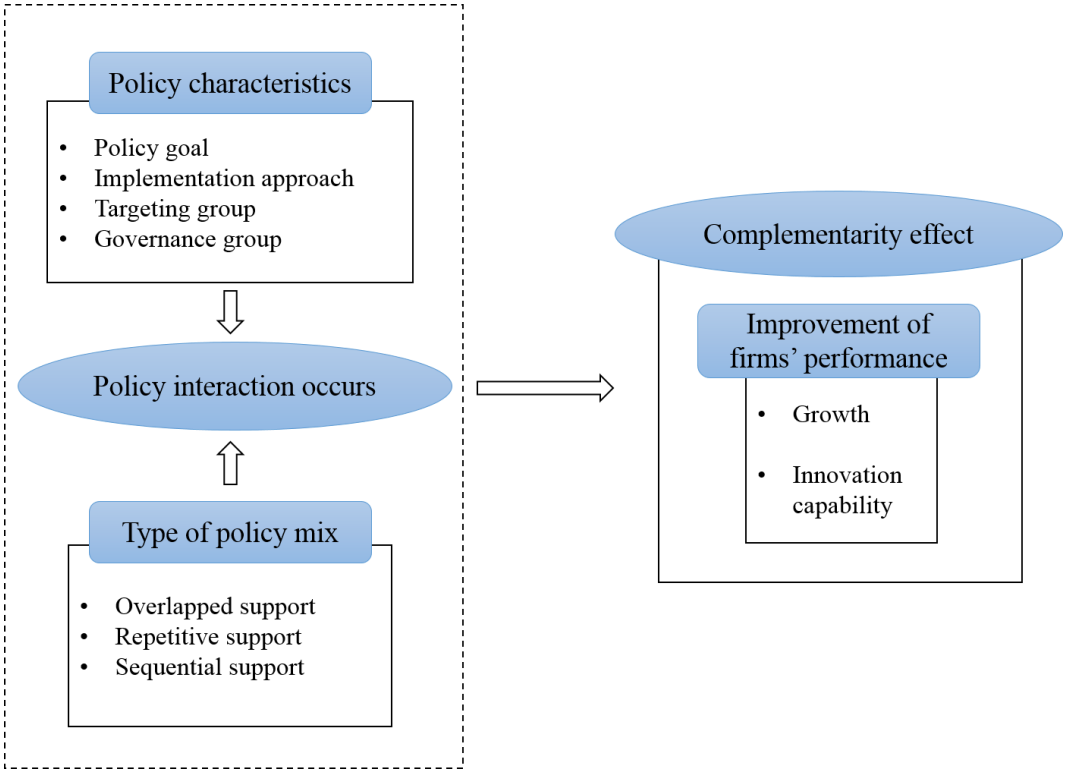


Figure 1. Conceptual outline of this study

This paper is focused on these interactions and the complementarity effects of innovation policy. For the analysis, a theoretical framework about interaction and complementarity effects will be suggested based on previous economic concepts. Along with the suggested theoretical framework, various analyses will be conducted in this paper, and various policy implications will be deduced.

1.3 Outline of the study

The remainder of the paper is organized as follows. Chapter 2 describes the theoretical framework of this study. It provides a comprehensive overview of the complementarity of innovation policy and importance of this study. Chapter 3 explains various methodologies used in this study. Especially, we focus on the matching estimators used for reducing the selection bias. In chapter 4, the complementarity effect according to overlapped support will be estimated. The discussion about the complementarity effect according to repetitive support and the complementarity effect according to sequential support will be performed in chapter 5 and chapter 6. Finally, in chapter 7, the summary of analysis result, policy implication, and limitation of this study will be suggested.

Chapter 2. Theoretical Background

2.1 Policy mix and its adoption in innovation policy studies

The concept of “Policy mix” started being analyzed and discussed as part of studies of economic policy in the 1960s (Mudell, 1960). Robert Mundell, who won the Nobel Prize for Economics noted that currency policies tend to stabilize the economy with a floating exchange system, while financial policy would be more efficient with a fixed exchange rate system (In other words, different types of policies are necessary in different situations). Mundell's concept has been developed continuously through economic policy disputes in the European Economic and Monetary Union (EMU) (Claeys, 2006).

Since Mundell suggested “policy mix,” discussions about it have often focused on macro-economic policy until the early 1990s. The discussions at that time were not only about the studies of relevant policies, but also about the necessity of studying the interactions between various policies and means towards different purposes and outcomes. (Stroick & Jenson, 1999). The concept of policy mix was applied to studies of environmental policy and environmental regulation, and it provided a number of suggestions. (Böhringer & Rosendahl, 2009; Goulder & Stavins, 2010; Gunningham & Sinclair, 1999; Morris, 2008; Sorrell & Sijm, 2003). With that background, several innovative policy researchers propounded that it would be necessary to study the interactions in innovation policy, namely the interactions of the goals and means for policy makers to apply in innovation policy. (Branscomb & Florida, 1998; K. Smith,

1994). However, the main concerns about policy mix were more focused on environmental and macro-economic policies rather than on innovation policy.

The milestone of the use of policy mix in innovation policy is perhaps the work of Soete and Corpakis (2003), who contended that the most efficient policies are attained when individual policy methods are combined properly in an NIS system, while promising discussions of STRATA-ETAN Expert Group on Benchmarking National RTD Policies. It resulted in the encouragement of the CREST Expert Group to implement an action plan regarding public research expenses and policy mix, and the 2003–2004 activity of CREST established mainstream policy analysis in Europe. Moreover, they studied the interactions between nations regarding OECD innovation and technology policy divisions and developed discussions through prolific research, which provided plans for efficient innovation policies and studies about what differences policy mix could make in OECD countries.

Flanagan et al. (2011) noted that the surfacing issue of policy mix in innovation policy study reflected two main developments. First, on the conventional point of view, it broke the belief of innovative economic success with a single S&T policy, and provided the necessity of a perspective understanding of dividing innovation policy into the different categories and combining them in a unified system (Edler & Georghiou, 2007; Edquist, Hommen, & Tsipouri, 2000; Soete & Corpakis, 2003). In other words, it is possible to simultaneously select a number of policies from various different categories to arrive at the ultimate goal of innovation policy, even though each of those policies maintain

various different means. According to Nauwelaers and Wintjes (2008), the reason for the consideration of synchronism in innovation policy is that innovation invades the agenda of the other conventional policies. It was referred to as a "widening and deepening" process, which was regarded as a process through which new and complicated policy methods could be introduced, and to expand the scope of innovation policy. Second, it provides a better understanding of how policy can have an effect not only in one direction, but also in various directions through the concept of the policy mix. This study shows that it is not limited to innovation policy research, but the traditional state centric model can be converted into new ideas such as multidimensional public administration or new public management (Bache & Flinders, 2004; Dunleavy & Hood, 1994).

Although many fresh ideas about innovation policy were revealed, in practice the policies were limited to conventional wisdom. A deeper understanding of the concept of policy mix in innovation policy is required before it can gain further acceptance. In reality, there are only some discussions about what would be the best way to establish a combination of various policies in an efficient and balanced fashion (Rammer, Sellenthin, & Holmberg, 2007; Soete & Corpakis, 2003; Wieczorek, Hekkert, & Smits, 2009). Therefore, those concepts need to be solidified and considered in a single mold so that the study of policy mix and those interactions in innovation policy can be established systematically.

In the following chapter, past studies on how the policy mix and those interactions in innovation policy were conceptualized will be surveyed, and the definition of how the

interactions and its complementary effects can be considered will be evaluated.

2.2 Conceptualization of interaction in innovation policy

Eliadis, Hill, and Howlett (2005) suggested that the result of combining policies with different time periods and different aims would be efficient, and analysis shows that the interactions of policy tools and the study of its conflicting relations are crucial for the concept of the policy mix. As mentioned previously, discussions related to this subject have often been controversial, but it was revealed through previous studies that it was only focused on the analysis of individual policy instruments, and it was only applied by the tacit presumption of perfect interchangeability in policies.

In this approach, as discussed by Witt (2003), the concept of public policy was regarded as selecting standardized policies from a toolbox of policy instruments with a fragmented vision, which were actually not related to each other. Rather, it would be more proper to approach with an understanding that each policy instrument, their legitimacy, purpose, executive method, and influence in certain periods and spaces are related, and that they have interactions and complementary effects rather than independence. Klappholz (1964) suggested that policy instruments in public policy in general have multiple purposes in broad frameworks rather than simple individual ones, and that there would be a lot of scope for contradictions between the purposes of different instruments.

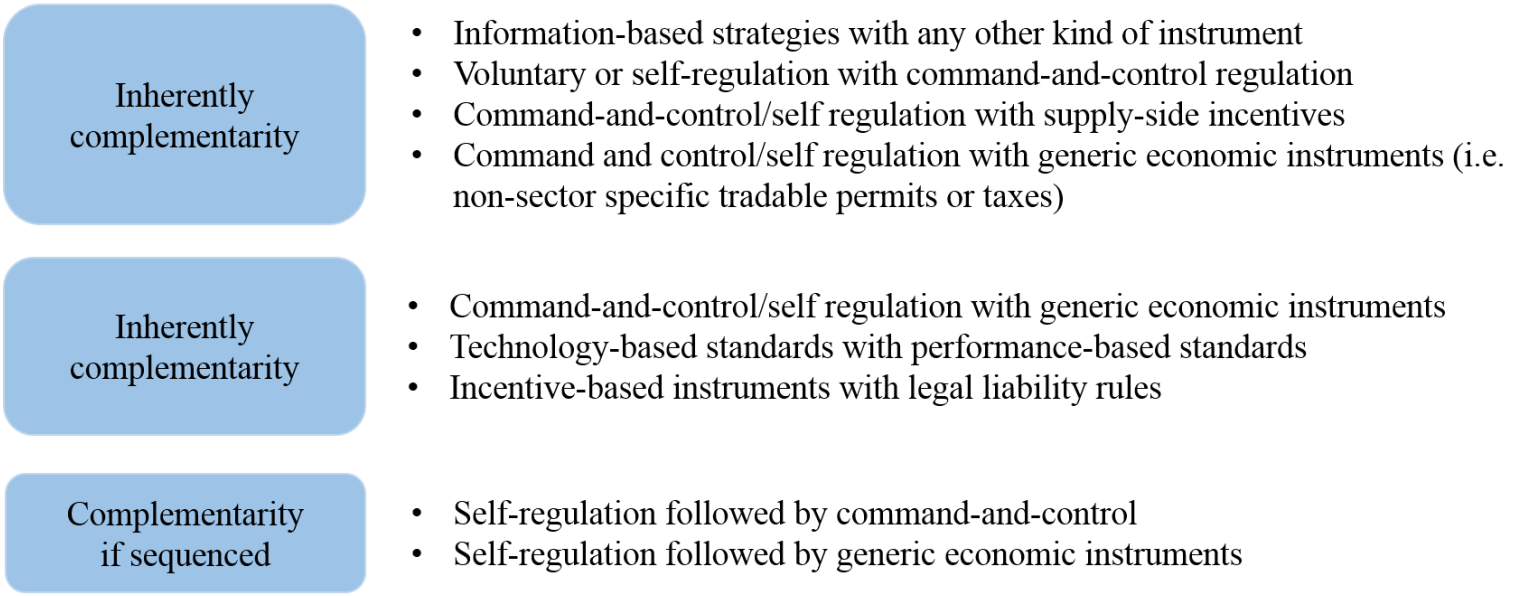
It is crucial to select goals, rationales, and implementations of policy instruments in

order to obtain effective public policies. Moreover, it was strongly emphasized by Pollitt (2008) that the analysis of the efficiency of policy instruments must take into account their evolution over time. Kay (2006) also stressed that without taking into account the period during which policies were in effect, conclusions regarding their results and the effectiveness of policy learning that varies for each time period and speed would be incomplete, and he emphasized the necessity of analyzing its evolution over time and the dynamic transitional process. Pollitt (2008) emphasized the importance of non-linear, path-dependent dynamic processes in public policy, and claimed the requirements in the analysis of interactions between economic cycles, organizational life cycles, and R&D budget and planning cycles. In other words, as with the result of dynamic processes in public policies, those of the goals, rationales, and implementations alter constantly over time while performers in an economic system under the policy instruments alter continuously over learning effects.

Therefore, various results can be predicted such as when the effectiveness of policy enforcements were applied, in which circumstances, and the path the economic system was applied to before the policy enforcement was effective. According to Uyarra (2010), public policy carries the characteristics of irreversibility and path-dependency, similar to the revolution. For instance, as mentioned by Kay (2006) and Bardach (2006), current policy makers restrict the scale of possible alternatives due to past policy decisions. It takes some time for particular policy procedures to achieve their eventual effectiveness, as a chain of events may occur that causes an evolution of policy instruments. Moreover,

it is possible that direct or indirect interactions may occur between older policy instruments and the new ones being implemented in either the short or long term. Ringeling (2005) suggested that an appraisal of the effectiveness of a single policy is meaningless, as the effectiveness of a single policy arises from the result of interactions between various different policies. Even though this approach by Ringeling is applied as a foundation of present policy analysis, in reality only a minority of studies are interested in methodical research studies on interactions between policy instruments.

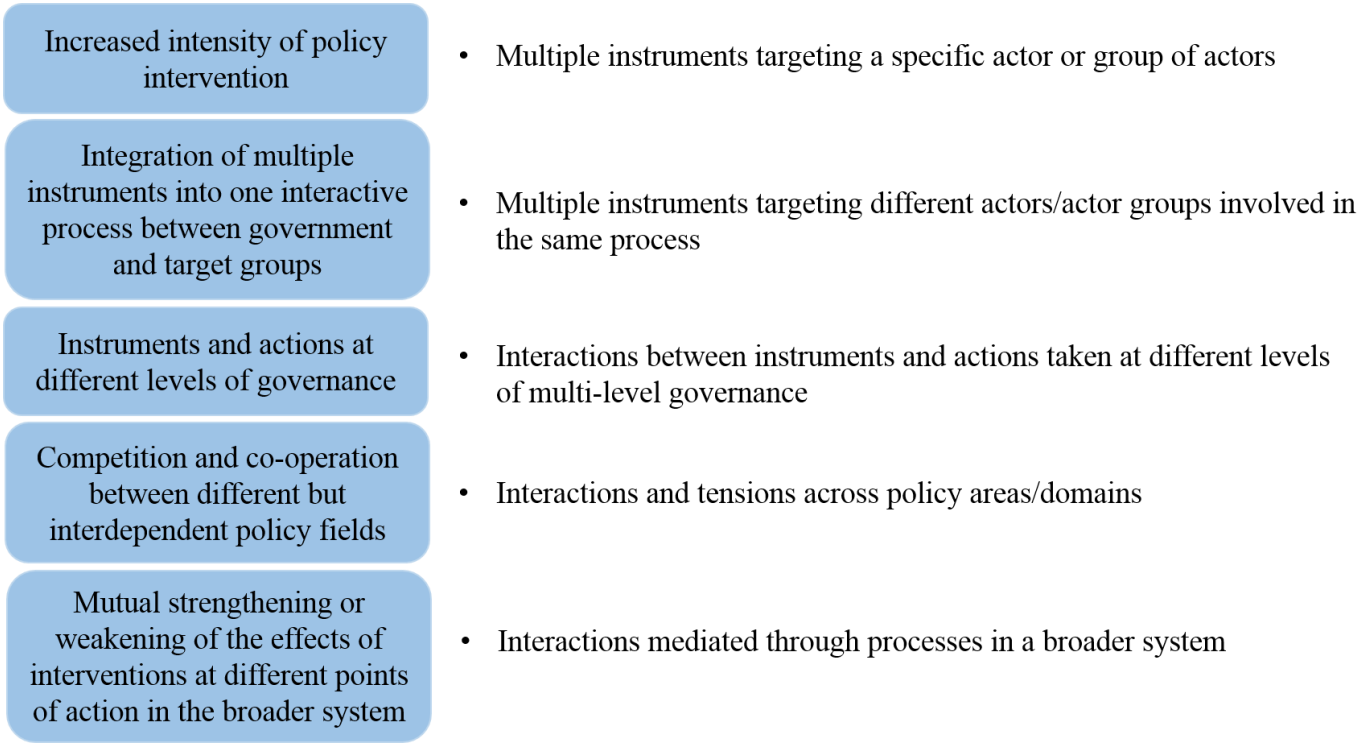
Gunningham and Sinclair (1999) introduced the concept and clarified the forms of policy mix in environmental policy. According this study, the forms of combinations of environmental policies can be clarified as inherently complementary, inherently incompatible, and complementary if sequenced, and the concept of combining various policy instruments was established through the clarification system. The clarification of Gunningham and Sinclair (1999) is shown in Figure 2. Rammer et al. (2007) studied the policy combination in R&D and innovation policy, and provided further clarification of policy combinations in interactions. In addition, Bressers and O'Toole Jr. (2005) introduced the five forms of influence or confluence in policy instrument mixes from the perspective of policy administrators, with purpose of the instruments in mind.



Source : Authors based on Gunningham and Sinclair (1999)

Figure 2. Theoretical policy instrument combinations

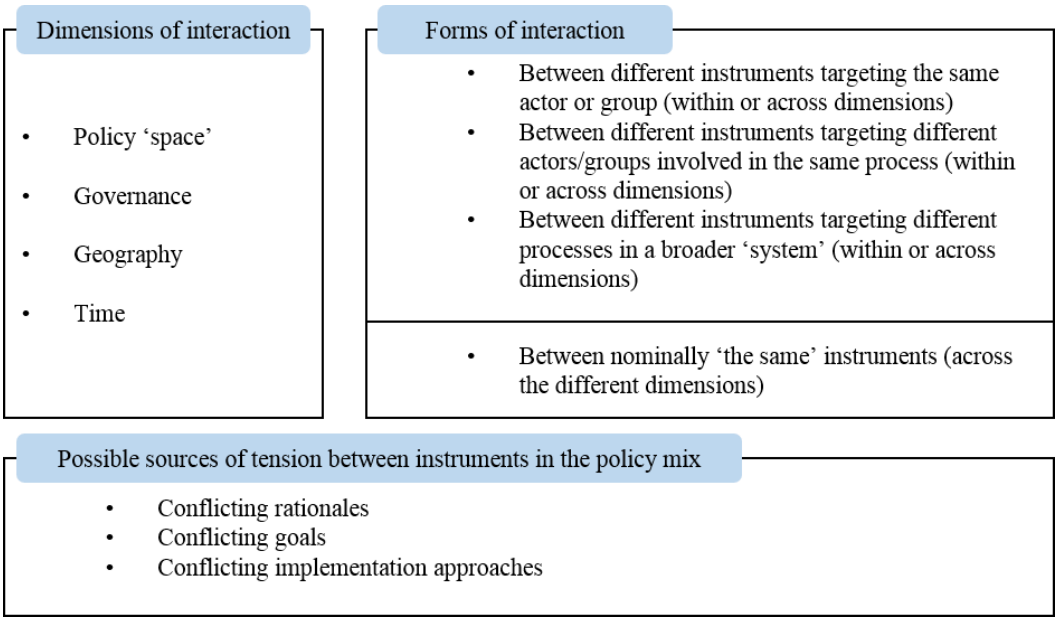
However, the approach mentioned above was found to have a limited boundary over time in prior studies, as it was focused on the interactions between the combined policy instruments. Flanagan, Uyarra, and Larangja (2010) pointed out that it is important to implement policy instruments simultaneously, and it would be possible to discover an unexpected types of potential interactions in the instruments over time. This would be congruent with the same concept mentioned above, that various results can be predictable within the different circumstances and paths to which an economic system was applied. As a result, with the endless change of an innovation environment with multiple systems and performers in NIS, multiple instruments that result from the continuous interactions between performers evolve flexibly over time. Therefore, it would be improper to regard the consideration in the combination of two or more instruments as a complimentary relation without the concept of time as the complementary relations between instruments vary over time. In this respect, the analysis of Bressers and O'Toole Jr (2005) with five interaction types of instruments was a significant point that provides the conceptual framework of the instruments.



Source : Authors based on Bressers and O'Toole Jr (2005)

Figure 3. Five forms of influence or confluence in policy instrument mix

In addition to the forms of Bressers and O'Toole, Flanagan et al. (2011) suggested considering the dimension of policy mix interactions, policy space, governance level, geographical dimension, and the dimension of time. He conceptualized the policy mix interactions at three levels: The first between different instruments targeting the same actor or group, the second between different instruments targeting different actors/groups involved in the same processes, and the third between different instruments targeting different processes in a broader system. Flanagan et al. (2011) also suggested possible sources of tension between instruments in the policy mix, and he noted conflicting rationales, conflicting goals, and conflicting implementation approaches. Finally, Flanagan et al. (2011) applied and conceptualized the dimensions of interaction, the forms of interaction, and possible sources of tension between different instruments in the policy mix, as shown in the following form.



Source : Authors based on Flanagan et al. (2011)

Figure 4. Conceptualising policy mix interactions: dimensions, forms of interaction and potential sources of tension

In this paper, the studies of Gunningham and Sinclair (1999), Bressers and O'Toole Jr. (2005), Flanagan et al. (2011) would be aggregated and classified so that complementarity effect from interactions in policy mix can be deduced as shown in following. The policy characters can be classified in the policy goal and implementation approach, in the ways that the governance supports. For instance, policy results will vary depending on whether the governing agency supports it directly or indirectly. This classification was considered with the dimension of the time and with the policy characters. With the theory about considering the past, present and future in policy, this

classification adds and suggests innovative analysis with the current overlapped support, future repetitive support, and past sequential support, as this newly introduced analysis has shown in the following form.

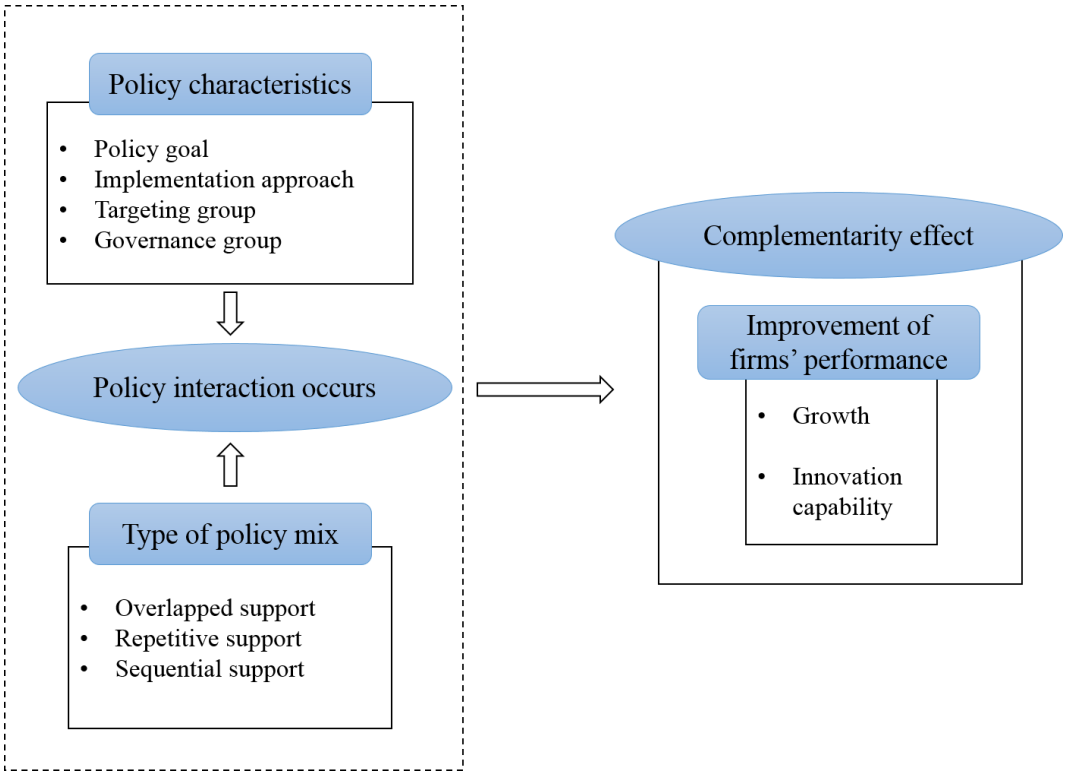


Figure 5. Policy mix, interactions and its complementarity effect

2.3 Complementarity effect in innovation policy

As was discussed above, it is significant that the interactions in policy instruments are understood to achieve the policy's purpose. The next question would be which way is the best to approach these interactions? This study suggests researching the complementarity effect to answer this question, as the analysis of a complementarity effect enables the classification of the relation of each complicated individual entity in an organized structure.

The concept of the complementary effect can be approached intuitively as "The whole becomes greater than the sum of its respective parts" (Mohnen & Röller, 2005), which tells us whether it shows a synergistic effect from a systematic point of view. One of the representative studies of this old original economic approach to the complementary effect would be Vives' (1990) study of optimization in a monopoly and complementary effects. After that, discussions about super modularity and complementary effect have been ongoing (Amir, 2005; Aziz & Westcott, 1997; De Macedo & Martins, 2008; Milgrom & Roberts, 1995; Topkis, 1998).

Innovation is complicated and it can be influenced by multiple elements; the characteristics of the innovation system would include that it encompasses a wide range of organs, related laws, benefits, customs, and ext. As those elements are interconnected, the complementarity effect will develop (Dosi, 1988). Therefore, a single policy can achieve an eventual purpose successfully through multiple policy plans.

Among the various methods of approaching the study of the complementary effect,

Athey and Stern (1998) proceeded as follows.

The first way began from the theory of revealed preference in the presumption of reasoned action. In the complementary effect with selected variables in governmental policy, variables have a tendency to be interrelated, and a good starting point to approach this interrelation is to calculate the uncontrolled interrelations. For the analysis of the complementary effect to be accurate, it is necessary to control the observable and non-observable elements and to induce a primary conditional function in order (Arora & Gambardella, 1990; Ichniowski, Shaw, & Prennushi, 1997; Miravete & Pernias, 2006). This does not require any data, but the fusibility of selected variables.

The second way, called as reduced form is the way of excluding restrictions (Holmstrom & Milgrom, 1994). This is based on the notion that there are no relations without the complementary effect between actions, and it is limited to calculating the effect with more than two variables (Arora, 1996).

The last way directly uses functional objects, and if the actions have the complementary effect, the final function and the product object will have supermodularity. The ability to obtain the complementarity effect directly would depend on whether the product object has supermodularity (Ichniowski et al., 1997). This study has selected the third way to deduce the complementarity effect, and the following method will be introduced.

$$Complementarity\,effect = \{F(x,y) - F(\bar{x},y)\} - \{F(x,\bar{y}) - F(\bar{x},\bar{y})\} \quad \cdots \text{Eq. (1)}$$

The analysis of multiple effects will be introduced in overlapped support, repetitive support, and sequential support in the policy complementarity effect.

Chapter 3. Methodology

3.1 Rubin's casual effect

Estimating the effect of government support on the outcomes of a firm involves speculating about how this firm would have performed, had they not received support. Various frameworks for the empirical analysis of this impact assessment have been suggested (Fisher, 1935; Neyman & Iwaszkiewicz, 1935; Quandt, 1972; Rubin, 1974), and it is usually called the Roy-Rubin model (RRM).

The most important concepts of RRM are firms, government support, and potential outcomes. In the basic model, there are two potential outcomes, Y_i^1 and Y_i^0 for each firm *i*, where Y_i^1 represents a situation with government support, and Y_i^0 represents a lack of government support. Then, the treatment effect of each firm *i* is defined as below.

$$\Delta_i = (Y_i^1 - Y_i^0) \quad \cdots\cdots \text{Eq. (2)}$$

Let *D* be the assignment indicator, then *D* equals 1 if a firm actually received government support and let *D* equal 0 otherwise.

$$Y_i = D_i Y_i^1 + (1 - D_i) Y_i^0 \quad \cdots\cdots \text{Eq. (3)}$$

Equation (3) means that Y_i^1 is observed for firms that received government support, and Y_i^0 is for those who did not. Unfortunately, Y_i^1 and Y_i^0 can never be observed for the same firm simultaneously; therefore, equation (2) cannot be estimated directly. The unobservable component in equation (2) is called the counterfactual outcome. That is to say, for a firm that participated in the government support, Y_i^0 is the counterfactual outcome, and for another firm that did not participate, Y_i^1 is the counterfactual outcome.

To overcome this problem, two parameters are used in policy evaluation study, one is the average treatment effect (ATE) and the other is the average treatment effect on the treated (ATT). ATE is simply the difference between the expected outcomes after support and non-support.

$$\Delta_{ATE} = E(\Delta) = E(Y^1) - E(Y^0) \quad \cdots\cdots \text{Eq. (4)}$$

This parameter can determine the outcome if firms in the population were randomly assigned to government support. Hence, estimating ATE cannot usually be relevant to policy, because in many cases, government policy makers intentionally select specific firms, and so interest focuses on the effects of support on those firms. Consequently, the most acceptable evaluation parameter is the average treatment effect on the treated (ATT), which focuses explicitly on those for whom the policy maker is actually intended. The expected value of ATT is defined as the difference between expected outcome values with

and without treatment, for those who actually participated in government policy.

$$\Delta_{ATT} = E(\Delta \mid D=1) = E(Y^1 \mid D=1) - E(Y^0 \mid D=1) \quad \cdots\cdots \text{Eq. (5)}$$

In equation (5), the second term on the right hand side is unobservable, because it represents the counterfactual outcome without treatment for those firms who received government support. If equation (6)

$$E(Y^0 \mid D=1) = E(Y^0 \mid D=0) \quad \cdots\cdots \text{Eq. (6)}$$

holds, then non-supported firms can be used as an adequate control group. However, supported firms usually have different characteristics compared to non-supported firms; thus, equation (6) will not be easy to hold with non-experimental data.

$$E(\mathrm{Y}^0 \mid X, D=1) \neq E(\mathrm{Y}^0 \mid X, D=0) \quad \cdots\cdots \text{Eq. (7)}$$

Consequently, estimating ATT by the difference in sub-population means of supported firms $E(Y^0 \mid D=1)$ and non-supported firms $E(Y^0 \mid D=0)$ will cause selection bias. To reduce this, Rosenbaum and Rubin (1983) discuss the following two assumptions, “Unconfoundedness” and “Overlap.”

The unconfoundedness assumption indicates that for a conditional on some covariates *X*, the outcome *Y* is independent of *D*, and Dawid (1979) describes it as:

Assumption 1　Unconfoundedness

$$Y^0, Y^1 \perp D \mid X$$

Here, $\perp$ denotes independence, and X is a pre-determined variable that is not influenced by governmental support. If the unconfoundedness assumption is true, then

$$F(\mathrm{Y}^0 \mid X, D=1) = F(\mathrm{Y}^0 \mid X, D=0) \quad \cdots\cdots \text{Eq. (7)}$$

$$F(\mathrm{Y}^1 \mid X, D=1) = F(\mathrm{Y}^1 \mid X, D=0) \quad \cdots\cdots \text{Eq. (8)}$$

Equation (7) and Equation (8) mean that, conditional on covariate *X*, non-supported firms' outcomes have the same distribution of outcomes as supported firms would have experienced if they had not been supported by the government (Heckman, Ichimura, & Todd, 1998). Consequently, the counterfactual outcomes can be obtained through this assumption.

$$E(\mathrm{Y}^0 \mid X, D=1) = E(\mathrm{Y}^0 \mid X, D=0) = E(\mathrm{Y}^0 \mid X) \quad \cdots\cdots \text{Eq. (8)}$$

$$E(\mathrm{Y}^1 \mid X, D=1) = E(\mathrm{Y}^1 \mid X, D=0) = E(\mathrm{Y}^1 \mid X) \quad \cdots\cdots \text{Eq. (9)}$$

With the unconfoundedness assumption, an additional assumption is required for each side of the equations to be defined well, which is called the overlap assumption.

Assumption 2 Overlap :

$$0 < \Pr(D=1 \mid X) < 1, \ \textit{for all } X$$

This assumption implies that the support of *X* is equal in both supported group and non-supported group, i.e. S = Support $(X \mid D=1)$ = Support $(X \mid D=0)$. If this assumption is true, then a counterpart for the supported group can be found in the non-supported group, and vice versa. If there are areas where the support of covariate *X* does not overlap for the supported and non-supported firms, matching only has to be performed in the common support area. Rosenbaum and Rubin (1983) called these two assumptions "strong ignorability," and under "strong ignorability," ATE in equation (4) and ATT in equation (5) can be defined for all covariates, *X*.

In sections 3.2 and 3.3, various methods for estimating the treatment effect will be introduced, and the reason why the matching method is the most useful method to estimate the complementarity effect in innovation policy will be described.

3.2 Alternative Evaluation Estimators

3.2.1 Before-After Estimator

The most specific and widely used method for impact assessment is the "Before–After Estimator (BAE)." The basic concept of BAE is that the outcome in the pre-treatment period (t') can be alternative with the potential counterfactual outcome of firms without treatment in the post-treatment period (t). By substituting the unobservable counterfactual performance of the treated firms with the outcome in the pre-treatment period, BAE solve the unobservable counterfactual problem.[1] The central assumption of BAE is followed as:

$$E(Y_{t'}^{0} \mid D=1) = E(Y_{t}^{0} \mid D=1) \quad \cdots\cdots \text{Eq. (10)}$$

Under this assumption, average treatment effect on the treated (ATT) can be stated as:

$$\Delta_{ATT}^{BAE} = E[(Y_{t}^{1} \mid D=1) - (Y_{t'}^{0} \mid D=1)] \quad \cdots\cdots \text{Eq. (11)}$$

The main advantage of BAE is that it does not require the information of non-treated firms. In order to calculate the ATT using BAE, just the pre-treatment outcomes and post-treatment outcomes of the treated firms are required. However, the validity of Eq. (10)

[1] The unobservable counterfactual problem refers to "what would occur to those who receive the treatment, if they have not received the treatment."

depends on two implicit assumptions. First, the pre-treatment outcomes have to be independent on the policy itself. However, most firms strive to receive the government support, and these firms' action can influence the outcomes. In other words, the relation between pre-treatment outcomes and policy cannot be independent. Second, the potential outcomes according to time have to be consistent. If the period of policy implementation is economically unstable or is influenced by economic cycle, the results calculated by Equation (10) cannot be regarded by the pure effect of the government policy (Heckman, LaLonde, & Smith, 1999).

3.2.2 Difference-in-Differences Estimator

Since there are various unobservable factors in estimation of treatment effect, only controlling for selection bias on observables is not sufficient. For solving the selection bias from unobservable factors, Heckman et al. (1999) suggest econometric models and the difference-in-differences (DID) model. The DID estimator can be seen as the extension of the BAE estimator because it uses longitudinal data. The DID estimator compares differences between untreated firms' outcomes and treated firms' outcomes over the same period, whereas the BAE estimator compares differences between pre-treatment outcome and post-treatment outcome of the treated firms. Therefore, the DID estimator can eliminate time trends by subtracting the before–after change of non-participant outcomes from the BAE estimator.

The DID estimator compares differences between changes in outcomes of untreated

firms and changes in outcomes of treated firms in the same period (Heckman et al., 1998).

$$\Delta_{ATT}^{DID} = E[(Y_t^1 - Y_{t'}^0 \,|D=1) - (Y_t^0 - Y_{t'}^0 \,|D=0)] \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{Eq. (12)}$$

The assumption of this method is,

$$E[(Y_t^0 - Y_{t'}^0 \,|D=1) = \mathrm{E}(Y_t^0 - Y_{t'}^0 \,|D=0)] \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{Eq. (13)}$$

This assumption means that the selection bias due to time trends for treated and untreated firms are similar. That is, each is equally affected by the unobservable factor during the treatment period. Therefore, the DID estimator can eliminate the outcome differences occurring from the economic circumstance or economic life cycle, and, ultimately, the selection bias occurring from unobservable factors can be removed (Heckman et al., 1998).

3.2.3 Cross-Section Estimator

Unlike comparing the outcome differences at two different time periods (like BAE and DID estimators), the cross-section estimator (CSE) compares the outcome differences between treated firms and non-treated firms at the same time; that is, it considers cross section data. The identifying assumption is stated as:

$$E(Y_t^0 \mid D=1) = E(Y_t^0 \mid D=0) \quad \cdots\cdots \text{Eq. (14)}$$

Equation (14) indicates that the outcomes occurring to those who receive the treatment, if they have not previously received the treatment, is equal to the outcomes of non-treated firms. Heckman et al. (1999) indicates that, if observable factors are controlled, the CSE estimator is a useful method for discerning treatment effect. If the distribution of covariate X is different between treated firms and non-treated firms, the outcomes difference from covariate X can be eliminated by conditioning on covariate X.

$$E(Y_t^0 \mid X, D=1) = E(Y_t^0 \mid X, D=0) \quad \cdots\cdots \text{Eq. (15)}$$

If this assumption holds, ATT can be derived as

$$\Delta_{ATT}^{CSE} = E[(Y_t^1 \mid X, D=1) - (Y_t^0 \mid X, D=0)] \quad \cdots\cdots \text{Eq. (16)}$$

CSE estimator is useful in case there is no longitudinal information, and it also can solve selection bias occurring from macroeconomic circumstance over time (Schmidt, 2001). However, in case motivation of firms plays a role in determining the desire to support, Equation (15) is not valid, and it is impossible to estimate correctly from the

CSE estimator.

3.2.4 Instrumental Variables

The method of instrumental variables (IV method) evaluates the treatment effect by controlling the selection bias occurring from unobservable factors. The basic idea of IV method is to find alternative variables which determine treatment participation but not affect the outcomes. That is, IV is the variable which influences indirectly the outcomes derived from government support, and the difference in the outcomes is the treatment effect of government support. Various discussions of IV method can be seen in Imbens and Angrist (1994) and Angrist, Imbens, and Rubin (1996).

The main key of IV method is to find an appropriate variable for using as IV. Especially, in the case of estimating the treatment effect of government support, it is very difficult to find the variable that perfectly carries out the IV role. As mentioned above, IV has to simultaneously satisfy the conditions determining treatment participation and those not affecting the outcomes. Moreover, Bound, Jaeger, and Baker (1995) point out the problems when using "weak instruments." They announced that if the unconvincing variables are used as IV, the reliability and efficiency of the results are lessened.

3.3 Matching Estimator as an instrument estimating the complementarity effect

3.3.1 Matching estimator

There are various studies concerning matching method in econometrics. The basic concept of the matching method is to find the firms most similar to treated firms among non-treated firms. The most common matching methods are multivariate matching and propensity score matching.

3.3.1.1 Multivariate matching

As mentioned in section 3.1, for each firm i, the treatment effect of government support can be represented as $\Delta_i = Y_i(1) - Y_i(0)$. However, it is impossible to obtain $Y_i(1)$ and $Y_i(0)$ simultaneously; therefore one of them is counterfactual. The matching estimators impute these missing outcomes by using average outcomes of firms having many similarities with the treated firm.

Let X_i be the set of covariates for a firm i, and let $\|x\|V = (x'Vx)^{1/2}$ be the vector norm with positive definite matrix V. Then, $\|z - x\|V$ means the distance between vector x and z. Let $d_M(i)$ be the distance from X_i to the Mth nearest matched firm among the non-treated firms, then this value is positive and the following equations can be derived,

$$\sum_{l: W_l = 1 - W_i} I\{ \|X_l - X_i\| v < d_M(i)\} < M \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{Eq. (17)}$$

$$\sum_{l:W_l=1-W_i} I\{\left\|X_l - X_i\right\| v < d_M(i)\} \geq M \quad \cdots\cdots\text{Eq. (18)}$$

$I\{\}$ means indicator function, that is, 1 if {} is true and 0 otherwise.

Let $\Im_M(i)$ be the set of the matched firms for firm i that are as close as the Mth; then, $\Im_M(i)$ can be expressed as following.

$$\varsigma_M(i) = \{I = 1,...,\mathrm{N} \mid W_l = 1 - W_i, \left\|X_l - X_i\right\| v < d_M(i)\} \quad \cdots\cdots\text{Eq. (19)}$$

If ties are not allowed, the number of $\varsigma_M(i)$ is M, but may be larger. Let $\#\Im_M(i)$ be the number of $\Im_M(i)$, and let $K_M(i)$ be the number of times firm i is used as a match for all observations, l, of the non-treated firms. In this case, each time has to be weighted by the total number of matches.

$$K_M(i) = \sum_{l=1}^{N} 1\{\mathrm{i} \in \varsigma_M(l)\} \frac{1}{\#\varsigma_M(l)} \quad \cdots\cdots\text{Eq. (20)}$$

Note that, $\sum_i K_M(i) = N$, $\sum_{i:W_i=1} K_M(i) = N_0$ *and* $\sum_{i:W_i=0} K_M(i) = N_1$

With these notations, the simple matching estimator can be considered first, and it estimates the outcomes with the following method.

$$Y_l(0) = \begin{cases} Y_i & if\ W_i = 0 \\ \dfrac{1}{\#\varsigma_M(i)} \sum_{l \in \varsigma_M(i)} Y_l & if\ W_i = 1 \end{cases} \quad \text{……Eq. (21)}$$

$$Y_l(0) = \begin{cases} \dfrac{1}{\#\varsigma_M(i)} \sum_{l \in \varsigma_M(i)} Y_l & if\ W_i = 0 \\ Y_i & if\ W_i = 1 \end{cases} \quad \text{……Eq. (22)}$$

Given that only one potential outcome is observed for each i, the observed outcome, Y_i, is $Y_i(0)$ or $Y_i(1)$. The unobserved outcome is estimated by averaging the observed outcomes of the non-treated firms that are selected as matches for i.

Using this method, the simple matching estimator for average treatment effect can be derived as

$$\Delta_M^{sm} = \frac{1}{N}\sum_{i=1}^{N}\{Y_i(1) - Y_i(0)\} = \frac{1}{N}\sum_{i=1}^{N}(2W_i - 1)\{1 + K_M(i)\}Y_i$$

$$\widehat{\Delta}_M = \frac{1}{N}\sum_{i=1}^{N}\{\widehat{Y}_i(1) - \widehat{Y}_i(0)\} = \frac{1}{N}\sum_{i=1}^{N}(2W_i - 1)\{1 + K_M(i)\}\,Y_i \quad \text{……Eq. (23)}$$

In addition, the simple matching estimator for average treatment effect on the treated (ATT) can be derived as.

$$\Delta^{sm}_{M,ATT} = \frac{1}{N}\sum_{i:W_i=1}\{Y_l - Y_l(0)\} = \frac{1}{N}\sum_{i=1}^{N}\{(W_i - (1-W_i)K_M(i)\}Y_l$$

$$\hat{\Delta}_{M,t} = \frac{1}{N}\sum_{i:W_i=1}\{Y_l - \hat{Y}_i(0)\} = \frac{1}{N}\sum_{i=1}^{N}(W_i - (1-W_i)K_M(i)\}Y_l \quad \cdots\cdots\cdots\text{Eq. (24)}$$

If more than one covariate is specified, the matching estimator depends on the inverse variance weighing matrix V, which indicates the differences in the scale of the covariates.

$$(X_i - X_l)'\mathrm{V}^{-1}(X_i - X_l) \quad \cdots\cdots\cdots\text{Eq. (25)}$$

In case of Mahalanobis metric matching, V is S^{-1}, where S is the variance covariance matrix of the covariates.

However, the simple matching estimator can be biased when the matching is not correct. Abadie and Imbens (2011) show that the simple matching estimator will cause the matching discrepancies with k covariates. Therefore, other attempts to remove the additional bias are required after matching.

For solving this problem, Abadie, Drukker, Herr, and Imbens (2004) introduced the bias-corrected matching estimator. This estimator corrects the difference of covariates between the firms, and the regression analysis is performed as

$$\mu_w(x) = E\{Y(w)\big|X = x\} \ \ for\ \ w = 0\ or\ 1$$

Following Rubin (1973) and Abadie and Imbens (2011), these regression functions are regarded as linear functions and estimated by using least square on the matched samples.

In case of calculating the average treatment effect, the regression functions are estimated by only using matched samples,

$$\mu_w(x) = \beta_{w0} + \beta'_{w1} x \quad \cdots\cdots \text{Eq. (26)}$$

for w = 0, 1, where

$$(\beta_{w0}, \beta_{w1}) = \arg\min_{\{\beta_{w0}, \beta_{w1}\}} \sum_{i: W_i = w} K_M(i)(Y_i - \beta_{w0} - \beta'_{w1} X_i)^2 \quad \cdots\cdots \text{Eq. (27)}$$

As the purpose of this paper is to estimate the ATT, $\mu_0(x)$, in case of w=0, is needed to be estimated.

In these regressions, the observations are weighted by $K_M(i)$, the number of times each firm is used as a matched firm, because the weighted distribution is similar to the distribution of covariates. In addition, only the matched sample is used in this step, because using the full sample could include observations disclosure from our interested sample. When estimating the ATT, control firms that are not used as matches have very different covariate values than those of the treated units we are trying to match. Hence, using these controls to predict outcomes for the treated units leads to results that can be

very sensitive to the exact specification applied.

Given the regression functions, for the bias-corrected matching estimator we can estimate the unobservable potential outcomes as

$$Y_i(0) = \begin{cases} Y_i & if\ W_i = 0 \\ \dfrac{1}{\#\varsigma_M(i)} \sum_{l \in \varsigma_M(i)} \{Y_l + \mu_0(X_i) - \mu_0(X_l)\} & if\ W_i = 1 \end{cases} \quad \cdots\cdots \text{Eq. (28)}$$

$$Y_i(1) = \begin{cases} \dfrac{1}{\#\varsigma_M(i)} \sum_{l \in \varsigma_M(i)} \{Y_l + \mu_1(X_i) - \mu_1(X_l)\} & if\ W_i = 0 \\ Y_i & if\ W_i = 1 \end{cases} \quad \cdots\cdots \text{Eq. (29)}$$

Finally, the ATT of bias-corrected matching estimators is derived as follows.

$$\Delta_{M,ATT}^{bcm} = \frac{1}{N_1} \sum_{i:W_i=1} \{Y_i - Y_i(0)\} \quad \cdots\cdots \text{Eq. (30)}$$

3.3.1.2 Propensity score matching

Propensity score matching (PSM) is also the most used method for evaluating the effect of government support (David et al., 2000). The fundamental idea of the PSM methodology is to find a “control firm” that is probabilistically similar to the “treated firm” and use it as the counterfactual of the performance that would have occurred with

participation in the program (Rosenbaum & Rubin, 1983). That is, by using the firm characteristics (X variable) right before the support, the propensity score can be obtained. According to Rosenbaum and Rubin (1983) and Caliendo (2006), the concept of PSM is based on the strongly ignorable treatment assignment assumption. This means that, conditioned on the observable characteristics (X variables) of possible participants, the decision for participation of the program should be independent of the outcome measures.

The propensity score is defined as the probability to be "treated (D=1)," and it is shown below.

$$\Pr opensity\ score = PS(X) = \Pr(D = 1 \mid X)$$

$$\text{Propensity score} = \text{PS(X)} = \text{Pr(D} = 1|\text{X)} \quad \cdots\cdots \text{Eq. (26)}$$

If P(X) has a similar value, it means that it has a similar probability of getting support. When P(X) is controlled, the biases from observable variables can be eliminated and it can be expressed as the following.

$$Y^0, Y^1 \perp D \mid PS(X) \quad \cdots\cdots \text{Eq. (27)}$$

Therefore, the ATT can be expressed as below.

$$\Delta_{ATT} = E(Y_1 - Y_0 \mid D=1) = E[E\{Y_1 - Y_0 \mid D=1,\ PS(X)\}]$$
$$= \mathrm{E}_{PS(X)}[E\{Y_1 \mid D=1, PS(X)\} - E\{Y_0 \mid D=0, PS(X)\} \mid D=1] \quad \cdots\cdots\cdots\cdots \text{Eq. (28)}$$

To calculate ATT, it should be matched between the firms that have the same P(X). It is impossible to find the matching pair for every observation, even if they have the same P(X). Caliendo (2006) and Becker and Ichino (2002) described an alternative matching method to find comparison observation. The most common form in the statistics literature is the nearest neighbor matching approach. In this paper, we also use the nearest neighbor matching method from among alternative matching methods.

3.3.2 Why matching estimator is useful to estimate the complementarity effect?

As mentioned above, there are various methods to evaluate the effects of government support. However, which is the most suitable method for estimating the complementarity effect in innovation policy remains contentious. Following the previous literature, matching can be a useful method for estimating the multiple treatment effect. Lechner (2001) introduced the method estimating the multiple treatment effect under the Conditional Independence Assumption (CIA). Using this method, he tied to solve the selection bias occurring from firms' heterogeneity (Lechner, 2001, 2002). In addition, Oh, Lee, Heshmati, and Choi (2009) and Oh and Lee (2011) expanded Lechner's discussion,

and analyzed the additional effect of overlapped support in guarantees. In their paper, Oh and Lee (2011) mentioned that the additional effect of overlapped support is not large.

However, the previous studies about multiple treatment effect have remained at a simple level, only investigating the outcome differences between firms receiving the overlapped support and firms receiving single support. However, in the present paper, it is attempted to estimate the complementarity effect according to the overlapped support—that is, the synergy effect between policies. To this end, close examination about how to estimate the complementarity effect is needed. As mentioned in chapter 2, the complementarity effect can be estimated as below:

$$Complementarity\ effect = \{ f(x,y) - \underset{①}{f(\bar{x},y)} \} - \{ f(x,\bar{y}) - \underset{②}{f(\bar{x},\bar{y})} \}$$

That is, function ① and function ② have to be calculated simultaneously in order to estimate the complementarity effect according to the overlapped support. Moreover, because both function ① and function ② have selection bias, one of the methodologies mentioned in chapter 3 has to be used. In this paper, the matching estimator is used for estimating the complementarity effect. In case of the function ①, $f(x,y)$ is regarded as treatment group and $f(\bar{x},y)$ is regarded as treatment group. Similarly, in case of function ②, $f(x,\bar{y})$ is regarded as treatment group and $f(\bar{x},\bar{y})$ is regarded as treatment group. The difference in the estimation results between function ① and

function ② is the complementarity effect of the overlapped support. If the complementarity effect if positive, it can be concluded that they (policy x and policy y) have a synergy effect on each other.

However, simple comparison between matching ① and matching ② can lead to another problem: selection bias. As mentioned above, the treatment group used in matching ① is $f(x,y)$, and the treatment group used in matching ② is $f(x,\bar{y})$. Therefore, the matched firms used in matching ① and matching ② have different characteristics. Therefore, if simply comparing the results of matching ① and matching ②, selection bias can occur. To solve this problem, a matching method is utilized once more to estimate the difference in results of matching ① and matching ②, that is, a "double matching method" is used.

The procedure of double matching is as follows. First, matching method is performed in each case of function ① and function ②. Through each matching, the treated firms, $f(x,y)$ and $f(x,\bar{y})$, have their matched firms, and the outcome difference between the treated firms and the matched firms can be obtained using a simple matching estimator. That is, each treated firm has its own ATT value. After that, matching method is performed again for $f(x,y)$ and $f(x,\bar{y})$. In this case, $f(x,y)$ is the treated group and $f(x,\bar{y})$ is the control group. By using the double matching method, all firms used for estimating the complementarity effect can be induced to have similar characteristics. Consequently, the double matching method is the most useful method to estimate the

complementarity effect of multiple treatments.

Chapter 4. Analysis on the complementarity effect according to overlapped support in innovation policy

4.1 Background and purpose of the study

As we outlined in chapter 2, several studies have been made on how overlapped support in innovation policy affects a firm's performance. The concept and framework of overlapped support of different policies at a given time is presented in Figure 5. Understanding whether and how duplicated policy supports lead to performance is a critical insight for managers and policy makers in innovation policy.

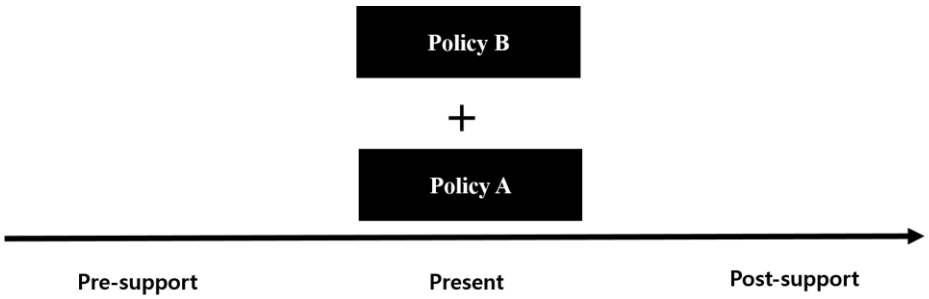


Figure 6. Conceptual diagram of overlapped support

It has been steadily recognized by economists and policy scientists that the effect of redundancy in policy supports needs to be examined theoretically and empirically. Table2 organized previous literatures on overlapped policy supports.

Table 1. Previous literature about overlapped policy support

	Authors	Contents
Positive	Osborne and Gabler (1992)	Duplication of government services and the resulting inefficiency always need to be removed for government innovation and organizational changes.
	Lim (2004)	Institutions that, horizontally, perform similar tasks must be merged.
	Ahn (2004)	In order to solve the overlap problem, the cooperative and competitive system should be prepared.
	GAO (1994)	Overlapped support causes an additional cost.
	GAO (1995)	In case similar policies exist, the moral hazard problem can occur, resulting in failure of policies.
Negative	GAO (2005)	"Second pair of eyes": Duplicated regulatory frameworks can be positive to achieve a policy's goal.
	Landau (1969)	Overlapped support contributes to lowering the possibility of policy failure.
	Von Neumann (1956)	To reduce the policy failure, it is necessary to add sufficient duplication in administrative organization.
	Landau, Chisholm and Weber (1980)	The introduction of redundant systems having different types of operating systems can improve the stability of the organization.
	Miranda and Lerner (1995)	When public organizations, non-profit organizations and private organizations are redundantly mixed, the effect of a system is higher.
	Terwiesch and Loch (1999)	Introduction of overlapped support relating to R&D plays a positive role to quicken the achievement of success.

A majority of researchers pointed out that duplicated support of different policies to the same firm resulted in inefficiency in achieving goals of each policy, so policy supports are necessary to provide benefit to as many firms as possible without duplication, while few researchers said that overlapped supports can contributes to lowering the possibility of policy failure by creating a tighter monitoring network (Landau, 1969).

Although there are mixed results on the effect of overlapped supports of different policies, most relevant studies have been silent on analyzing what makes these results presented, or how it can be explained within a unified framework. In particular, the traditional evaluation of effect of overlapped supports in innovation policy is increasingly unable to describe underlying reasons that cause different results. The lack of empirical research evaluating such an effect in innovation economy allows us to conceive the idea of addressing this issue practically.

Out of diverse innovation policies, we try to focus on two different types of innovation policies: “Guarantee policy” and “Certification policy.” These two different types of innovation policy reflect different ways of implementation to promote performance of promising small businesses in Korea. Thus, based on characteristics of each innovation policy, examining whether complementary effects exist or not is required, because individual innovation policies have their own policy targets and key roles. Before we set the framework for empirical modeling to evaluate the complementary effect of overlapped policies, the Guarantee policy and Certification policy conducted in Korea are

introduced and explained more specifically.

According to the principle of economics, adverse selection and information asymmetry have been regarded as one of the major sources of market failure. This makes the financial institution require tangible collaterals when they make a loan to small businesses, because the financial institutions are unable to address and accurately determine credit of small businesses (Cowling & Mitchell, 2003). Due to this practice in the financial industry, small businesses that do not have enough assets as a form of collateral face difficulties in borrowing money and eventually pay more interest. This market failure caused by information asymmetry justifies the government's intervention into the loan market for small businesses (Evans & Jovanovic, 1989). In fact, the world's major industrialized nations such as U.S.A., France, and Germany have financed small businesses as a form of subsidy and even entrepreneurs who are about to start a new business have directly received substantial financial support from the government. (Bendick Jr & Egan, 1987)

In Korea, the Korea Credit Guarantee Fund (KCGF) is a public financial institution established on June 1st 1976 under the provisions of the Korea Credit Guarantee Fund Act. As stipulated in Article 1 of the Korea Credit Guarantee Fund Act, the objective of KCGF is to lead the balanced development of the national economy by extending credit guarantees for the liabilities of promising Small and Medium Enterprises (SMEs) that lack tangible collateral. Further, KCGF stimulates sound credit transactions through the efficient management and use of credit information.

Along with KCGF, the Korea Technology Finance Corporation (KTFC) was founded in 1989 by the Korean Government as a non-profit credit guarantee institution under the special enactment, “Financial Assistance to New Technology Businesses Act.” SMEs with 1,000 or fewer employees and 100 billion won or less total assets can be candidates for a guarantee from KTFC. One of the main roles of KTFC is to guarantee outstanding technology of selected SMEs to financial institutions. In particular, KTFC assess future value of technological potentials, marketability, and business feasibilities to use it as basis for technology finance for providing guarantees. The comparison between KCGF and KTFC can be represented in Table 3.

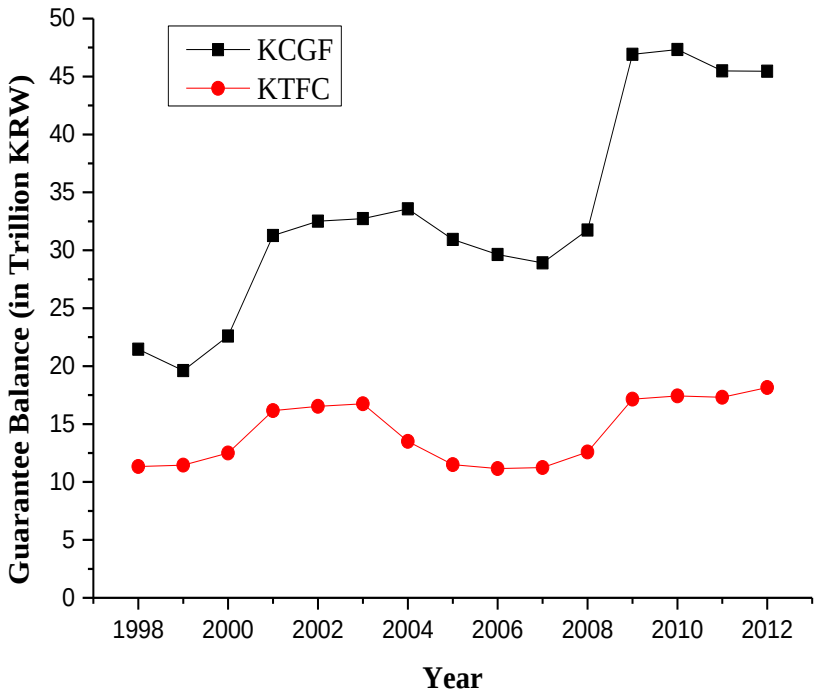
Table 2. Comparison of KCGF and KTFC

	KCGF	KTFC
Targeting group	SME	Innovative SME
Source of revenue	Government and financial institution	Government and financial institution
Way of examination	Corporate Credit Rating System (CCRS)	Kibo Technology Rating System (KTRS)
Limit of guarantee	3 billions in KRW	3 billions in KRW

* Source: Annual reports of KCGF and KTFC

As shown in Table 3, the fact that that both are conducted by the Korean government and help SMEs as a form of guarantee is similar for the two policies, while the point that

KCGF aims at credit guarantee and KTFC encourages innovative and tech-oriented SMEs through a technology guarantee makes them different. Figure 6 shows how much government budget for both policies has been executed from 1998 to 2012. The steadily rising trend of budget amount of both policies means that the Korean government continues to try to support SMEs using the credit guarantee and technology guarantee policies.



* Source: Annual reports of KCGF and KTFC

Figure 7. Guarantee Balance of KCGF and KTFC

As the Korean government has expanded the budget of KCGF and KTFC over a few decades, the number of companies that receive overlapped supports from both guarantee programs also continues to increase. In this context, the economists raised a question as to whether overlapped supports to a company from both policies empirically lead to a positive effect. The majority of them pointed out that duplication of supports is unnecessary and wasteful in terms of government budget allocation because overlapped supports to a company provides more supports than one firm needs. Reflecting this perspective, the Korean government has been trying to reduce the number of companies getting overlapped supports from both KCFG and KTFC since 2005. Table 4 shows the ratio of the overlapped support of KCGF and KTFC; it shows that the ratio of such companies supported by KCGF decreased from 26% in 2005 to 5.3% in 2013. Similarly, the ratio of firms receiving a loan guarantee from both policies also decreases from 52.9% in 2005 to 8.7% in 2013.

Table 3. Ratio of the overlapped support of KCGF and KTFC

(unit : %)

	2005	2010	2011	2012	2013
KCGF	26.0	5.5	5.2	5.3	5.3
KTFC	52.9	9.3	8.8	8.9	8.7

* Source: National Assembly Budget Office

The reason why the number of companies that get overlapped support from both KCFG and KTFC has been falling for years is that it has long been considered an inefficient allocation of government budget. This is acceptable on the basis that giving certain SMEs much greater loan guarantees has not been encouraging every dimension of firm performance, only sales (Oh et al., 2009; Oh & Lee, 2011).

However, (Chai, 2012) is opposed to the view, showing that overlapped policy support to a firm leads to a rise in firm profitability and growth. Given that there are contradictory claims and research results on the complementarity effect of duplicated supports, it is not clear so far that overlapped supports of different polices to a single firm influences its performance positively. Therefore, it is necessary to demonstrate whether a complementarity effect exists according to overlapped support in innovation policy. Further, it should be examined as tounder what conditions the complementary effect of multiple policies take place.

In principle, to address the complementary effect, we need to know the characteristics of each policy concerning SMEs at a given time since the complementary effect of multiple innovation policies varies depending upon the objective and scope of individual innovation policies.

As we overviewed briefly, the key tasks of KCGF and KTFC differ in objective and scope. The main objective of KCGF is to provide promising SMEs with a credit guarantee in order to enable those lacking collateral sufficient to obtain requisite funds to make smooth headway in financial or business transactions; the essential purpose of

KTFC is to support companies that are financially vulnerable but technologically competent by establishing a future-oriented guarantee framework based on thorough technology appraisal and support for companies with growth potential, such as tech start-ups, to build future growth momentum and create quality work. The important goal of the guarantee policy implemented by KCGF is to facilitate the financing of SMEs through the credit guarantees and stimulate sound credit transactions through the efficient management of credit information. The imperative goal of KTFC, however, is supporting tech-oriented companies to grow into competitive players to compete in the global market by establishing support framework customized to companies at each growth stage as well as enhancing credibility and integrity of technology appraisal systems.

To put is simply, KCGF guarantees the credit of promising SMEs, while KTFC guarantees the future value of promising technology of SMEs. The comparison between the two different guarantee policies is given in Table 5.

Table 4. Conceptualization of KCGF and KTFC

Factors which can occur policy interaction		KCGF and KTFC
Policy	Policy goals	Different
	Implementation approaches	Same
Actor	Targeting group	Different
	Governance group	Same

Table 5 reveals that KCGF and KTFC use the same policy tool, called the guarantee policy, in terms of implementation approach, though the targeting groups are obviously different. This means that a firm needs to satisfy different requirements suggested by KCGF and KTFC in order to get benefit from each guarantee policies. Therefore, using empirical data given by KCGF and KTFC, we can verify the existence of a complementary effect of overlapped policies in case of different targeting groups and goals implemented by different innovation policies.

A growing body of empirical research suggested that new firms, especially technology-intensive ones, may receive insufficient capital to fund all positive net present value projects due to the information problems between firms and investors—so-called information asymmetry. In this context, the other kind of major innovation policy the Korean government implemented to eliminate hurdles that SMEs face in their growth stage is "certification." As with guarantee-styled policy, the Korean government intervenes in the market using a certification method to avoid market failure caused by information asymmetry. This innovation policy implemented in the form of certification by the Korean government is based on the findings of Lerner (2002), who argued that if public institutions could certify that firms are of high quality, then information asymmetry problems could be overcome, and investors could confidently invest in these firms.

In the late 1990s, the Korean government launched two different types of certification policy to contribute to national economic growth by helping Korean venture companies achieve technological innovation and improve competitive power in

management. One of them is “Venture certification” and the other is “Inno-Biz.”.

In general, the venture firm often refers to technology-oriented firms with considerable uncertainty and informational asymmetries, which permit opportunistic behavior of entrepreneurs; however, in Korea it only refers to a company certificated by the governmental venture institution. The venture certification by the Korean government means that these signals provided by government awards are likely to be particularly valuable in technology-intensive industries where traditional financial measures are of little use, because certification itself carries out signaling effect to say which one is promising or not.

Therefore, SMEs who want to become venture firms verified by governmental institution have to satisfy three requirements. The first is that the firm is invested in by private venture capitalists. This exactly coincides with the general definition of venture firm. The seconds is that the applicant should invest in R&D above a certain ratio. This is because the government institution considers R&D intensity as a proxy representing how intensively the firm takes a concrete action toward technology innovation. The third requirements is that a firm is able to acquire a loan through the credit-guarantee program given by the KTFC (discussed above). A firm that gets certification does not need to satisfy all conditions discussed. In fact, it is noticeable that the second and third requirements are a particular case in Korea in order to achieve venture firm status.

Specifically, the Korean Venture Corporation Verification System identifies companies that satisfy the conditions specified in Clause 2 of Article 2 of the Act of the

Special Measures to Foster Venture Corporations as venture companies, and provides them with support for human and material resources during the early stages when they have difficulty entering the market. The purpose of this Act is summarized as follows.

a. To stimulate capital supply.
    - Fund investment toward venture firms
    - Tax exemption benefit to those who make an investment to venture firms
b. To encourage business and labor supply
    - Stock trade inter-venture and simplification of M&A
c. To encourage location supply
    - Designating the integrated area of technology start-up firms

Once a firm is identified as a venture corporation, multiple benefits through financial and non-financial supports are given. These benefits are categorized in Table 6.

Table 5. Various benefits of venture certification

	Benefits	
	Firm's under 3 years of age	Firm's over 3 years of age
Assistance to business starter	Assistance to professors and researchers	Null
Taxation support	Tax exemption or reduction	Null
Financial support	IPO Preference in KOSDAQ Credit Guarantee Preference Fund investment toward venture firms	
Provision of human resource	Special admission to the additional job of the public educational personnel and staff. Special admission to the military service business.	
Overseas expansion support	Legal advice Brand marketing support	
Patent and marketing support	First investigation object in patent and utility model PR support in TV and radio	

* Source: Korea Venture Business Association (KOVA)

Along with venture verification, the Korean government has run the "Inno-Biz" policy since 2002. Inno-Biz is a compound word formed from "Innovation" and "Business." The policy selects SMEs with excellent technologies based on the Oslo

Manual, which is the first international standard for evaluating innovative research of institutions including SMEs. The Korean government developed an innovation evaluation indicator in 2001 and has been using it ever since. Based on evaluation using this manual, government officers choose corporations with technological competence secured by consistent innovation through systematic R&D among candidates. The SMEs should have been operating for more than 3 years of business history with have high growth potential in the future in order to apply to be an Inno-biz company. In other words, if a firm is chosen as an "Inno-Biz" corporation, then it means that the selected SMEs are outstanding government-certified SMEs through international innovation criteria evaluation.

In order to be selected as an Inno-Biz corporation, the applicants are evaluated by four different criteria: competence of technological innovation, competence of technology commercialization, management of technological innovation, and output of innovation. Every criterion includes multiple items to evaluate each construct. For instance, output of innovation is measured by technological output and non-technological output. Non technological outputs are sub-divided by growth rate, profitability and stability of firm. Consequently, only if a firm acquires a high score in every dimension is it deemed an Inno-Biz corporation.

Since the Inno-Biz policy was introduced by the Korean government in 2001, the number of firms which are certified as Inno-Biz has been growing continuously. Table 7 shows the number of firms regarded as Inno-Biz corporations by year. Especially, since

2006, the number has been skyrocketing and peaked at 2011.

Table 6. Number of inno-biz firms and venture firms

Yaer	Venture firms	Innobiz firms
2000	8,798	-
2001	11,393	1,090
2002	8,774	1,856
2003	7,702	2,375
2004	7,967	2,762
2005	9,732	3,454
2006	12,218	7,183
2007	14,015	11,526
2008	15,401	14,636
2009	18,893	15,940
2010	24,645	16,243
2011	26,376	16,944
2012	28,193	
2013	29,135	

As with venture verification, which provides SMEs with taxation supports, financial supports, and marketing supports, multiple supports, such as financial support, R&D support, human support, and market exportation are given to certified SMEs.

Table 7. Various benefits of Inno-Biz certification

Benefits	
R&D support	Development of technology innovation Technology transfer support School–industry cooperation
Financial support	Raising the guarantee limit. Reduction or exemption in the guaranteed fee.
Provision of human resources	Special admission to the military service business
Marketing support (Including patent support)	First investigation object in patent and utility model Export support

Several studies have been made on whether certification policies such as Venture Certification and Inno-Biz in an innovation economy has a positive effect on firm growth (Kim et al., 2011; Kim, 2013; Song & Park, 2013). However there seems to be no established study to empirically analyze complementarity effect between different certification policies, although many firms are verified by a couple of certification policies.

Table 9 represents how many firms have been verified by both certification policies over past few years. You and Roh (2012) analyzed the effect on the performance of firms that received overlapped supports through two different certification policies, emphasizing that the ratio of SMEs supported by both certification policies was already

over 40% of the SME population in 2008. Kang and Lee (2011) mentioned that a policy maker needs to consider if overlapped supports by Venture Verification and Inno-Biz lead to positive effects. However, these researches merely describe the current situation, and very few attempts have been made at empirical modeling to see if overlapped supports through certification have a synergy effect on firm performance statistically. Therefore, based on statistical modeling to evaluate policy impact, synergy effect between two different verification policies in innovation policy will be examined in detail in the present study.

Table 8. Number of government certification according type of certification

Type	2004	2005	2006	2007	2008	2009	2010	2011
Venture	7,967	9,732	12,218	14,015	15,401	18,893	24,645	26,148
Innobiz	2,762	3,454	7,183	11,526	14,626	15,940	16,243	16,944
Manage Innovation	0	0	2,619	6,510	11,324	13,988	16,642	17,558
Overlapped	10,729	13,186	22,020	32,051	41,351	48,821	57,530	60,650

*Source: Small and Medium Business Administration.

It is noteworthy that Venture Certification and Inno-Biz are very similar in their policy goal, targeting group, and scope of support. In principle, the purpose of the two policies is to support the leap from a potential business to a midsize business by strengthening the capabilities for innovation and sustainable growth using the policy tool named

verification. The only difference is that firms of over three years since establishment are able to apply for both Venture Verification and Inno-Biz status, and firms of less than three years since establishment are permitted to apply only “Venture verification” policy. The comparison of both policies are given in Table 10.

Table 9. Conceptualization of venture certification and inno-biz certification

Factors related to policy interaction		Venture and Inno-biz
Policy	Policy goals	Same
	Implementation approaches	Same
Actor	Targeting group	Same
	Governance group	Same

As mentioned so far, it seems that The Korean government uses similar policy means so-called “certification” which is known as a useful tool to implement signaling mechanism in economy for eliminating uncertainty caused by information asymmetry between firms and investors. To sum up, The Korean government expects to enhance competitiveness of promising SMEs with technological competence by introducing similar verification policies (Venture Verification and Inno-Biz). Therefore, it is time to take a close look at the existence of a synergy effect through overlapped policy supports to certain firms.

4.2 Data and variables

4.2.1 Data and variables

The empirical analysis was performed in order to verify the effect on overlapped support of different policies to the same firm. The data used in this study are lists of the firms which have received support from “Guarantee” and “Verification,” and the data also includes list of firms that have not been selected despite application.

In regard to the “Guarantee” policy, data includes the firms that had been supported by either KCGF or KTFC from 2001 to 2004. The data also includes firms that got policy support from both KCGF and KTFC. The decision making for choosing an applicant was done on a yearly basis. In the case of “Verification,” firms that have been selected as a Venture Verification or Inno-Biz firm from 2000 until 2006 are selected. Firm’s financial and non-financial data are collected from the Korea Enterprise Data (KED) and Korea Investor Service (KIS), which are leading corporate credit agencies in Korea.

The total number of firms that have been selected through KCGF policy from 2001 to 2004 is 157,290, while 74,259 firms were selected as KTFC-guaranteed during same period.

Smith (2000) explained that as many firm-specific variables as possible need to be introduced in estimation of propensity score when evaluating policy effect without bias using Propensity Score Matching (PSM). Moreover, firm-specific variables included in list of independent variables of probit analysis should be factors affecting both firm performance and likelihood of being supported by the policy (Caliendo & Kopeinig,

2008).

The meta analysis conducted by Murphy, Trailer, and Hill (1996), reviewing fifty-one studies about firm growth in entrepreneurship research, determined that sales growth and growth of the number of employees have been used as proxy variables to measure firm performance.

When evaluating policy impact, avoiding selection bias is one of the essential issues. Thus, in this study, probit analysis is applied to estimate propensity score and to match non-supported firms with supported firms based on this score. To do so, the probit analysis uses independent variables that are firm-specific variables, and their values are measured on the basis of time before being chosen by each policy. The firm-specific independent variables used here are the variables related to the firm size, business performance, and innovation capacity. Using propensity score estimated from the probit analysis, we select non-supported firms that have similar firm characteristics to firms that have been supported by policy. Therefore, it is possible to estimate the effect of overlapped supports of innovation policies without incurring a selection bias problem. The details of independent variables used in the probit analysis are summarized in Table 11.

Table 10. Definition of variables using in the estimation

Categories	Variables	Definition
Size	Wage	Amount of Wage
	Worker	Number of employees
	Total asset	Amount of total asset
	Total Liability	Amount of total liability
	Capital	Amount of capital (current, total)
	Age	Years from the foundation of firms
Business Performance	Export	Amount of export
	Sales	Amount of sales
Innovation Capacity	R&D expenditure	Amount of R&D expenditure

	R&D per sales	Proportion of R&D expenditure per sales
	R&D per worker	R&D expenditure per worker
Region	Reg1	Dummy variables :
	Reg2	Reg1 is 1 if the firm belongs to metropolitan area (seoul) and 0 if not,
	Reg3	Reg 2 is 1 if the firm belongs to Dae-jeon city or Chungcheong-do,
	Rege4	Reg 3 is 1 if the firm belongs to Kwang-ju city or Jeolla-do,
	Reg5	Reg 4 is 1 if the firm belongs to Busan city or Gyeongsang-do,
		Reg 5 is 1 if the firm belongs to another area like Ganwon-do.

4.2.2 Descriptive statistics

The number of firms supported by both KCGF and KTFC policy from 2001 until 2004 are presented in Table 12.

Table 11. Number of firms guaranteed by KCGF, KTFC and Both

Year	KCGF	KTFC	Both
2001	37,183	19,898	2,406
2002	37,238	15,641	1,580
2003	43,191	16,933	1,618
2004	39,678	9,792	815

The raw data of corporations that have been supported by credit guarantee policies are collected from Korea Enterprise Data (KED). In addition, based on the following standards, the data set for analysis of policy effect is constructed.

i. To choose only manufacturing firms by SIC code
ii. To exclude firms that have zero sales, asset, liabilities, number of employees, and R&D expenditure in their record
iii. To exclude conglomerates with 100 billion won or more of total capital, 1000 employees, and 500 billion won in total assets
iv. To exclude small scale enterprises with less than five employees

v. To exclude the firms whose employments and R&D expenditure data are missing

The data set processed for analysis consists of 2,137 firms that were supported by both credit guarantee policies, and 20,082 firms that were supported by only KCGF, 8,405 firms that were supported by only KTFC, and 51,974 non-supported firms.

The complementarity effect of overlapped supports by both credit-guarantee policies is represented as follows.

$$\textit{Complementarity effect} =$$

$$\{\underbrace{F(KTFC, KCGF) - F(\overline{KTFC}, KCGF)}_{①}\} - \{\underbrace{F(KTFC, \overline{KCGF}) - F(\overline{KTFC}, \overline{KCGF})}_{②}\}$$

Basically, analyzing complementarity effect using the above equation requires two stages of matching. In order to analyze complementarity effect of "guarantee policy" and "certification policy" respectively, four stages of matching should be done.

In the case of credit guarantee policy, the firms that have received supports from both policies are regarded as the treatment group, and the firms supported by only KCGF are considered control group in ① in the above equation. In ② in the above equation, the firms chosen by KTFC policy are the treatment group and the firms which have not received support from any other policies are the control group.

As indicated in the result of t-test with respect to mean of firm-specific variables in

different groups, there are significant differences in firm characteristics between different groups. This result gives validity of matching analysis using propensity score. In other words, the analysis would inevitably incur a selection bias problem without matching. T-test were carried out based on the following hypothesis.

$$H_0 : \mu_{overlapped\ guarantee} = \mu_{only\ credit\ guarantee}$$
$$H_1 : \mu_{overlapped\ guarantee} \neq \mu_{only\ credit\ guarantee}$$

T statistics are as follows to run test mean difference between different groups.

$$t = \frac{\bar{d}}{s/\sqrt{n}} \sim t(n-1) \quad \cdots\cdots \text{Eq. (19)}$$

note that, $\bar{d} = \bar{X} - \bar{Y}$

In the above equation, S^2 is sample deviation of d_i and can be estimated using Eq. (19)

$$s = \frac{1}{n-1}\sum_{i=1}^{n}(d_i - \bar{d})^2 \quad \cdots\cdots \text{Eq. (19)}$$

Table 12. Descriptive Statistics of non-guaranteed firms, firms guaranteed by one of KCGF, KTFC, or both in the year 2000.

Variables	Overlapped guarantee		Only credit guarantee		Sig.[c]	Only technology guarantee		None guarantee		Sig.[c]
	Mean	Std.	Mean	Std.		Mean	Std.	Mean	Std.	
Sales[a]	10.66	16.04	6.85	13.5	***	7.37	14.7	12.12	31.38	***
Age(year)	7.22	6.63	7.52	6.56	***	7.29	6.21	10.12	8.17	***
Asset[a]	8.03	13.49	4.68	10.5	***	5.87	12.0	10.08	24.87	***
Employees	45.0	53.38	30.7	42.8	***	36.0	51.0	50.2	83.42	***
Wage[a]	0.35	0.51	0.25	0.44	***	0.27	0.5	0.43	1.0	***
Liabilities[a]	5.49	8.79	3.13	6.87	***	4.04	8.5	6.65	38.51	***
R&D expenditure[a]	0.12	0.46	0.043	0.23	***	0.1	0.4	0.09	0.49	***
Ratio of Expot[b]	2.85	16.7	1.34	11.5	***	2.63	16.0	4.09	19.8	***
Reg1[b]	46.6	49.9	57.2	49.5	***	48.4	50.0	56.8	49.54	***

Reg2[b]	12.8	33.4	9.43	29.2	***	10.1	30.2	8.45	27.82	***
Reg3[b]	9.2	28.9	6.06	23.9	***	8.1	27.2	5.64	23.08	
Reg4[b]	28.2	45.0	25.6	43.7	**	31.7	46.5	27.6	44.72	
Reg5[b]	2.8	16.5	1.28	11.3	***	1.57	12.4	1.05	10.2	

a. Monetary units in billion KRW

b. units in %

c. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The data set processed for analysis on "certification" policy effect consists of three different types of companies. The first group includes firms only chosen by "Venture Verification, while the second group consists of firms only selected by Inno-Biz certification. The last group is firms certificated as both. From 2001 to 2006, the number of firms in the first group is 52,951 and the number in the second group is 14,225. The number of firms certified under both certification policies during same period is summarized in Table 14.

Table 13. Number of Venture firms, Inno-Biz firms, and firms certificated as both venture and Inno-Biz

Year	Venture firms	Inno-biz firms	Firms certificated as both venture and innobiz
2001	9,985	1,080	720
2002	8,711	1,846	1,234
2003	7,472	2,365	1,451
2004	7,562	1,855	1,232
2005	9,347	1,897	1,396
2006	9,874	5,182	2,824

The raw data related to firm specific variables were collected from Korea Enterprise Data (KED) and were processed using the same rule applied in guarantee analysis in

order to eliminate outliers. As a result of data processing, the number of firms which certified by both policies was 4,467, the firms with only venture certification 8,665, and the firms with only Inno-Biz 3,135. The number of firms that have not received either certification is 51,974.

The complementarity effect of different certification policies can be captured using the following equation as in analysis of guarantee policy.

$$\textit{Complementarity effect} =$$

$$\{\underbrace{F(Innobiz, Venture) - F(\overline{Innobiz}, Venture)}_{③}\} - \{\underbrace{F(Innobiz, \overline{Venture}) - F(\overline{Innobiz}, \overline{Venture})}_{④}\}$$

As with guarantee policy, the firms that are certified by both verification policies are considered as a treatment group and the firms certified by only venture are treated as a control group in ③ in the above equation. In ④ in the above equation, the firms selected by Inno-Biz policy are the treatment group and the firms not certified by either policy are the control group. The descriptive statistics of variables in each group appears in Table 13.

Table 14. Descriptive Statistics of Non-guaranteed firms, firms guaranteed by one of KCGF, KTFC, or both in the year 2000.

Variables	Overlapped certification		Only venture certification		Sig.[c]	Only inno-biz certification		None certification		Sig.[c]
	Mean	Std.	Mean	Std.		Mean	Std.	Mean	Std.	
Sales[a]	14.99	23.29	13.17	19.76	***	26.30	51.21	14.99	23.29	***
Age(year)	10.76	7.79	8.14	6.14	***	12.72	9.32	10.76	7.79	***
Asset[a]	11.67	17.77	11.56	16.71	***	20.09	35.96	11.67	17.77	***
Employees	54.62	65.34	47.77	55.68	***	78.62	112.59	54.62	65.34	***
Wage[a]	0.52	0.73	0.52	0.58	***	0.82	1.62	0.52	0.73	***
Liabilities[a]	7.52	11.86	7.18	10.72	**	12.59	54.51	7.52	11.86	***
R&D expenditure[a]	0.19	0.40	0.41	0.77	***	0.16	0.94	0.19	0.40	***
Ratio of Expot[b]	0.04	0.19	0.06	0.23	***	0.06	0.25	0.04	0.19	***
Reg1[b]	0.44	0.50	0.58	0.49	***	0.50	0.50	0.44	0.50	***

Reg2[b]	0.12	0.32	0.12	0.33		0.11	0.31	0.12	0.32	*
Reg3[b]	0.07	0.26	0.07	0.25		0.05	0.22	0.07	0.26	***
Reg4[b]	0.35	0.48	0.22	0.41	***	0.33	0.47	0.35	0.48	
Reg5[b]	0.01	0.11	0.01	0.11		0.01	0.08	0.01	0.11	***

a. Monetary units in billion KRW

b. units in %

c. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

4.3 Estimation Results

4.3.1 Complementarity effect according to overlapped credit guarantee

4.3.1.1 Estimation of propensity score

As mentioned above, the estimation of propensity score is preceded before we evaluate complementarity effect on overlapped support of different guarantee policies. Given propensity score of every corporation in different policy supported groups, it is possible to capture complementarity effect of different guarantee policies by avoiding selection bias problem.

Complementarity effect =

$$\{\underbrace{F(KTFC, KCGF) - F(\overline{KTFC}, KCGF)}_{①}\} - \{\underbrace{F(KTFC, \overline{KCGF}) - F(\overline{KTFC}, \overline{KCGF})}_{②}\}$$

The firms that have received credit and technology guarantee by KTFC and KCGF, respectively, are regarded as the treatment group, and the firms supported by only KCGF are considered the control group in ① in the above equation. One may raise the question of whether it is possible to regard the firms that have already been supported by policy as the control group, because control group generally refers the group that has not had any treatment by researchers. However, in the case of studies that evaluated multiple treatment effects of policies, such as Lechner (2001) and Oh and Lee (2011), the firms

with single policy support were regarded as the control group while the firms with multiple policy supports are the treatment group. What these previous studies make clear is that the firms with single policy support can be treated as the control group in studies of multiple treatment effect. Following the methodological framework applied in studies of M. Lechner(2001), Oh and Lee (2011), we regard the firms that have had credit-guarantee support as control group. The coefficient and standard error of probit analysis between the two groups appears in Table 16.

Table 15. Probit parameter estimates in case of function ①

D = 1 : firms guaranteed by both KTFG and KCGF D = 0 : firms guaranteed by KCGF			
Variables	Coef.	Std. Err.	Sig. [b]
lsales[a]	0.010	0.026	
lage[a]	-0.190	0.017	***
lass[a]	-0.136	0.113	
lworker[a]	0.048	0.023	**
lfixass[a]	0.076	0.033	**
lcurass[a]	0.116	0.045	***
lwage[a]	-0.035	0.017	**
lliab[a]	0.144	0.058	**
ltotcap[a]	-0.020	0.036	
lrnd[a]	0.028	0.003	***
d_expo	-0.115	0.088	
reg2	0.188	0.040	***
reg3	0.318	0.047	***
reg4	0.147	0.029	***
reg5	0.465	0.086	***
Constant	-3.488	0.243	***

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The ② in the above equation represents comparison between the firms chosen by technology guarantee and the non-guaranteed firms. The results of probit analysis between these two groups are shown in Table 17.

Table 16. Probit parameter estimates in case of function ②

D = 1 : firms guaranteed by KTFG D = 0 : non-guaranteed firms			
Variables	Coef.	Std. Err.	Sig. [b]
lsales[a]	0.125	0.012	***
lage[a]	-0.224	0.009	***
lass[a]	-0.312	0.025	***
lworker[a]	-0.043	0.012	***
lwage[a]	-0.073	0.009	***
lliab[a]	0.148	0.017	***
lcap[a]	0.043	0.009	***
lrnd[a]	0.006	0.008	
lrnd2[a]	0.003	0.001	***
d_expo	-0.066	0.042	
reg2	0.198	0.023	***
reg3	0.276	0.026	***
reg4	0.203	0.015	***
reg5	0.343	0.057	***
Constant	0.197	0.112	*

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

4.3.1.1 Estimation of complementarity effect

We run matching twice in respect to ① and ② of the following equation.

Complementary effect =

$$\{\underbrace{F(KTFC, KCGF) - F(\overline{KTFC}, KCGF)}_{①}\} - \{\underbrace{F(KTFC, \overline{KCGF}) - F(\overline{KTFC}, \overline{KCGF})}_{②}\}$$

Table 18 shows the comparison of ATT of ① and ② between two groups in which ATT is a result of matching analysis to avoid incurring a selection bias problem. If the ATT of ① is larger than that of ②, then it means that there is complementarity effect on guarantee policy programs. Otherwise, it proves that there is no synergy between credit guarantee and technology guarantee programs.

As a result of t-test with respect to multiple performance dimensions, we can find out that sales growth, asset growth, R&D growth and R&D growth per employee are statistically significant. Among them, sales growth and asset growth are performance variables that have negative complementarity effect during first, second, and third years after certification. However, four years after the firm was certified, the positive complementarity effect is found in sales growth and asset growth. In the dimension of innovation capacity, R&D growth rate and R&D growth rate per employment each represent negative complementarity effects in the short and long term. Consequently, what has been demonstrated in this analysis is that overlapped support between credit guarantee and technology guarantee influences growth rate in the long term while, in the short term, it represents a negative complementarity effect.

Table 17. Mean differences of average treatment effect on the treated between Matching ① and Matching ②

	After 1 year			After 2 years			After 3 years		
	ATT from Matching ①	ATT from Matching ②	Sig.	ATT from Matching ①	ATT from Matching ②	Sig.	ATT from Matching ①	ATT from Matching ②	Sig.
Sales growth	0.047	0.092	***	0.069	0.105	**	0.092	0.097	
	(0.43)	(0.47)		(0.603)	(0.623)		(0.740)	(0.715)	
Assets growth	0.095	0.122	***	0.117	0.147	**	0.133	0.148	
	(0.369)	(0.358)		(0.497)	(0.465)		(0.585)	(0.553)	
Worker growth	0.031	0.007	**	0.056	0.034	*	0.070	0.050	
	(0.413)	(0.253)		(0.467)	(0.391)		(0.543)	(0.474)	
R&D growth	0.490	0.513		0.535	0.582		0.616	0.681	
	(3.67)	(3.52)		(4.18)	(4.08)		(4.47)	(4.43)	
Growth of R&D	0.339	0.368		0.365	0.427		0.491	0.416	
per worker	(2.57)	(2.49)		(2.92)	(2.90)		(3.17)	(3.10)	
Growth of R&D	0.28	-3.93	**	0.569	-3.43	**	-4.80	-3.40	
per sales	(4.45)	(142.8)		(8.83)	(150.1)		(154.7)	(129.5)	

	After 4 years			After 5 years			After 6 years		
	ATT from Matching ①	ATT from Matching ②	Sig.	ATT from Matching ①	ATT from Matching ②	Sig.	ATT from Matching ①	ATT from Matching ②	Sig.
Sales growth	0.110	0.103		0.123	0.091		0.153	0.091	**
	(0.818)	(0.802)		(0.878)	(0.882)		(0.964)	(0.902)	
Assets growth	0.136	0.136		0.131	0.124		0.145	0.121	
	(0.665)	(0.627)		(0.754)	(0.700)		(0.827)	(0.752)	
Worker growth	0.060	0.056		0.071	0.061		0.097	0.073	
	(0.591)	(0.540)		(0.639)	(0.600)		(0.735)	(0.651)	
R&D growth	0.459	0.797	**	0.756	0.934		0.847	1.02	
	(4.99)	(4.96)		(5.34)	(5.24)		(5.59)	(5.53)	
Growth of R&D	0.254	0.479	**	0.391	0.617	*	0.602	0.739	
per worker	(3.41)	(3.50)		(3.70)	(3.73)		(3.87)	(4.04)	
Growth of R&D	-0.33	-3.70	*	0.188	-1.33	*	0.021	-1.33	
per sales	(16.37)	(129.0)		(5.55)	(60.7)		(7.63)	(72.3)	

Note 1. Rows marked “growth” indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

However, in this analysis, one may raise a question on methodological framework in comparing ATT results between ① and ②, pointing out that this comparison causes another selection bias between ① and ②. This is because there is significant difference in firm characteristics between chosen firms by matching analysis of ① and ②. In other words, selected firms by matching analysis in ① and corresponding firms by matching in ② are heterogeneous over firm-specific characteristics. Table 19 confirms that there are significant differences between chosen firms in each matching process over firm characteristics. Therefore, the argument that ATT analysis may include selection bias is acceptable, and suggested solution to this bias is required.

Table 18. Mean differences of characteristics of matched firms from Matching ① and Matching ②

Variables	Matched firms from Matching ①		Matched firms from Matching ②		Sig.[c]
	Mean	Std.	Mean	Std.	
Sales[a]	8.97	16.48	8.76	21.64	
Age(year)	7.25	6.55	8.53	6.60	***
Asset[a]	6.48	13.78	6.69	17.07	
Employees	38.93	53.76	38.66	59.52	
Wage[a]	0.31	0.53	0.30	0.65	
Liabilities[a]	4.33	9.08	4.58	15.08	*
R&D expenditure[a]	0.07	0.27	0.06	0.31	
Ratio of Expot[b]	0.02	0.14	0.02	0.15	
Reg1[b]	0.51	0.50	0.52	0.50	**
Reg2[b]	0.11	0.32	0.09	0.29	***
Reg3[b]	0.08	0.27	0.06	0.25	***
Reg4[b]	0.28	0.45	0.31	0.46	***
Reg5[b]	0.02	0.14	0.01	0.11	***

a. Monetary units in billion KRW

b. units in %

c. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

In order to solve the selection bias problem raised here, matching in matching (so-called “double matching”) could be a solution and is easily applied. The idea is that one applies matching again between selected firms in ① and ② after firms in each control

groups are selected using propensity score and ATT for ① and ② are estimated, respectively. In other words, in order for comparison between firms in ① and ②, one chooses firms in ② that show similar firm characteristics to firms in ① using propensity score, and, eventually, every selected firm represents a similar distribution with respect to firm-specific variables, and one can compare ATT result without selection bias.

The matching in matching results appears in Table 20, where the value indicates complementarity effect on overlapped guarantee policies. The negative value represents that there is no synergy effect between credit guarantee and technology guarantee programs. However, the positive value means that there is a positive significant complementarity effect on overlapped supports.

Table 19. Complementarity effect according to overlapped support in guarantee policy

	After 1 years	After 2 years	After 3 years	After 4 years	After 5 years	After 6 years
Sales growth	-2.33 **	-1.62	2.71	4.91 *	7.07 **	8.99 ***
Assets growth	-2.39 **	-2.32	-0.81	0.86	2.23	4.29
Worker growth	1.50	0.57 *	0.89	0.08	1.45	3.14
R&D growth	-26.34 **	-37.3 ***	-27.95 *	-52.2 ***	-35.21 *	-53.21 ***
Growth of R&D per sales	-17.55 **	-24.4 ***	-24.51 **	-32.8 ***	-24.96 *	-13.60
Growth of R&D per worker	-0.08	0.69	-4.64	0.18	-0.13	0.30

Note 1. Rows marked “growth” indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The results in Table 20 show that, in the firm growth dimension, sales growth, asset growth rate, and the number of employees growth rate all represent the complementarity effect in the long term. It follows from what has been shown so far that there is a synergy effect in the long term between the government's credit guarantee program and technology guarantee program for promoting growth of promising SMEs. However, we cannot say that the complementarity effect is found in terms of innovation capacity since both R&D growth rate and R&D growth rate per employee indicate negative value in the short and long term views. This means that marginal growth of innovation capacity in case of granting participation in the technology guarantee program additionally to the firms that have already been granted participation in the credit guarantee program is less than that of innovation capacity in case of granting technological guarantee program participation to the previously non-guaranteed firms.

Consequently, we found that the complementarity effect on overlapped supports by guarantee policies is effective in growth dimension but not in innovation capacity dimension. However, one needs to be careful in interpreting this result when implementing practical policies because the complementarity effect in terms of sales growth and asset growth may lead to prevalence of "zombie companies" which is used to describe a situation where a failing company continues to operate dependent on government support (Ahearne & Shinada, 2005; Caballero, Hoshi, & Kashyap, 2006).

It is not appropriate to prejudge that zombie companies survive due to overlapped supports by guarantee programs, because one cannot confirm that the performance of a

zombie company is solely attributable to policy support with only this result. In order to examine the behavior of zombie companies in view of innovation policy, further research on zombie companies and non-zombie companies that have received overlapped support by different guarantee programs needs to be done.

4.3.2 Complementarity effect according to overlapped certification

4.3.2.1 Estimation of propensity score

Along the same lines applied in analysis of guarantee policy, the same methodological framework will be applied in measuring policy effect of overlapped certification (venture certification and Inno-Biz). The complementarity effect of different verification policies are represented as follows.

$$\textit{Complementarity effect} =$$

$$\{\underbrace{F(Innobiz,Venture)-F(\overline{Innobiz},Venture)}_{③}\}-\{\underbrace{F(Innobiz,\overline{Venture})-F(\overline{Innobiz},\overline{Venture})}_{④}\}$$

The firms that have been verified by both venture certification and Inno-Biz are the control group in ③ in the above equation, and the firms verified by only "venture certification" are the treatment group. To avoid a selection bias problem in comparing performance between two groups, the propensity score matching in both groups are used.

To do so, the firms in the control group that show similar firm-characteristics to those of the treatment group are selected as matched firms based on the propensity score evaluated by probit analysis (results are given in Table 19).

Table 20. Probit parameter estimates in case of function ③

D = 1 : firms certificated as both Venture firm and Innobiz frim D = 0 : firms certificated as the Venture firm			
Variables	Coef.	Std. Err.	Sig. [b]
lsales[a]	-0.272	0.032	***
lage[a]	0.385	0.112	***
lage2[a]	-0.186	0.026	***
lass[a]	0.011	0.115	
lworker[a]	-0.165	0.033	***
lfixass[a]	-0.108	0.033	***
lwage[a]	0.126	0.025	***
lliab[a]	0.184	0.066	***
ltotcap[a]	0.228	0.044	***
lrnd[a]	-0.076	0.015	***
lrnd2[a]	0.010	0.001	***
d_expo	0.093	0.080	
reg2	-0.165	0.050	***
reg3	-0.050	0.061	
reg4	-0.336	0.037	***
reg5	-0.167	0.136	
Constant	-1.338	0.364	***

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The results shows that firms in the control group in ③ are more likely to secure liability, wage, and total asset but less likely to record total sales and number of employees when compared to the treatment group.

Similarly, the firms that were certified by only Inno-Biz are the control group in ④ and firms with neither support are the treatment group. Probit analysis results on these two groups are suggested in Table 20.

Table 21. Probit parameter estimates in case of function ④

D = 1 : firms certificated as the Innobiz firm D = 0 : non-certificated firms			
Variables	Coef.	Std. Err.	Sig.[b]
lsales[a]	0.122	0.233	
lsales2[a]	-0.006	0.007	
lage[a]	-0.026	0.020	
lass[a]	-0.097	0.078	
lworker[a]	-0.132	0.024	**
lwage[a]	0.053	0.018	**
lliab[a]	0.096	0.048	**
ltotcap[a]	1.613	0.172	***
ltotcap2[a]	-0.058	0.006	***
lrnd[a]	0.118	0.009	***
d_rnd	-0.336	0.106	***
d_expo	0.017	0.041	
reg1	-0.159	0.028	***
reg2	0.167	0.051	
reg3	0.223	0.122	***
reg5	-12.813	1.618	*
Constant	0.122	0.233	***

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

4.3.2.2 Estimation of complementarity effect

Based on the propensity score evaluated by probit analysis between the two groups, the firms in treatment groups need to be matched to the firms in control groups and be selected for evaluating complementarity effect without bias.

Complementarity effect =

$$\{\underbrace{F(Innobiz,Venture)-F(\overline{Innobiz},Venture)}_{③}\}-\{\underbrace{F(Innobiz,\overline{Venture})-F(\overline{Innobiz},\overline{Venture})}_{④}\}$$

The complementarity effect of overlapped certification policies is evaluated in the same way as analysis of overlapped guarantee policies. To put it plainly, ATT are estimated after the list of corporations that represent similar firm-specific characteristics to the treatment group were selected in the control group using propensity score matching. The value of ATT from propensity score matching appears in Table 23.

Table 22. Mean differences of average treatment effect on the treated between Matching ③ and Matching ④

	After 1 year			After 2 years			After 3 years		
	ATT from Matching ③	ATT from Matching ④	Sig.	ATT from Matching ③	ATT from Matching ④	Sig.	ATT from Matching ③	ATT from Matching ④	Sig.
Sales growth	0.0045	0.055	***	0.011	0.088	***	0.011	0.114	***
	(0.45)	(0.36)		(0.604)	(0.503)		(0.718)	(0.618)	
Assets growth	0.033	0.075	***	0.076	0.116	***	0.053	0.140	***
	(0.336)	(0.331)		(0.465)	(0.440)		(0.549)	(0.495)	
Worker growth	0.032	0.037		0.063	0.059		0.056	0.067	
	(0.367)	(0.369)		(0.468)	(0.407)		(0.554)	(0.533)	
R&D growth	0.332	2.32	***	0.627	3.09	***	0.602	3.29	***
	(4.07)	(4.83)		(4.59)	(5.15)		(4.85)	(5.28)	
Growth of R&D per worker	0.249	1.64	***	0.458	1.91	***	0.375	2.25	***
	(3.02)	(3.46)		(3.33)	(3.64)		(3.52)	(3.76)	
Growth of R&D per sales	0.921	-0.410		-2.93	1.22	**	3.13	0.065	
	(50.54)	(50.88)		(113.8)	(7.00)		(129.3)	(54.48)	

	After 4 years			After 5 years			After 6 years		
	ATT from Matching ③	ATT from Matching ④	Sig.	ATT from Matching ③	ATT from Matching ④	Sig.	ATT from Matching ③	ATT from Matching ④	Sig.
Sales growth	-0.002	0.138	***	0.007	0.119	***	0.032	0.170	**
	(0.784)	(0.697)		(0.861)	(0.798)		(0.987)	(0.923)	
Assets growth	0.036	0.166	***	0.075	0.156	***	0.041	0.175	***
	(0.629)	(0.547)		(0.700)	(0.592)		(0.824)	(0.697)	
Worker growth	0.108	0.086		0.132	0.063	**	0.120	0.098	
	(0.621)	(0.550)		(0.669)	(0.586)		(0.743)	(0.672)	
R&D growth	0.653	3.36	***	1.09	3.35	***	1.53	3.18	***
	(5.24)	(5.55)		(5.49)	(5.71)		(5.51)	(6.01)	
Growth of R&D per worker	0.392	2.33	***	0.63	2.25	***	0.761	1.74	***
	(3.69)	(3.84)		(3.78)	(3.83)		(3.72)	(3.94)	
Growth of R&D per sales	2.05	0.416		2.58	-1.62		3.34	-7.67	
	(115.3)	(52.39)		(56.83)	(85.86)		(77.28)	(134.6)	

Note 1. Rows marked “growth” indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

However, as with the selection bias problem discussed in estimation of complementarity effect between different guarantee policies, one may notice the same problem in comparison of performance between the list of firms in ③ and ④. This argument is reasonable to the point that the mean of firm-specific variables between the matched firms list of ③ and ④ are statistically different.

Table 23. Mean differences of characteristics of matched firms from Matching ③ and Matching ④

Variables	Matched firms from Matching ③		Matched firms from Matching ④		Sig.[c]
	Mean	Std.	Mean	Std.	
Sales[a]	14.95	23.04	27.74	50.12	***
Age(year)	9.4	7.31	12.86	9.54	***
Asset[a]	12.57	19.55	21.21	35.61	***
Employees	53.28	67.77	80.42	110.1	***
Wage[a]	0.56	0.74	0.86	15.23	***
Liabilities[a]	7.18	10.72	12.24	23.19	***
R&D expenditure[a]	0.31	0.62	0.22	0.98	***
Ratio of Expot[b]	0.04	0.21	0.07	0.26	***
Reg1[b]	0.5	0.5	0.46	0.5	**
Reg2[b]	0.12	0.33	0.11	0.32	
Reg3[b]	0.08	0.27	0.06	0.24	***
Reg4[b]	0.28	0.45	0.35	0.48	***
Reg5[b]	0.01	0.11	0.01	0.09	

a. Monetary units in billion KRW

b. units in %

c. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

It is indeed true that selection bias takes place in two different groups. Thus, this is the same case with the previous selection bias raised in analyzing the effect of guarantee policies, and matching in matching can be applied again in a similar way. The result of comparison through double matching are given in Table 25.

Table 24. Complementarity effect according to overlapped support in certification

	After 1 years	After 2 years	After 3 years	After 4 years	After 5 years	After 6 years
Sales growth	-7.80 ***	-8.87 ***	-13.5 ***	-21.7 ***	-18.2 ***	-19.7 ***
Assets growth	-2.69 **	-0.79	-6.56 ***	-14.1 ***	-10.3 ***	-17.2 ***
Worker growth	-0.20	1.66	-2.78	-0.81	3.33	0.16
R&D growth	-132.8 ***	-172.6 ***	-217.0 ***	-246.7 ***	-154.1 ***	-99.51 **
Growth of R&D per worker	-80.30 ***	-100.0 ***	-135.3 ***	-149.3 ***	-114.1 ***	-40.26
Growth of R&D per sales	5.25	-4.03 *	7.26	6.02	6.92	13.04 *

Note 1. Rows marked “growth” indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The result obviously reveal a negative complementarity effect between Venture Verification and Inno-Biz policies on every performance dimension except growth rate of number of employees. So to speak, certifying “Inno-Biz” additionally to the firms that are currently operating as venture-verified does not lead to a synergy effect. The result implies, rather than overlapped supports through double verification to a firm, verifying

“Inno-Biz” to non-supported firm by any other verification policy could increase performance. To sum up, the overlapped supports by verification policies are not effective.

4.4 Summary and policy implication

In this chapter, we overviewed and estimated the complementarity effect of overlapped support of two different types of innovation policy (guarantee and certification) on firm performance in the short and long term. It was found that whether overlapped support to a firm achieves synergy or not is different with respect to types of innovation, as seen in Figure 7. In the figure, the X-axis is the number of years after being supported by innovation policy and the Y-axis represents the magnitude of complementarity effect on multiple performance dimensions.

In terms of firm growth measured by sales growth and asset growth, complementarity effect was not discovered during the first and second year after being supported by both policies. However, after three years, the guarantee policy created a synergy effect between technology guarantee and credit guarantee policies, while overlapping of certification policies by Venture Verification and Inno-Biz to a firm still shows no complementarity effect. The gap of effect between different types of innovation policies continues to increase through time.

In terms of innovation capacity measured by R&D growth rate and R&D growth per employee, we did not find complementarity effect, regardless of kinds of innovation policy. To put it intuitively, the result suggests that policy makers are not supposed to

expect synergy in R&D capacity through duplicated support to a firm. This implies that encouraging a single firm by multiple innovation policies does not lead to expansion of innovation capacity. Rather, the innovation policy should be designed in order to support as many firms as possible if the policy maker aims at increasing R&D capacity of SMEs through the policy.

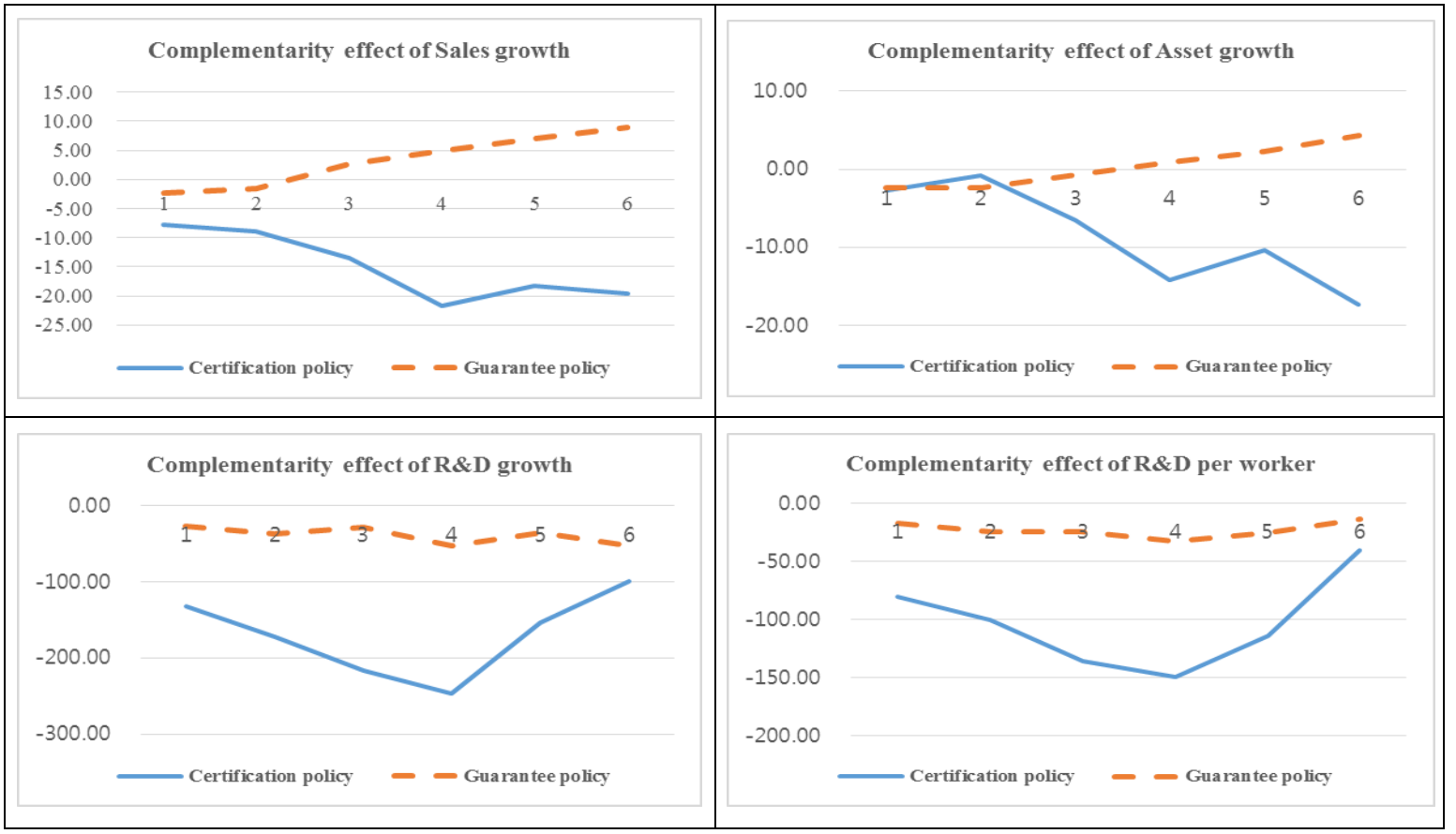


Figure 8. Comparison of the complementarity effect of the overlapped support between guarantee and certification

Then, what makes these different results occur? As described well in the background of this chapter, the most important factor affecting existence of complementarity effect is the type of innovation implemented. The type of innovation policy is categorized by goal and targeting group. Depending upon similarity of goal and scope of policy, the complementarity effect may or may not occur. Given that the two different certification policies have the same policy goal and share same targeting group in fact, it is reasonable that we could not find synergy effect between these innovation policies. However, in the case of circumstance where different goals and targeting groups are implemented, like credit guarantee and technology guarantee, overlapped supports of innovation policy may create a synergy effect. Therefore, the results suggest existence of synergy between policies are affected and decided by characteristics of innovation policy implemented by a policy maker. The following table shows the similarity of innovation policies in terms of goal and targeting group.

Table 25. Comparison between guarantee and certification

Factors which can occur policy interaction		KCGF & KTFC	Venture certification & inno-biz certification
Policy	Policy goals	Different	Same
	Implementation approaches	Same	Same
Actor	Targeting group	Different	Same
	Governance group	Same	Same

The results suggest imperative implication in implementing of innovation policy and decision making on who would benefit from such a policy. When the policies that have different goals and targeting groups are implemented, the overlapped support to a firm may lead to a positive complementarity effect. However, if two different policies share the same goal and targeting group in fact, then overlapped supports to a firm result in a negative complementarity effect and causes ineffective result in view of firm performance.

One could criticize that this result on complementarity effect comes from properties of guarantee policy and certification policy by nature. This view draws attention to an essential difference of heterogeneous innovation policies and indicates that synergy can be made by policy itself regardless of goal and scope of corresponding policy.

In order to support this argument, the performance of each firm that has received policy support should be different depending on the type of policy. That is to say, the performance of firms that are certified Inno-Biz and the firms that have been benefit from technology guarantee have to be different, apparently. If this result appears in the performance domain, then this argument is reasonable.

However, the firms certified as Inno-Biz and the firms that have received benefit by technology guarantee show similar results in their performance. This means that, fundamentally, two different policies are intended to boost performance of SMEs in growth and innovation capacity, although these follow different modes of implementation.

Thus, the argument that essential differences between two policies induces the different result in terms of complementarity effect cannot be acceptable. In addition, it

makes sense to say that existence of complementarity effects is influenced by the similarity of scope and targeting group of two policies.

From what has been discussed above, we can conclude that we cannot simply say that overlapped support in the innovation field is effective or not since it is affected by parallelism of different policies. As for the analysis in this chapter, guarantee policy represented a complementarity effect on firm growth in the long term, while certification policy showed negative complementarity effect in every performance dimension. Our interpretation could be a rational explanation in this case, but we need to be careful when generalizing this interpretation. In addition, the examination of complementarity effect on a great variety of innovation policies remains as a matter to be discussed further in future studies.

Chapter 5. Analysis on the complementarity effect according to repetitive support in innovation policy

5.1 Background and purpose of the study

The purpose of this chapter is to examine the complementarity effect according to repetitive support, and this discussion differs from the overlapped support mentioned in chapter 3 because it deals with policy interaction in a multiple-time dimension. The framework of "repetitive support" is shown in Figure 8.

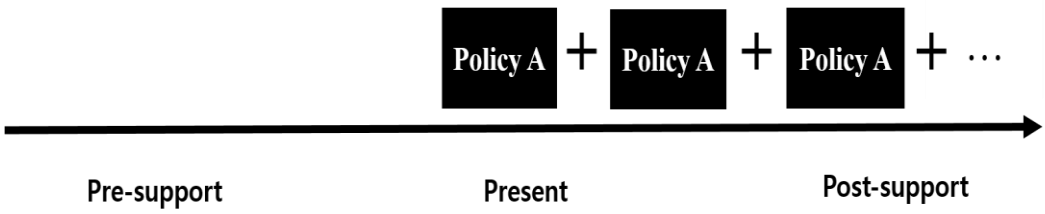


Figure 9. Conceptual diagram of repetitive support`

The reason we should distinguish between repetitive supports at a single moment and at multiple moments is that those supports could result in different effects on beneficiary companies. In the case of repetitive supports at a single moment, companies favored with supportive instruments are likely to make short-term revenue gains with higher benefits from supports. The response to repetitive supports at multiple moments could be

contrasted with that to supports at a single time. Companies that benefited from repeated policy instruments at different times are likely to form relation systems and networks with enterprise-supporting agencies/institutions. Through these networks and relations with supporting institutions, firms could establish paths for sustainable growth with long-term R&D projects and innovative activities. It requires continuous funding for innovative activities and technological innovation to be shown as tangible achievements. Thus, repetitive supports at different times could have positive effects on technological innovations for beneficiary firms. Thus, we could anticipate that these repetitive supports contribute not only to short-term performances but also to long-term growth of firms. The purpose of this chapter is to make general conclusions about the effects of repetitive supports on firms' performances. To analyze these effects, it is essential to review and compare the performance of firms considering two cases: when repetitive policy instruments have and have not occurred.

The methodological procedures to analyze impacts of repetitive supports on firm's performance can be summarized as follow. Firstly, the additional effects on performance of firms from the specific policy instruments could be estimated using matching techniques and comparing with firms who are not benefitting from supportive instruments. This approach for analyses can be described as general matching methodologies, as outlined in chapter 3. With this approach, net effects from supporting policies could be extracted with values of Average Treated effect on the Treated (ATT). This ATT value is not an estimated statistical value, but a numerical value calculated by subtracting the

performance of firms who are matched from the performance of firms who are benefitting from supporting policies. Thus, it is valid for ATT value to be used as an explanatory variable or a dependent variable in the regression analysis. Czamitzki and Licht (2006) used this methodological approach to analyze the effects of R&D subsidies to firms. Matching techniques were applied for comparing firms that are supported by subsidies and those that are not in terms of effects on the enlargement of internal R&D activities. After conducting the primary efficacy analysis with the derived ATT value, Czamitzki and Licht (2006) carried out the regression analysis of innovation outcomes with the ATT value as an explanatory variable for the secondary analysis.

Similar methods of analysis can be found in other literatures (Aerts, 2008; Czarnitzki & Hussinger, 2004; Kim, 2011). Thus, this approach, using matching techniques for deriving ATT value and conducting the secondary regression analysis using the derived ATT value, could be appropriate for further analysis.

Based on the approach mentioned above, the analyses are carried out using the value of ATT. Samples for the regression are chosen as firms supported by policy instruments. Controlling for characteristics of firms, the effects of repetitive supports on the ATT value are analyzed by regression analyses. To be specific, credit guarantee funds, technology guarantee funds, and venture certification are considered as policy instruments for repetitive supports for firms, and the complementary effects among those instruments are analyzed using the methodology mentioned above.

$$Y = \beta \cdot (\mathrm{X}_{nuber\ of\ repitition}) + \beta_i \cdot X_i + e_i$$

Y : *Average Treatment effect on the Treated*

X_i : *Firm characteristics* $\left(\begin{array}{l} sales,\ age,\ total\ asset,\ liabilities,\ R\&D\ expenditure, \\ exports,\ regions\ dummy,\ ect. \end{array} \right)$

5.2 Data and variables

Data for analysis were collected from data containing the information on credit guarantee funds, technology guaranteed funds, venture certification data, and KED data at the firm level. In the case of guarantee programs, lists of beneficiary companies are renewed every year, and companies having these supports could easily get opportunities to be re-guaranteed. Thus, many firms that have benefited from these guarantee programs exist. This tendency can be confirmed through the data from 2001 to 2004.

For the venture certification program, benefits last for two years after certification from the government. In addition, it is very common for supported companies to get opportunities to be re-guaranteed as credit guarantee funds or technology guaranteed funds. The data for firms who had obtained the venture certification from 2001 to 2006 is listed in the table below. In this respect, the only difference between the venture certification program and the guarantee funding program is the period of validity: two years for the venture certification program and a year for the guarantee funding program. Thus, for the period from 2001 to 2006, the maximum number of times certification can be granted is three, as for the venture certification program.

The information on the proportion of firms who had consecutive supports from the guarantee funding programs and venture certification program is described as follows.

Table 26. Number of firms according to the number of repetition

No. of repetition	KCGF		KTFC		Venture certification	
1 time	261,844	(70.0%)	96,381	(77.7%)	67,049	(59.1%)
2 times	83,173	(22.2%)	22,319	(18.0%)	28,891	(25.5%)
3 times	22,790	(6.1%)	4,597	(3.7%)	15,249	(15.4%)
4 times	6,244	(1.7%)	776	(0.6%)		

The proportion of firms who had obtained benefits from all of these policy instruments twice or more is large: 28.3% for KCGF, 21.7% for KTFC, and 40.9% for the venture certification program. With these data, we can ascertain that a number of firms have been repeatedly supported by those policy instruments after once obtaining these supports. Even though repetitive supports for existing businesses could be an undesirable concept in terms of the distribution of benefits, it could be recognized as providing steady support for competitive firms in terms of efficiency. Thus, selective supports can bring about positive effects for achieving policy goals as compared with non-differential supports.

Now, it is necessary to think about characteristics of firms who recieved supportive instruments repeatedly. In general, it is common for the government to present support to

top-ranking companies and outstanding enterprises. This is also confirmed by data, as it is shown by the high estimated value for explanatory variables for a firm's characteristics. Therefore, it is interpreted that firms who have comparative advantages can easily receive repetitive supports from the government. This gives rise to several implications. Firstly, we can anticipate that the selection mechanisms by the government for policy implementations is somewhat risk-averse. Secondly, instruments supportive to firms have little impacts on the growth of SMEs with the biased selection by the government. Though the main reason for implementing a wide range of policy instruments is to set foundations for small companies lacking as growth engines, actual implementations for supportive instruments by the government have tendencies to be focused on large companies. This implies that the supportive instruments with a biased selection mechanism could substantially increase the gap between large and the small companies. Lastly, the fact that there are differences in basic statistics among firms who had recieved repetitive supports means that there is a selection bias problem. To solve this problem, the matching technique as mentioned in the chapter 3 was applied for analyses.

Table 27. Descriptive statistics of firms' characteristics according to repetitive number of KCFG

Variables	1 time		2 times		3 times		4 times	
	Mean	Std. err	Mean	Std.	Mean	Std.	Mean	Std.
Sales[a]	4.40	9.24	5.50	10.40	7.68	12.86	11.58	15.22
Age(year)	7.58	6.15	6.94	6.11	7.60	6.51	9.11	7.29
Assets[a]	3.10	6.80	3.74	8.34	5.20	10.45	7.74	10.57
Employees	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wage[a]	0.17	0.32	0.20	0.31	0.28	0.41	0.41	0.64
Liabilities[a]	2.12	4.47	2.58	5.49	3.52	7.08	5.00	6.39
R&D expenditure[a]	0.03	0.20	0.03	0.16	0.04	0.20	0.07	0.25
Ratio of export[b]	0.01	0.09	0.01	0.10	0.01	0.10	0.03	0.17
Reg1[b]	0.60	0.49	0.59	0.49	0.56	0.50	0.49	0.50
Reg2[b]	0.07	0.26	0.09	0.29	0.10	0.30	0.14	0.35
Reg3[b]	0.06	0.24	0.05	0.22	0.06	0.24	0.08	0.27
Reg4[b]	0.26	0.44	0.25	0.44	0.25	0.43	0.26	0.44
Reg5[b]	0.01	0.09	0.01	0.11	0.02	0.13	0.03	0.16

a. Monetary units in billion KRW

b. units in %

Table 28. Descriptive statistics of firms' characteristics according to repetitive number of KTFC

Variables	1 time		2 times		3 times		4 times	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Sales[a]	8.16	19.54	8.91	15.09	10.35	17.00	11.58	15.22
Age(year)	7.92	6.58	7.55	6.05	7.65	6.17	9.11	7.29
Assets[a]	6.62	16.09	7.38	12.11	8.62	14.31	7.74	10.57
Employees	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wage[a]	0.30	0.60	0.34	0.49	0.39	0.53	0.41	0.64
Liabilities[a]	4.67	12.45	5.13	8.56	5.87	9.11	5.00	6.39
R&D expenditure[a]	0.10	0.45	0.15	0.52	0.14	0.44	0.07	0.25
Ratio of export[b]	0.03	0.16	0.04	0.19	0.05	0.21	0.03	0.17
Reg1[b]	0.53	0.50	0.48	0.50	0.45	0.50	0.49	0.50
Reg2[b]	0.09	0.28	0.11	0.31	0.11	0.31	0.14	0.35
Reg3[b]	0.07	0.25	0.07	0.25	0.10	0.30	0.08	0.27
Reg4[b]	0.30	0.46	0.33	0.47	0.33	0.47	0.26	0.44
Reg5[b]	0.01	0.11	0.01	0.11	0.02	0.13	0.03	0.16

a. Monetary units in billion KRW

b. units in %

Table 29. Descriptive statistics of firms' characteristics according to repetitive number of venture certification

Variables	1 time		2 times		3 times	
	Mean	Std.	Mean	Std.	Mean	Std.
Sales[a]	10.92	20.50	11.69	17.85	15.28	20.71
Age(year)	7.22	6.59	7.82	6.54	7.99	5.95
Assets[a]	8.89	15.67	10.84	15.29	15.65	22.89
Employees	0.00	0.00	0.00	0.00	0.00	0.00
Wage[a]	0.40	0.56	0.49	0.55	0.62	0.67
Liabilities[a]	5.56	9.62	6.37	9.19	8.25	14.44
R&D expenditure[a]	0.22	0.60	0.31	0.68	0.44	0.83
Ratio of export[b]	0.04	0.19	0.07	0.26	0.15	0.36
Reg1[b]	0.61	0.49	0.65	0.48	0.56	0.50
Reg2[b]	0.10	0.30	0.11	0.31	0.14	0.35
Reg3[b]	0.07	0.25	0.07	0.25	0.06	0.24
Reg4[b]	0.21	0.41	0.33	0.47	0.22	0.41
Reg5[b]	0.01	0.11	0.01	0.11	0.02	0.14

a. Monetary units in billion KRW

b. units in %

5.3 Estimation results

5.3.1 Complementarity effect according to repetitive support of KCGF

5.3.1.1 Estimation of propensity score

To analyze the effects of repetitive supports from trust guarantee funds, the propensity score has been estimated by probit analysis. Firms who had obtained credit guarantee funds were selected as the treatment group, and those excluded from this support were regarded as the control group for the probit analysis. Based on the estimated results below, the propensity score could be calculated. With this propensity score, net effects of the credit guarantee funds can be derived. As mentioned in chapter 3, the matching techniques were applied for analysis considering the propensity score as well as other key variables relevant to policy supports. For the estimation of the performance of the credit guarantee funds, current ratio, debt ratio, and BIS ratio were considered as variables with the propensity score.

Table 30. Probit parameter estimates

D = 1 : firms guaranteed by KCGF D = 0 : non-guaranteed firms			
Variables	Coef.	Std. Err.	Sig. [b]
lsales[a]	0.408	0.010	***
lage[a]	-0.205	0.008	***
lass[a]	-0.234	0.030	***
lworker[a]	-0.354	0.045	***
lworker2[a]	0.050	0.007	***
lwage[a]	-0.074	0.007	***
lliab[a]	0.008	0.018	
ltotcap[a]	0.059	0.013	***
d_expo	-0.052	0.051	
reg1	-0.039	0.022	*
reg2	0.117	0.027	***
reg4	-0.081	0.023	***
reg5	0.156	0.052	***
Constant	-2.302	0.121	***

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

5.3.1.2 Estimation of complementarity effect

The results after matching firms with a similar propensity score are listed in Table 31. As shown in the table, the performance of firms who benefited from the credit guarantee funds shows a relatively higher performance than those who were excluded from this support. In particular, variables explaining the growth of a company, such as increased rate of sales, total asset growth, and increased number of employees, are shown to have

beenremarkably positively affected by the credit guarantee funds. Moreover, the variables presenting innovative activities by firms, such as the growth of R&D expenditures and R&D per employee, also show higher values for firms who benefited from the credit guarantee funds.

Table 31. The effect of KCGF on firms' performance

	After 1 years	After 2 years	After 3 years	After 4 years
Sales growth	7.64 ***	9.59 ***	9.05 ***	9.46 ***
Assets growth	11.66 ***	13.61 ***	12.81 ***	12.31 ***
Worker growth	4.75 ***	5.13 ***	4.95 ***	5.19 ***
R&D growth	12.96 ***	11.79 ***	13.70 ***	14.43 ***
Growth of R&D per worker	4.91 *	5.36 **	9.30 ***	15.77 ***
Growth of R&D per sales	-0.06	-0.03	1.15	0.02

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

However, the above results show information on overall firms who had gotten supports from the credit guarantee funds. Our concern is to focus on repetitive supports and their impacts on the performance of firms. To analyze this, it is necessary to review the relation between the ATT value describing the net effects of supportive instruments and the number of repetitive supports to firms by means of multiple regression analysis. Procedures for this analysis can be described as follows.

$$Y = \beta \cdot (\mathrm{X}_{nuber\ of\ repitition}) + \beta_i \cdot X_i + e_i$$

Y : *Average Treatment effect on the Treated*

X_i : *Firm characteristics* $\begin{pmatrix} sales,\ age,\ total\ asset,\ liabilities,\ R\&D\ expenditure, \\ exports,\ regions\ dummy,\ ect. \end{pmatrix}$

Here, Y represents the net effects of firms resulting from the supports by the credit guarantee funding program. In addition, by controlling for the variables relevant for characteristics of firms, we can estimate the impacts of the number of repetitive supports by means of the credit guarantee funding programs on the performance of firms with the results of regression analysis.

The results of the regression analysis are listed in the table below. In this table, only relations between variables describing the performance of firms and explanatory variables are contained. The full results for this regression analysis are presented in the Appendix. As shown in the table, the increase rate of sales and that of assets show a statistically significant relation with overlapped supports of the credit guarantee funding program. The increase rate of sales after a year shows positive relation with the number of repetitive supports, with p-value 0.0491; the increase rate of sales after two years shows 0.0832, after three years shows 0.1027, after four years shows 0.1075, and after five years shows 0.1050. As for the increase rate of assets, it also shows positive relation with the number of repetitive supports with p-value 0.0189 after a year; the increase rate of assets after two years shows the value of 0.0480, after three years shows 0.0405, after four years

shows 0.0266, and after five years shows 0.0153. Through these results, it is concluded that repetitive supports by the credit guarantee funding program have positive impacts on the increase of sales and assets of beneficiary firms, not only in the short-term, also in the long-term. However, as for other variables except for the increase of sales and assets, they have not shown any significant results with repetitive supports by the credit guarantee funding program.

It should be noted from the results that the effect of repetitive supports on the performance of firms reduces as time passes. In the case of the increase rate of sales, impacts of repetitive supports increases steadily to a p-value of 0.1027 until three years after supports provided to firms, whereas effects decline thereafter. These patterns are also discerned in the case of the increase of assets of firms. Until two years after supports were provided to firms, the effects of repetitive supports on the increase of assets show the tendency of increase, with a p-value of 0.0480. However, increasing trends of effects on the assets of firms halted thereafter. With these results, it is confirmed that repetitive supports by the credit guarantee funding program have led to the short-term growth of firms rather than the long-term impacts on the growth. Thus, we can conclude that the consecutive supports with the same policy instruments are likely to bring out the inefficiency in the long term. Therefore, it seems to be desirable to limit the repetitive supports of the credit guarantee funding program to existing companies. However, this conclusion could be specific to the credit guarantee funding program. Thus, it is necessary to review the other policy instruments and their impacts on the performance of

firms in the form of repetitive supports.

Table 32. The effect of repetitive support of KCGF on firm's performance

Variables		Coefficient	Variables		Coefficient
Sales growth	After 1 year	0.0491 ***	Asset growth	After 1 year	0.0189 ***
	After 2 year	0.0832 ***		After 2 year	0.0480 ***
	After 3 year	0.1027 ***		After 3 year	0.0405 ***
	After 4 year	0.1075 ***		After 4 year	0.0266 ***
R&D growth	After 1 year	0.0259	Worker growth	After 1 year	-0.0004
	After 2 year	-0.0090		After 2 year	0.0015
	After 3 year	0.0458 **		After 3 year	0.0036
	After 4 year	-0.0444		After 4 year	-0.0075 *
Growth of R&D per sales	After 1 year	0.0027	Growth of R&D per worker	After 1 year	0.0027
	After 2 year	0.0257		After 2 year	-0.0349 *
	After 3 year	-0.2836		After 3 year	-0.0155
	After 4 year	-0.0444		After 4 year	-0.0444

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

5.3.2 Complementarity effect according to repetitive support of KTFC

5.3.2.1 Estimation of propensity score

As shown in section 5.3.1, even though the overlapped supports of the credit guarantee funding program have positive impacts on the performance of firms, these impacts tend to decline as time passes. To check whether this pattern occurs in the technology guaranteed funds, probit analysis has again been applied to estimate the propensity score. Firms that had obtained technology guaranteed funds were selected as a treatment group, and those excluded from this support were regarded as control group for the probit analysis. The table listed below shows the results of the estimation of probit analyses. Based on the estimated results below, the propensity score could be calculated. With this propensity score, net effects of the technology guaranteed funds could be derived. Moreover, for the matching techniques to estimate the performance of the technology guaranteed funds, we consider another variable, R&D expenditures of firms, along with the propensity score. In addition, the multivariate metric matching techniques were applied for analyses.

Table 33. Probit parameter estimates

D = 1 : firms guaranteed by KTFG D = 0 : non-guaranteed firms			
Variables	Coef.	Std. Err.	Sig.[b]
lsales[a]	0.125	0.012	***
lage[a]	-0.224	0.009	***
lass[a]	-0.312	0.025	***
lworker[a]	-0.043	0.012	***
lwage[a]	-0.073	0.009	***
lliab[a]	0.148	0.017	***
lcap[a]	0.043	0.009	***
lrnd[a]	0.006	0.008	
lrnd2[a]	0.003	0.001	***
d_expo	-0.066	0.042	
reg2	0.198	0.023	***
reg3	0.276	0.026	***
reg4	0.203	0.015	***
reg5	0.343	0.057	***
Constant	0.197	0.112	*

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

5.3.2.2 Estimation of complementarity effect

The results after matching firms with a similar propensity score are listed in the table below. As shown in the table, firms that benefited from the technology guaranteed funds show a relatively higher performance than those excluded from the support. In particular, not only variables explaining the growth of a company (such as increase rate of sales,

total asset growth, and increased number of employees), but also variables presenting innovative activities by firms (such as, the growth of R&D expenditures, and R&D per employee) show higher values for firms who had benefited from the credit guarantee funds. These results imply that the technology guaranteed funding program is an effective instrument with respect to promoting a firm's growth and innovative activities. This comes from the nature of the technology guaranteed funding program in that it supports companies by focusing on the technology and innovation outcomes.

Table 34. The effect of KTFC on firms' performance

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

	After 1 years	After 2 years	After 3 years	After 4 years
Sales growth	9.18 ***	10.47 ***	9.67 ***	10.28 ***
Assets growth	12.19 ***	14.71 ***	14.78 ***	13.54 ***
Worker growth	19.48 ***	24.24 ***	25.58 ***	23.84 ***
R&D growth	0.71 ***	3.34 ***	5.04 ***	5.57 ***
Growth of R&D per worker	36.8 ***	42.72 ***	49.13 **	47.96 ***
Growth of R&D per sales	-3.93 ***	-3.43 ***	-3.39 ***	-3.7 ***

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

To analyze the repetitive supports of the technology guaranteed funds and their impacts on the performance of firms, multiple regression analysis was conducted.

Procedures for analysis can be described as follows. As shown in the equation below, Y represents the net effects of firms resulting from the supports by the technology guaranteed funding program. In addition, by controlling for the variables relevant for characteristics of firms, we can estimate the impacts of the number of repetitive supports by means of the technology guaranteed funding programs on the performance of firms with results of the regression analysis.

$$Y = \beta \cdot (\mathrm{X}_{nuber\ of\ repitition}) + \beta_i \cdot X_i + e_i$$

Y : *Average Treatment effect on the Treated*

X_i : *Firm characteristics* $\begin{pmatrix} sales,\ age,\ total\ asset,\ liabilities,\ R\&D\ expenditure, \\ exports,\ regions\ dummy,\ ect. \end{pmatrix}$

The results of the regression analysis are listed in the table below. In this table, only relations between variables describing the performance of firms and explanatory variables are contained. The complete results for this regression analysis are given in the Appendix. Results from the regression analysis reveal a similarity with the credit guarantee funding program. As shown in the table, the increase rate of sales and that of assets show statistically significant relations with overlapped supports of the technology guaranteed funding program. The increase rate of sales after a year shows a positive relation with the number of repetitive supports, with p-value 0.0508; the increase rate of sales after two years shows 0.0831, after three years shows 0.0966, after four years shows 0.0993, and after five years shows 0.1133. As for the increase rate of assets, it also shows a positive

relation, with the number of repetitive supports with p-value 0.0170 after a year; the increase rate of assets after two years shows the value of 0.0459, after three years shows 0.0445, after four years shows 0.0301, and after five years shows 0.0309. Through these results, it is concluded that, like the credit guarantee funding program, repetitive supports by the technology guaranteed funding program had positive impacts on the increase of sales and assets of beneficiary firms, not only in the short-term, but also in the long-term. However, as for other variables, except for the increase of sales and assets, they have not shown any significant results with repetitive supports by the technology guaranteed funding program.

Table 35. The effect of repetitive support of KTFC on firm's performance

Variables		Coefficient	Variables		Coefficient
Sales growth	After 1 year	0.0508 ***	Asset growth	After 1 year	0.017 ***
	After 2 year	0.0831 ***		After 2 year	0.046 ***
	After 3 year	0.0966 ***		After 3 year	0.045 ***
	After 4 year	0.0993 ***		After 4 year	0.030 ***
R&D growth	After 1 year	0.1092 **	Worker growth	After 1 year	0.002
	After 2 year	0.0137		After 2 year	-0.006
	After 3 year	0.0151		After 3 year	-0.017 **
	After 4 year	-0.0234		After 4 year	0.003
Growth of R&D per sales	After 1 year	2.2054	Growth of R&D per worker	After 1 year	0.027
	After 2 year	-0.2902		After 2 year	0.029
	After 3 year	2.2437		After 3 year	0.013
	After 4 year	1.7333		After 4 year	0.112 *

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The important thing we should notice from the results is that the effect of repetitive supports on the performance of firms shrinks as time passes, as with the credit guarantee funds. In the case of the increase rate of sales, impacts of repetitive supports increases steadily to a p-value of 0.0966 until three years after supports provided to firms, subsequently declining. These patterns are also determined in the case of the increase of assets of firms. Until two years after supports provided to firms, the effects of repetitive supports on the increase of assets show a tendency of increase, with p-value 0.0459. However, increasing trends of effects on the assets of firms have halted thereafter. With these results, it is confirmed that repetitive supports by the technology guaranteed funding program have led to short-term growth of firms rather than long-term impacts on the growth. Therefore, it could be concluded that these results are very similar to those for the credit guarantee funds. However, it is hard to generalize the impacts of repetitive supports based on the results of just two policy instruments. As these two instruments are parts of the guarantee systems in common, it is necessary to analyze impacts of repetitive supports of policy instruments that are in different scopes. Therefore, in the next chapter, the analysis of the venture certification program will be discussed.

5.3.3 Complementarity effect according to repetitive support of venture certification

5.3.3.1 Estimation of propensity score

In the previous chapters, it was revealed that even though overlapped supports have positive impacts on the performance of firms, the effects of these supports recede through time. To cover the policy instrument in another scope, the venture certification program has been considered to analyze effects of repetitive supports. To check whether patterns occurred in the guarantee system are shown in the venture certification program, the probit analysis has been applied again to estimate the propensity score. Firms who had obtained technology-guaranteed funds were selected as the treatment group, and those excluded from this support were regarded as the control group for the probit analysis. The table listed below shows the results of the estimation of probit analyses. Based on the estimated results below, the propensity score could be calculated. With this propensity score, net effects of the technology guaranteed funds could be derived. Moreover, for the matching techniques to estimate the performance of the technology guaranteed funds, we consider another variable, R&D expenditures of firms, along with the propensity score. In addition, the multivariate metric matching techniques has been applied for analyses.

Table 36. Probit parameter estimates

D = 1 : firms receiving venture certification D = 0 : non-certificated firms			
Variables	Coef.	Std. Err.	Sig. [b]
lsales[a]	-0.295	0.018	***
lage[a]	-0.402	0.014	***
lass[a]	-0.068	0.061	
lworker[a]	-0.224	0.019	***
lwage[a]	0.069	0.014	***
lliab[a]	0.115	0.038	***
ltotcap[a]	0.258	0.027	***
d_rnd	0.909	0.020	
reg1	-0.012	0.039	*
reg2	-0.082	0.047	
reg4	-0.164	0.042	***
reg5	0.236	0.097	**
Constant	-0.601	0.182	***

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

5.3.3.2 Complementarity effect of policy repetition

Table 37 shows the results with comparison of performance of firms after matching those firms having similar values and distributions in the light of derived propensity scores and R&D expenditures. Therefore, these results could be used to determine the net effects toward firms resulting from the supports by the venture certification program. As with previous instruments, firms who had benefited from the venture certification program showed superior performance compared to those who were excluded from this

policy instrument. Moreover, not only for the growth of firms, but also for the innovative capabilities, it was proved that this policy instrument is an effective way for promoting both.

Table 37. The effect of KTFC on firms' performance

	After 1 years	After 2 years	After 3 years	After 4 years
Sales growth	6.42 ***	8.26 ***	10.02 ***	13.1 ***
Assets growth	11.34 ***	17.0 ***	18.89 ***	20.59 ***
Worker growth	4.13 ***	7.22 ***	10.9 ***	13.9 ***
R&D growth	174.4 ***	251.15 ***	273.61 ***	285.4 ***
Growth of R&D per worker	127.31 ***	175.79 ***	180.23 ***	195.3 ***
Growth of R&D per sales	2.00	-2.63 **	-1.19	-2.13 **

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Furthermore, the secondary regression analysis has been conducted to look on the effects of repetitive supports of the venture certification program using the derived ATT value and its relationship with the number of repetitive supports. Methodological approaches for analysis are similar to those in previous chapters. The multiple regression analysis has been carried out, and the results show that only the growth of sales has a statistically significant relation with the overlapped support of the venture certification program.

$$Y = \beta \cdot (\mathrm{X}_{nuber\ of\ repitition}) + \beta_i \cdot X_i + e_i$$

Y : *Average Treatment effect on the Treated*

X_i : *Firm characteristics* $\begin{pmatrix} sales,\ age,\ total\ asset,\ liabilities,\ R\&D\ expenditure, \\ exports,\ regions\ dummy,\ ect. \end{pmatrix}$

The increase rate of sales after a year shows positive relation with the number of repetitive supports with p-value 0.0327; the increase rate of sales after two years shows 0.0783, after three years shows 0.0885, after four years shows 0.0944, after five years shows 0.1079, and after six years shows 0.0937. Through these results, we can conclude that repetitive supports by the venture certification program have positive impacts on the increase of sales of beneficiary firms in both the short- and long-term. However, as for other variables, except for the increase of sales, they have not shown any significant results with repetitive supports by the technology-guaranteed funding program.

Table 38. The effect of venture certification on firms' performance

Variables		Coefficient	Variables		Coefficient
Sales growth	After 1 year	0.0327 ***	Asset growth	After 1 year	0.0274 ***
	After 2 year	0.0783 ***		After 2 year	0.0233 ***
	After 3 year	0.0885 ***		After 3 year	0.0165
	After 4 year	0.0944 ***		After 4 year	0.0152
R&D growth	After 1 year	-0.0176	Worker growth	After 1 year	0.003
	After 2 year	-0.2419		After 2 year	0.0133
	After 3 year	0.3452 **		After 3 year	-0.0155
	After 4 year	-0.2672 *		After 4 year	0.0164
Growth of R&D per sales	After 1 year	-5.0362	Growth of R&D per worker	After 1 year	-0.0218
	After 2 year	0.5504		After 2 year	-0.0312
	After 3 year	-3.3573		After 3 year	-0.181
	After 4 year	4.6593 **		After 4 year	-0.0664

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

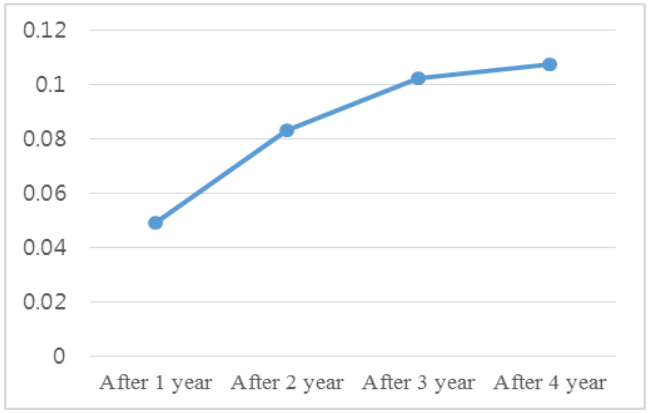
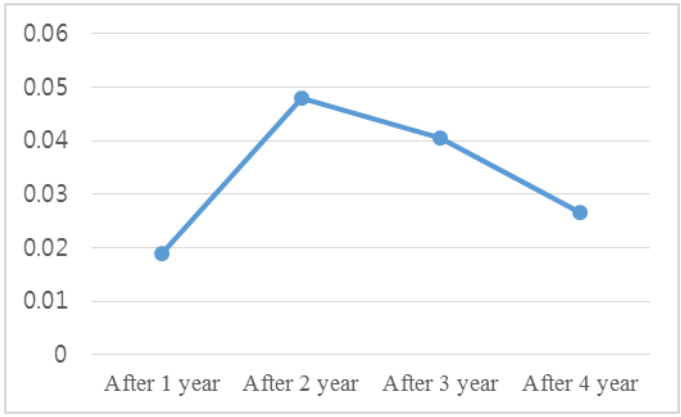
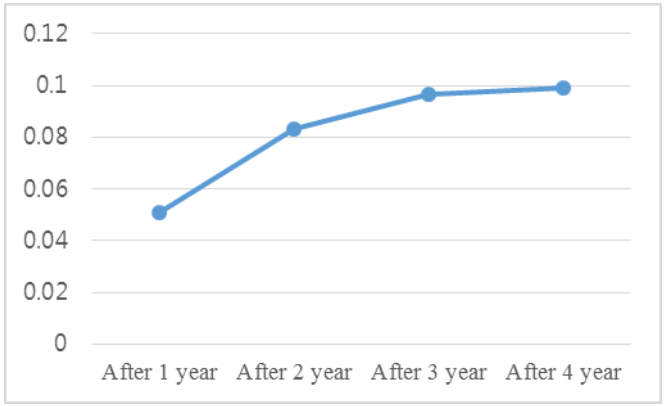
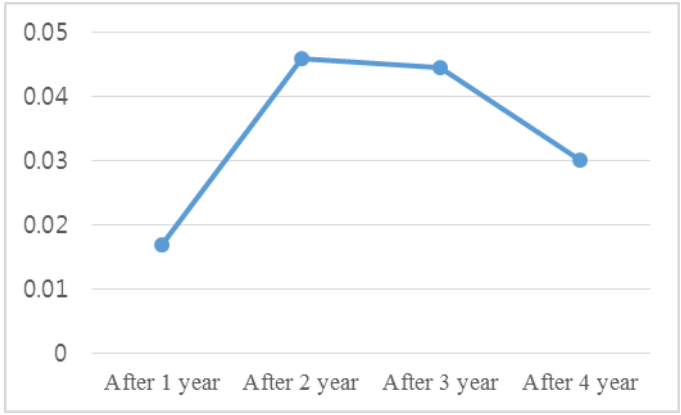
In addition, it was found that effects of repetitive supports on the performance of firms recede with time, as in previous instruments. In the case of the increase rate of sales, impacts of repetitive supports increase steadily to a p-value of 0.0944 until four years after supports provided to firms, whereas effects have shown a tendency to slow down afterwards. With these results, it is confirmed that repetitive supports by the venture certification program have led to the short-term growth of firms rather than long-term impacts on growth, consistent with the results of the guarantee funding programs. Therefore, it could be generalized that repetitive supports by the government wields great influence upon short-term performance and growth of firms and that its effects tend to

decline as time passes.

5.4 Summary and policy implication

In this chapter, we have investigated the effects of repetitive supports toward performance of firms. To analyze this, the credit guarantee funds, the technology-guaranteed funds, and the venture certification program have been considered. The interpretations of results can be summarized as follows. Firstly, it has revealed that overlapped supports by policy instruments have positive impacts on the performance of firms, especially for the increase of sales and assets. This means that repetitive supports of firms have a great influence on their capabilities for raising funds positively. In addition, it was found that firms who had benefited from supportive instruments show superior performance compared to those who were excluded from supports.

Secondly, it was found out that effects of repetitive supports on the performance of firms recede as time passes. While effects of supports at a single time or twice in consecutive order showed increasing tendencies, those for more than three consecutive times show a statistically insignificant effect on the performance of firms. To be specific, for the increase rate of sales and assets, it was found that impacts of repetitive support increase steadily until two or three years after supports provided to firms, and show slowdown from the four years after supports provided to firms, regardless of types of policy instruments. With these results, it could be generalized that repetitive supports by the government wield great influence upon short-term performance and growth of firms, though its effects tend to decline as time passes. Those implications are illustrated in the figure below.

	Sales growth	Asset growth
KCGF		
KTFC		

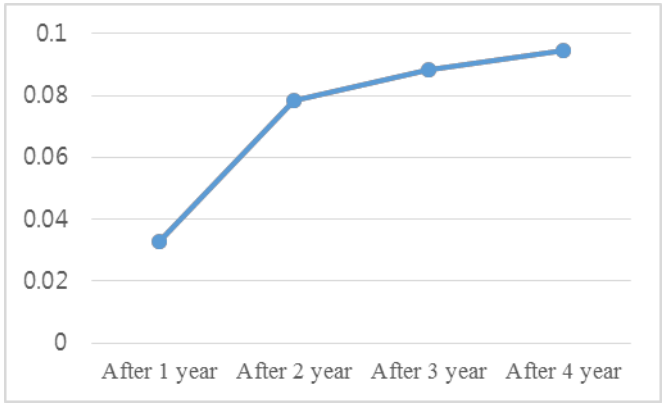
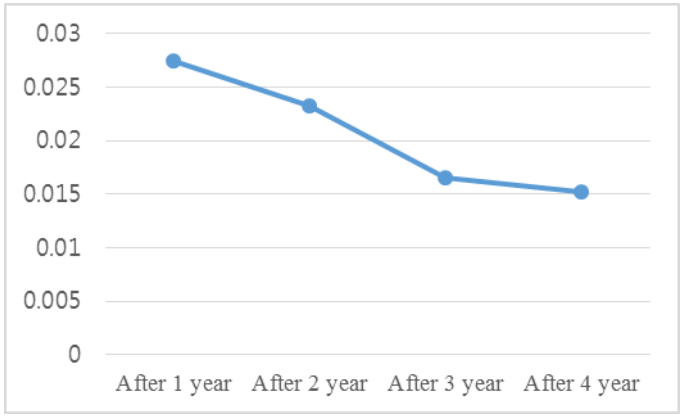
Venture certification		

Figure 10. Complementarity effect of the repetitive support in various policies

The fact that effects of supportive instruments become stagnant or declined gives clear implications to policy makers. First of all, results derived from this chapter imply positive impacts of repetitive supports by the same policy instrument, and policymakers should consider the repetitive implementations of policy instruments rather than a single-time implementation of policy. However, policymakers also should keep in mind that the marginal impacts of repetitive implementations of policy instruments have a tendency to decline as time passes. Therefore, the government should think of other policy instruments targeted to beneficiary firms who have already recieved repetitive supports for coordinating the distribution of benefits.

Chapter 6. Analysis on the complementarity effect according to sequential support in innovation policy

6.1 Background and purpose of the study

The purpose of this chapter is to examine the complementarity effect according to repetitive support in innovation policy. The conceptual description of "sequential support" can be shown as **Figure 10.**

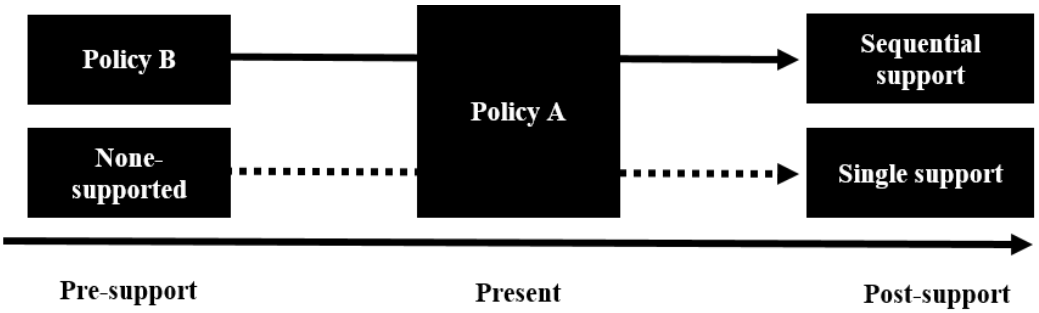


Figure 11. Conceptual diagram of sequential support

As mentioned in Gunningham and Sinclair (1999), the complementarity effect can occur when heterogeneous policies are supported sequentially; therefore, policy makers have to consider this effect when implementing the government policy. For example, the policy mix for obtaining the most efficient outcome or path-dependency of policy that the firm has experienced before is considered. This consideration is very important to achieve

the ultimate goal of the policy. Hacker (1998) found that the sequence and the forehandedness of policy implementation are certainly considered to explain the development of government policy, and that path dependency of policy is very important for successful implementation of the policy. This “path dependency” concept has been emphasized by many economists (Arthur, 1989; David, 1985; North, 1990). In a similar context, Levy (1993) found that the effect of policy mix and policy sequence varies by countries, and emphasized that all policies have to be well systemized for efficient policy implementation. Pralle (2006) also emphasized the policy sequence and forehandedness. Although various studies about policy sequence have been performed, there are not sufficient studies about this with respect to innovation policy. Therefore, the complementarity effect of sequential support in innovation policy will be discussed in this chapter.

For analysis of the complementarity effect of sequential support in innovation policy, venture certification may be one useful example. As mentioned in chapter 4, venture certification in Korea is a very unique policy. The Korean government has directly supervised the venture industry, and in order to acquire venture certification, the firms have to satisfy one requirement among the following three:

i. Invested in by venture capitalist(s)
ii. Satisfying the R&D investment requirement
iii. Being conferred the guarantee from KTFC

Table 39. Number and ratio of venture firms according to the certification type

Year	Venture capital Investment		R&D investment		Guarantee from KTFC		Total
	No.	Ratio	No.	Ratio	No.	Ratio	
2000	357	(4.1%)	734	(8.3%)	7,707	(87.6%)	8,798
2001	401	(3.5%)	1,261	(11.1%)	9,731	(85.4%)	11,393
2002	1,113	(12.7%)	1,315	(15.0%)	6,346	(72.3%)	8,774
2003	714	(9.3%)	1,466	(19.0%)	5,522	(71.7%)	7,702
2004	442	(5.5%)	1,413	(17.7%)	6,112	(76.7%)	7,967
2005	330	(3.4%)	1,426	(14.7%)	7,976	(82.0%)	9,732
2006	367	(3.0%)	1,548	(12.7%)	10,303	(84.3%)	12,218
2007	523	(3.7%)	1,986	(14.2%)	11,506	(82.1%)	14,015
2008	604	(3.9%)	2,320	(15.1%)	12,477	(81.0%)	15,401
2009	555	(2.9%)	1,899	(10.1%)	16,439	(87.0%)	18,893
2010	622	(2.5%)	1,588	(6.4%)	22,435	(91.0%)	24,645
2011	577	(2.2%)	1,479	(5.6%)	24,320	(92.2%)	26,376
2012	651	(2.3%)	1,446	(5.1%)	26,096	(92.6%)	28,193
2013	700	(2.4%)	1,497	(5.1%)	26,938	(92.5%)	29,135

*Source : Korea Venture Business Association

In particular, the firms that obtain the venture certification by satisfying the third requirement, “being conferred the guarantee from KTFC,” can be regarded as the firms that already have received the guarantee from KTFC before venture certification. That is, these firms can be categorized as the firms which received sequential support by government. However, the firms that obtain the venture certification by satisfying the first

or second requirement (i.e. “invested in by venture capitalist(s)” or “Satisfying the R&D investment requirement,” respectively, cannot be regarded as receiving sequential support. Therefore, the Korean venture firms can be categorized according to whether the firm received sequential support. Consequently, through the analysis of venture certification, the complementarity effect according to sequential support can be estimated.

Analysis for estimating the complementarity effect according to sequential support can also be estimated by the analysis model used in chapter 5. First, using matching method, ATT is estimated, and then secondary regression analysis is performed. In the secondary regression analysis, estimated ATT by matching is the dependent variable, and the dummy variable about whether the firm received sequential support or not is a key explanatory variable. The analysis model is specified as follows.

$$Y = \beta \cdot (D_{sequential\ \text{support}}) + \beta_i \cdot X_i + e_i$$

$$D_{sequential\ \text{support}} : \left\{ \begin{matrix} 1\ in\ case\ of\ sequential\ \text{support} \\ 0\ in\ case\ of\ none - sequential\ \text{support} \end{matrix} \right\}$$

Y : *Average Treatment effect on the Treated*

$$X_i : Firm\ characteristics \left(\begin{matrix} sales,\ age,\ total\ asset,\ liabilities,\ R\&D\ expenditure, \\ exports,\ regions\ dummy,\ ect. \end{matrix} \right)$$

6.2 Data and variables

KED data and venture certification data are used in this analysis. As mentioned above, KED data provides firms' financial data until 2011. Venture certification data includes the list of venture firms and certification date, and it is provided by the Korea Venture Business Association (KVBA). Through searching the venture certification data, 44,875 firms were found to have been certificated as venture firms. These two datasets (KED data and venture certification data) were merged according to corporate registration number and year.

Before estimating the propensity score for matching, an unbalanced panel dataset was constructed by the following standards:

i. Unbiased all the financial data using Producer Price Index (PPI) of 2010 as deflator

ii. Deleted the firms that are not included in the manufacturing industry based on KSIC

iii. Excluded observations that have missing data on the major financial statements

iv. Deleted the firms with negative value variables that should be positive.
(e.g., worker, age, sales, etc.)

v. Excluded firms for which the value on the financial statement was below the minimum value or above the maximum values of supported firms

Through above process total 2,191 venture firms are finally used for the analysis.

6.3 Estimation results

6.3.1 Estimation of propensity score

As mentioned in section 6.1, the complementarity effect according to sequential support is estimated through venture certification. For this, first, the effect of venture certification on firms' growth has to be estimated, and Table 41 shows the estimation result of probit analysis. In this probit analysis, the firms that receive the venture certification are the treatment group and those that did not comprise the control group. Through the probit analysis, the propensity score can be calculated, and based on this propensity score, the most similar firms comparing with the treated firm are matched. Finally, the treatment effect of venture certification can also be estimated. Moreover, the multivariate matching considering R&D expenditure with propensity score is performed.

Table 40. Probit parameter estimates

D = 1 : firms receiving venture certification D = 0 : non-certificated firms			
Variable	Coef.	Std. Err.	Sig.[b]
Constant	-0.38	0.20	*
Age[a]	-0.0058	0.011	
Wage	0.061	0.015	***
Total asset[a]	0.249	0.042	***
Total liability[a]	-0.107	0.025	***
Capital[a]	0.076	0.020	***
R&D expenditure[a]	0.098	0.002	***
Sales[a]	-0.350	0.020	***
Export	0.129	0.079	

Kibo	0.765	0.032	***
Venture capital	1.79	0.130	***
Net profit[a]	0.043	0.006	***
R2	-0.011	0.046	
R3	-0.095	0.057	*
R4	-0.198	0.033	***
R5	-0.212	0.129	*
Di1	-0.184	0.055	***
Di2	-0.475	0.043	***
Di3	-0.210	0.034	***
Number of observations		27,998	
Pseudo R^2		0.211	
Prob > χ^2		< 0.001	

a. in logarithmic form

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

6.3.2 Complementarity effect of sequential policy

Table 42 shows the results of multivariate matching estimator as well as outcome difference between the treated firms and the matched firms. That is, this result describes the treatment effect of venture certification on the firm's outcome. Similar to the result of section 5.3, the growth and innovative capacity of the treated firms is superior to those of the matched firms. In particular, the growth of R&D expenditure and R&D per worker of treated firm is much better than that of matched firms, and this result shows that the venture certification policy plays a much more crucial role in a firm's innovative capacity. These results accord closely with the ultimate goal of the venture certification.

However, the purpose of this chapter is to estimate the complementarity effect of

sequential support, not the effect of venture certification. The results of Table 42 cannot be the results of a complementarity effect of sequential support. Therefore, another analysis (i.e. secondary regression) is needed to estimate the complementarity effect of sequential support.

Table 41. The effect of venture certification on firms' performance

	After 1 year	Sig. [b]	After 2 year	Sig. [b]	After 3 year	Sig. [b]	After 4 year	Sig. [b]
Sales growth[a]	19.60	***	21.29	***	30.79	***	44.71	***
Assets growth[a]	26.34	***	41.20	***	45.58	***	52.12	***
Employment growth[a]	10.39	***	12.50	***	18.28	***	23.99	***
Growth of R&D per sales[a]	-0.35		17.99	*	13.05	**	1.94	
R&D growth[a]	293.18	***	423.87	***	511.31	***	554.53	***

a. Rows marked "growth" indicate log differences converted to percentage growth

b. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

For estimating the complementarity effect of sequential support, the following regression analysis is performed.

$$Y = \beta \cdot (D_{sequential\ \text{support}}) + \beta_i \cdot X_i + e_i$$

$$D_{sequential\ \text{support}} : \begin{Bmatrix} 1\ in\ case\ of\ sequential\ \text{support} \\ 0\ in\ case\ of\ none-sequential\ \text{support} \end{Bmatrix}$$

Y : *Average Treatment effect on the Treated*

$$X_i : Firm\ characteristics \begin{pmatrix} sales,\ age,\ total\ asset,\ liabilities,\ R\&D\ expenditure, \\ exports,\ regions\ dummy,\ ect. \end{pmatrix}$$

In this regression, we categorize all venture firms by two groups. One is firms which received guarantee by KTFC before venture certification, and the other is firms not guaranteed by KTFC. As mentioned above, the firms that received guarantee by KTFC before venture certification can be categorized as the firms that received sequential support by government, and the other firms as those that did not. Therefore, the dummy variable about whether the firm received sequential support or not can be the key independent variable. Table 43 shows the results of regression analysis.

Table 42. The effect of sequential support on firm's performance

Variables		Coefficient	Variables		Coefficient
Sales growth	After 1 year	0.0315	Asset growth	After 1 year	0.1023 ***
	After 2 year	-0.0460		After 2 year	0.1562 ***
	After 3 year	-0.0005		After 3 year	0.2257 ***
	After 4 year	0.0603		After 4 year	0.2492 ***
R&D growth	After 1 year	1.2370 ***	Worker growth	After 1 year	-0.0087
	After 2 year	1.3510 ***		After 2 year	0.156 ***
	After 3 year	2.1338 ***		After 3 year	0.0658
	After 4 year	2.5963 ***		After 4 year	0.1125 *
Growth of R&D per sales	After 1 year	-8.4707	Growth of R&D per worker	After 1 year	19.654
	After 2 year	-41.5911 *		After 2 year	11.778
	After 3 year	-23.4779		After 3 year	-49.298 ***
	After 4 year	-8.5699		After 4 year	-8.5699

Note 1. Rows marked "growth" indicate log differences converted to percentage growth

Note 2. The ***, ** and * indicate the 1%, 5% and 10% levels of significance

The results describe that the effect of the sequential support on the growth of firm's asset and R&D is positive. Moreover, in long term, this effect continues or grows. These results have some important implications. First, both KTFC and venture certification are intended for innovative SME; therefore, they aim to improve the innovation capacity of SMEs. The ultimate goals of these two policies are similar, but the implementation methods differ. KTFC provides a loan with low interest rate with the SMEs' technology as security. In case of venture certification, the government gives a signal to the market through certification, resulting in various benefits for the certificated firms. That is, the increase of assets can be regarded as a natural result. However, the increase of assets is not always concluded as the results of R&D growth. Therefore, it can be concluded that the firms that receive the sequential support were more likely to increase their assets through guarantee provided by KTFC, and, subsequently, were more likely to improve their innovative capacity. Moreover, the effects of the sequential support on employment growth are also positive, though some of them are not significant. Consequently, the intentional connection of government policies can play a positive role in the growth of SME's innovative capacity or employment, and it makes it easy for policy makers to achieve the goal of the policy.

6.4 Summary and policy implication

In this chapter, the complementarity effect of sequential support in innovation policy is analyzed based on the firms that received the sequential support from government. For estimating the complementarity effect of sequential support, discussion concerning the sequential support is needed (i.e. a definition of sequential support is required). This is because the intentional sequential support is quite different from the unintentional one, and unintentionally sequenced support is outside policy makers' interests. In this respect, venture certification of the Korean government can be a useful example for the analysis of sequential support. In order to acquire venture certification from the government, the firms have to satisfy one requirement among the three requirements given in section 6.1. Finally, the firms that received guarantee by KTFC before venture certification can be categorized as the firms that received the sequential support by government. Therefore, by using the venture certification data, the complementarity effect of sequential support in innovation policy can be analyzed.

The results indicate that the sequential support in innovation policy had positive effects on the firm's growth and the improvement of the firm's innovative capacity (i.e., assets and R&D expenditure). Figure 11 shows these results. That is, if the policy sequence is properly constructed by policy maker, the effect of policy can be much bigger.

Moreover, a more interesting point can be seen by comparing this with the results presented in chapter 5. Following the results of chapter 5, it was found out that effects of repetitive supports on the performance of firms recede with time. However, effects of

sequential support increase continuously. These results indicate that the sequential support of heterogeneous policy is much more effective for the firm's growth than the repetitive support of homogeneous policy; therefore, policy makers should consider these characteristics of innovation policy when designing or refining the policy structure.

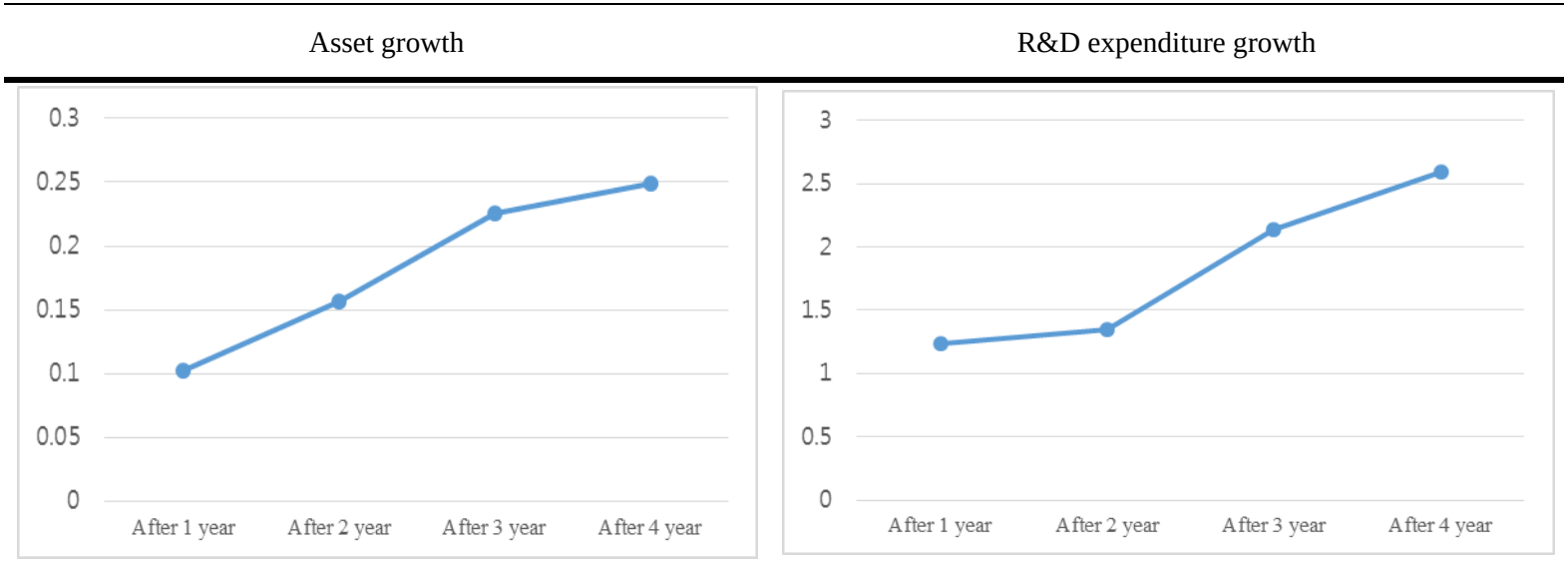


Figure 12. Complementarity effect of the sequential support in venture certification

Chapter 7. Concluding Remarks

7.1 Summary and policy implications

In this paper, we have tried to investigate the complementarity effect occurring between policies in the innovation policy field. In particular, breaking away from the normative approaches of previous discussion, the economic concept and methodology are applied for the analysis. For this, a variety of analyses have been performed in the respect of the overlapped, repetitive, and sequential support. Through these analyses, we sought to draw an objective and general conclusion with regard to the innovation policy field. This paper can be summarized as follows.

In chapter 2, the concept of policy mix, which has been discussed in the field of economics, is demonstrated, and the reason why this concept has to be applied for innovation policy field is discussed. Subsequently, based on economic theory, we also sought to explain why the interaction between policies occurs. In particular, we suggested how to derive the complementarity effect in innovation policy. Finally, a theoretical framework for the policy interaction occurring from policy mix has been proposed, and the analysis framework for the complementarity effect of innovation policy has been also suggested.

In chapter 3, the varied econometric methodologies for the policy evaluation were summarized, and the advantages and disadvantages of these methodologies were also introduced. In particular, the detail description about the matching method, which is used

in this paper, was included, and the reason why the matching method was chosen for the analysis of the complementarity effect was also discussed. Consequently, it was found that the matching method is the most useful method to solve the selection bias problem, and it also can be the best choice for estimating the complementarity effect.

In chapter 4, we outlined and estimated the complementarity effect of overlapped support of two different types of innovation policy (guarantee and certification) on firm performance in the short- and long-term. It was found that whether overlapped support to a firm achieves synergy or not is determined according to types of innovation. The most important factor affecting existence of complementarity effect is the type of innovation implemented. Given that two different certification policies (venture certification and Inno-Biz) have the same policy goal and share the same targeting group in fact, it is reasonable that we could not find a synergy effect between these innovation policies. However, in the case of circumstances where different goals and targeting groups are implemented (like credit guarantee and technology guarantee), overlapped supports of innovation policy may create a synergy effect. Therefore, the results suggest existence of synergy between policies is affected and decided by characteristics of innovation policy implemented by a policy maker. From what has been discussed in chapter 4, we can conclude that we cannot simply say that overlapped support in innovation field is effective or not, since it is affected by parallelism of different policies. As for the analysis in chapter 4, we found that guarantee policy represented a complementarity effect on firm growth in the long term, while certification policy showed a negative complementarity

effect in every performance dimension. Our interpretation could be a rational explanation in this case; however, we need to be careful in generalization of interpretation. In addition, the examination of complementarity effect on a great variety of innovation policies remains as a matter to be discussed further.

In chapter 5, we have investigated the effects of repetitive supports on performance of firms. To analyze this, the credit guarantee funds, the technology guaranteed funds, and the venture certification program were considered. The interpretations of results can be summarized as follows. Firstly, it was revealed that overlapped supports by policy instruments have positive impacts on the performance of firms, especially in terms of the increase of sales and assets. This means that repetitive supports for firms have a great, positive influence on firms' capabilities for raising funds. In addition, we found that firms that benefited from supportive instruments show superior performance compared to those excluded from those supports. Secondly, it was found out that effects of repetitive supports on the performance of firms decline as repetition number increases. While effects of supports at a single time or twice in consecutive order showed increasing tendencies, those more than three consecutive times show insignificant impacts on the performance of firms. To be specific, for the increase rate of sales and assets, it was found that impacts of repetitive support increase steadily until two or three years after supports provided to firms, and that there is a slowdown from the four years after supports provided to firms, regardless of types of policy instruments. Given these results, it could be generalized that repetitive supports by the government wields great influence upon

short-term performance and growth of firms, and its effects tend to decline as time passes. Therefore, the government should think of other policy instruments targeted to beneficiary firms who have already received repetitive supports for coordinating the distribution of benefits.

In chapter 6, the complementarity effect of sequential support in innovation policy is analyzed based on the firms that received the sequential support from government. The venture certification of the Korea government can be a useful example for the analysis of sequential support. The results describe that the sequential support in innovation policy had positive effects on the firm’s growth and the improvement of firm’s innovative capacity (i.e., assets and R&D expenditure). That is, if the policy sequence is constructed properly by policy makers, the effect of policy can be much greater. These results accord with the argument of Gunningham and Sinclair (1999) and Pralle (2006). Moreover, a more interesting point can be seen by comparing this with the results of chapter 5. The results indicate that the sequential support of heterogeneous policy is much more effective on the firm's growth than the repetitive support of the same policy.

7.2 Significance and limitation of study, future research

When comparing with the previous studies, this paper about the study on the complementarity effect of overlapped, repetitive and sequential support has the uniqueness in respect with followings. First, previous studies on innovation policy have focused on the evaluation of single policy. However, in this paper, based on the concept

of policy mix which is mentioned in previous economics, a theoretical framework about interaction and complementarity effects were suggested. Second, a variety of impact assessment methodologies which are discussed in economics were contemplated, and the most proper method were suggested for the objective and quantitative policy evaluation. Finally, various application studies to the complementarity effect were performed, and a variety of implications for policy maker was also suggested, i.e. in terms of overlapped, repetitive, and sequential support. This approach is a new approach for policy evaluation in innovation policy field.Even though these uniqueness of this paper, there are some limitations in this paper. First, the scope of policy classification which is suggested in this paper is too wide. In chapter 2, it is mentioned that one policy can be classified by four standards. i.e. policy goal, implementation approach, targeting group and governance group. However, it is difficult to analyze precisely the policy interaction through only these classification system. Therefore, it is required to subdivide the policy characteristics at the future study, and more various policy implications can be deduced through this framework. Second, the firm data which is used in this analysis doesn't include all firms in Korea. Therefore, it is necessary to obtain the data which have all Korean firms' information, and reanalyze using this data. Lastly, more application analyses are needed, and more policy implications are required to be suggested to policy makers. As can be seen in Gunningham and Sinclair (1999), the analysis results according to various policy mix have to be summarized. If so, more practical implications to policy makers can be provided, i.e. policy mix for the best effectiveness. Using the framework which is

suggested in this paper, various studies related to the complementarity effect occurred by policy interactions are expected to be performed at the future.

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Appendix 1. Regression results of complementarity effect according to repetitive support of KCGF

Sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_sinbo	0.049	***	0.083	***	0.103	***	0.107	***
Sales	-0.145	***	-0.202	***	-0.208	***	-0.233	***
Assets	0.116	***	0.140	***	0.136	***	0.156	***
Pro4	0.000	***	0.000	***	0.000	***	0.000	**
Wage	0.003		0.014	***	0.018	***	0.020	***
Worker	-0.002		-0.007		-0.003		-0.014	
Age	-0.114	***	-0.146	***	-0.176	***	-0.192	***
ROA	-0.001	*	-0.002	***	-0.003	***	-0.002	**
ROE	0.000		0.000		0.000		0.000	
R&D	0.000		0.001		0.003	**	0.005	***
Export	0.085	***	0.131	***	0.116	***	0.096	**
Reg2	0.017	*	0.058	***	0.082	***	0.086	***
Reg3	0.019		0.024		0.046	**	0.068	***
Reg4	0.008		0.034	***	0.073	***	0.090	***
Reg5	-0.002		-0.022		-0.053		-0.106	**
Constant	0.645	***	1.040	***	1.130	***	1.232	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Asset growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_sinbo	0.019	***	0.048	***	0.041	***	0.027	***
Sales	0.021	***	0.014	*	-0.005		-0.056	***
Assets	-0.114	***	-0.169	***	-0.145	***	-0.097	***
Pro4	0.000	***	0.000	***	0.000	***	0.000	*
Wage	0.031	***	0.054	***	0.058	***	0.059	***
Worker	0.007		0.007		-0.013		0.004	
Age	-0.048	***	-0.063	***	-0.065	***	-0.070	***
ROA	0.002	***	0.003	***	0.004	***	0.004	***
ROE	0.000		0.000		0.000		0.000	
R&D	0.004	***	0.005	***	0.005	***	0.004	***
Export	0.049	**	0.093	***	0.100	***	0.144	***
Reg2	-0.036	***	-0.055	***	-0.067	***	-0.085	***
Reg3	-0.028	***	-0.053	***	-0.051	***	-0.082	***
Reg4	-0.001		0.006		0.008		-0.010	
Reg5	-0.059	***	-0.097	***	-0.148	***	-0.147	***
Constant	1.109	***	1.722	***	1.713	***	1.765	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Worker growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_sinbo	0.000		0.001		0.004		-0.007	*
Sales	-0.004		-0.008		0.001		0.000	
Assets	0.008		0.006		-0.004		0.002	
Pro4	0.000		0.000		0.000		0.000	
Wage	0.000		0.005		0.002		0.001	
Worker	-0.005		-0.004		0.000		0.009	
Age	0.004		-0.007		-0.003		-0.010	
ROA	0.001	***	0.000		0.000		0.000	
ROE	0.000		0.000		0.000		0.000	
R&D	0.000		0.000		0.000		0.000	
Export	-0.001		-0.008		0.015		-0.008	
Reg2	0.000		-0.004		0.012		-0.004	
Reg3	-0.008		-0.003		0.011		0.021	
Reg4	-0.006		-0.011		-0.007		0.009	
Reg5	-0.013		-0.011		-0.007		-0.026	
Constant	-0.004		0.046		0.077		0.006	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D expenditure	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_sinbo	0.026		-0.009		0.046		-0.044	
Sales	-0.011		-0.041		-0.138	*	-0.073	
Assets	0.048		0.068		-0.045		-0.017	
Pro4	0.000		0.000	*	0.000	**	0.000	
Wage	0.019		0.022		0.156	***	0.056	
Worker	-0.046		-0.045		-0.052		-0.030	
Age	-0.004		0.017		0.054		-0.130	**
ROA	0.003		0.004		0.007		0.005	
ROE	0.000		0.000		0.000		0.000	
R&D	0.002		0.010		-0.010		0.012	
Export	0.049		0.237		0.208		0.052	
Reg2	-0.053		-0.096		0.029		0.244	
Reg3	-0.258	***	-0.168		-0.121		-0.332	*
Reg4	-0.002		-0.087		-0.107		-0.225	
Reg5	-0.105		-0.185		-0.319		-0.570	
Constant	-0.480		-0.390		1.097		1.255	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per worker	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_sinbo	0.003		-0.035	*	-0.016		-0.044	
Sales	-0.024		0.039	**	0.028		-0.073	
Assets	-0.052		-0.086	*	-0.100		-0.017	
Pro4	0.000		0.000		0.000		0.000	
Wage	0.032		0.050	*	0.052		0.056	
Worker	0.014		-0.021		0.085		-0.030	
Age	0.008		0.013		0.057		-0.130	**
ROA	-0.002		-0.002		0.000		0.005	
ROE	0.000		0.000		0.000	*	0.000	
R&D	0.000		0.004		-0.013		0.012	
Export	0.096		-0.147		0.005		0.052	
Reg2	0.024		0.159	**	0.018		0.244	
Reg3	0.030		0.004		0.022		-0.332	*
Reg4	0.043		0.041		0.120	*	-0.225	**
Reg5	-0.096		-0.092		-0.037		-0.570	
Constant	0.720	**	0.195		0.145		1.255	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_sinbo	0.003		0.026		-0.284		-0.044	
Sales	-0.024		0.364	*	-0.067		-0.073	
Assets	-0.052		-0.412	**	-1.281		-0.017	
Pro4	0.000		0.000		0.000		0.000	
Wage	0.032		-0.007		-0.533		0.056	
Worker	0.014		0.161		-0.675		-0.030	
Age	0.008		-0.048		-3.574	**	-0.130	**
ROA	-0.002		-0.080	***	-0.165		0.005	
ROE	0.000		0.000		0.001		0.000	
R&D	0.000		0.033		0.824	***	0.012	
Export	0.096		-1.022		-2.081		0.052	
Reg2	0.024		-0.080		-2.057		0.244	
Reg3	0.030		-0.129		-2.544		-0.332	*
Reg4	0.043		0.014		-1.173		-0.225	**
Reg5	-0.096		-1.081		-1.639		-0.570	
Constant	0.720	**	0.611		36.422	*	1.255	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Appendix 2. Regression results of complementarity effect according to repetitive support of KTFC

Sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_kibo	0.051	***	0.083	***	0.097	***	0.099	***
sales	-0.070	***	-0.078	***	-0.097	***	-0.109	***
age	-0.080	***	-0.096	***	-0.081	***	-0.085	***
ROA	-0.006	***	-0.008	***	-0.010	***	-0.010	***
ROE	0.000	***	0.000	***	0.000	*	0.000	
R&D	0.023	***	0.027	***	0.019		0.024	*
R&D per worker	-0.032	***	-0.038	***	-0.029	*	-0.035	*
R&D per sales	0.000	***	0.001	***	0.001	***	0.001	***
Export	0.122	***	0.199	***	0.241	***	0.241	***
Reg2	-0.008		-0.022		-0.025		-0.041	
Reg3	-0.036	*	-0.046	*	-0.081	**	-0.064	*
Reg4	-0.016		-0.002		-0.006		-0.008	
Reg5	-0.014		-0.051		-0.048		-0.081	
Constant	1.231	***	1.350	***	1.591	***	1.779	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Asset growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_kibo	0.017	***	0.046	***	0.044	***	0.030	***
sales	-0.014	***	-0.023	***	-0.017	**	-0.034	***
age	-0.066	***	-0.085	***	-0.076	***	-0.047	***
ROA	0.005	***	0.007	***	0.003	***	0.003	***
ROE	0.000	***	0.000	**	0.000	**	0.000	
R&D	-0.002		-0.007		-0.005		0.008	
R&D per worker	0.000		0.006		0.001		-0.014	
R&D per sales	0.000	**	0.000	*	0.000		0.000	
Export	0.053	**	0.106	***	0.166	***	0.100	**
Reg2	-0.059	***	-0.097	***	-0.140	***	-0.127	***
Reg3	-0.097	***	-0.177	***	-0.226	***	-0.250	***
Reg4	-0.073	***	-0.115	***	-0.134	***	-0.145	***
Reg5	-0.088	***	-0.151	***	-0.222	***	-0.222	***
Constant	0.451	***	0.613	***	0.547	***	0.782	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Worker growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_kibo	0.002		-0.006		-0.016	**	0.002	
sales	-0.002		-0.004		0.001		0.005	
age	-0.003		-0.004		0.003		-0.007	
ROA	0.000		0.000		0.000		0.000	
ROE	0.000		0.000		0.000		0.000	
R&D	0.005		-0.001		-0.005		0.000	
R&D per worker	-0.007		0.002		0.008		-0.003	
R&D per sales	0.000		0.000		0.000		0.000	
Export	0.009		0.022		0.003		-0.025	
Reg2	-0.002		-0.002		-0.005		-0.018	
Reg3	-0.009		-0.003		-0.012		0.025	
Reg4	-0.007		-0.002		-0.030	**	0.004	
Reg5	-0.024		-0.024		-0.091		0.026	
Constant	0.042		0.103		0.041		0.001	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D expenditure	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_kibo	0.109	**	0.014	**	0.015		-0.023	
sales	-0.060		0.001		-0.099	*	0.086	
age	0.005		-0.054		-0.025		-0.132	
ROA	0.006	*	-0.005	*	0.000		-0.002	
ROE	0.000		0.000		0.000		0.000	
R&D	0.021		0.153	**	-0.076		0.124	
R&D per worker	0.009		-0.236	**	0.124		-0.149	
R&D per sales	0.000		0.001	***	0.000		0.010	
Export	0.002		0.109		0.398		-0.244	
Reg2	0.072		0.163		0.021		-0.019	
Reg3	-0.137		0.300		0.095		-0.728	***
Reg4	-0.100		-0.128		-0.040		-0.104	
Reg5	-0.256		0.076		0.080		-1.426	**
Constant	1.288	**	0.686	**	2.213	***	-0.220	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per worker	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_kibo	0.027		0.029		0.013		0.112	*
sales	0.035		0.022		0.049		0.015	
age	-0.077	*	-0.025		-0.048		0.092	
ROA	-0.001		0.003		0.004		0.006	
ROE	0.000		0.000		0.000		0.000	
R&D	0.039		0.042		-0.018		-0.042	
R&D per worker	-0.058		-0.047		0.013		0.086	
R&D per sales	0.000		0.000		0.009		0.000	
Export	0.010		-0.067		0.215		-0.343	
Reg2	-0.212	**	0.118		-0.252	*	-0.064	
Reg3	-0.138		0.134		0.048		0.076	
Reg4	-0.019		0.033		-0.020		0.050	
Reg5	0.046		-0.201		-0.010		-0.151	
Constant	0.013		0.063		-0.149		-0.063	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_kibo	2.205		-0.290		2.244		1.733	
sales	-0.732		-0.758		0.684		0.431	
age	-0.203		-4.857	*	0.562		-0.037	
ROA	-0.142		0.144		0.022		-0.085	
ROE	0.000		0.011	***	0.000		0.001	
R&D	1.350		0.179		0.484		1.104	
R&D per worker	-1.461		0.002		-0.523		-1.534	
R&D per sales	-0.005		0.000		0.001		0.009	
Export	1.469		0.889		0.211		0.330	
Reg2	-12.156	**	5.810		0.055		-0.067	
Reg3	1.023		3.895		-0.103		-0.542	
Reg4	-5.279		-5.434		2.612		-10.181	
Reg5	0.686		4.932		5.888		0.021	
Constant	8.430		17.802		-17.851		-8.343	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Appendix 3. Regression results of complementarity effect according to repetitive support of Venture certification

Sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_certification	0.033	***	0.078	***	0.089	***	0.094	***
Sales	-0.108	***	-0.205	***	-0.227	***	-0.236	***
Assets	0.059	***	0.097	***	0.085	***	0.082	***
Pro4	0.000	**	0.000	***	0.000	***	0.000	*
Wage	-0.004		0.009		0.023		0.026	
Worker	0.053	***	0.088	***	0.091	***	0.084	***
Age	-0.045	***	-0.070	***	-0.096	***	-0.114	***
ROA	0.000		0.002		-0.001		-0.003	
ROE	0.000	**	0.000	**	0.000	*	0.000	
R&D	-0.002		-0.003		-0.003		-0.002	
Export	0.020		-0.002		0.054		0.073	
Reg2	0.040		0.032		0.048		0.079	
Reg3	0.007		0.078	*	0.135	**	0.168	***
Reg4	0.034	*	0.056	**	0.105	***	0.138	***
Reg5	-0.170	***	-0.239	***	-0.039		-0.018	
Constant	0.740	***	1.374	***	1.742	***	1.963	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Asset growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_certification	0.027	***	0.023	***	0.016		0.015	
Sales	0.081	***	0.111	***	0.113	***	0.119	***
Assets	-0.154	***	-0.231	***	-0.263	***	-0.247	***
Pro4	0.000		0.000	**	0.000		0.000	
Wage	0.016	*	0.032	**	0.045	***	0.033	*
Worker	0.031	***	0.060	***	0.062	***	0.037	
Age	-0.101	***	-0.133	***	-0.142	***	-0.108	***
ROA	0.004	***	0.005	***	0.006	***	0.005	***
ROE	0.000		0.000		0.000		0.000	
R&D	0.004	***	0.005	***	0.002		0.000	
Export	0.057	**	0.081	**	0.118	***	0.201	***
Reg2	0.016		0.044	*	0.085	***	0.064	*
Reg3	-0.015		0.018		-0.016		-0.029	
Reg4	-0.001		-0.012		0.040		0.028	
Reg5	-0.044		-0.042		0.030		0.083	
Constant	1.018	***	1.557	***	1.899	***	1.792	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Worker growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_certification	0.003		0.013		-0.015		0.016	
Sales	0.006		0.016		-0.002		0.001	
Assets	-0.011		-0.024		0.020		0.016	
Pro4	0.000		0.000		0.000		0.000	
Wage	0.003		-0.019		-0.005		-0.011	
Worker	0.008		0.025		-0.020		0.010	
Age	0.005		0.017		-0.010		-0.002	
ROA	0.000		0.000		-0.004	**	0.001	
ROE	0.000		0.000		0.000	*	0.000	
R&D	0.000		-0.001		-0.001		-0.002	
Export	-0.025		0.056		0.031		-0.027	
Reg2	-0.003		0.070	**	0.009		0.044	
Reg3	0.012		0.046		0.035		-0.041	
Reg4	-0.007		0.020		-0.024		-0.025	
Reg5	-0.113	*	0.012		0.013		0.163	
Constant	0.039		0.276	*	0.004		-0.010	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D expenditure	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_certification	-0.018		-0.242		0.345	**	-0.267	*
Sales	0.044		-0.226		0.214		-0.303	
Assets	-0.012		0.194		-0.047		0.099	
Pro4	0.000		0.000		0.000	*	0.000	
Wage	0.031		0.029		-0.048		0.032	
Worker	-0.035		-0.135		0.052		0.156	
Age	-0.165		0.049		0.075		0.091	
ROA	0.019		0.043	***	0.035	**	-0.006	
ROE	0.000		-0.001		0.000		0.001	
R&D	0.002		0.021		-0.039	**	0.024	
Export	-0.183		1.065	**	0.671		-0.486	
Reg2	-0.543	**	-0.758	**	0.376		-0.209	
Reg3	-0.147		-0.734	*	-0.135		0.546	
Reg4	-0.282		-0.353	*	-0.323		0.072	
Reg5	-1.337		0.361		-1.599		2.637	*
Constant	1.375		2.976	*	0.270		4.912	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per worker	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_certification	-0.022		-0.031		-0.181		-0.066	
Sales	-0.129		-0.095		0.008		-0.068	
Assets	0.162		-0.070		0.377	**	-0.069	
Pro4	0.000		0.000		0.000		0.000	
Wage	-0.058		0.028		-0.201	*	0.111	
Worker	0.204	*	0.036		-0.069		-0.082	
Age	-0.105		-0.079		0.009		-0.032	
ROA	-0.006		-0.004		0.022	**	-0.006	
ROE	0.000		0.000		-0.001		-0.001	
R&D	-0.023	*	0.020		0.015		0.013	
Export	-0.280		0.189		-1.266	***	0.438	
Reg2	0.069		0.642	***	-0.061		0.011	
Reg3	-0.102		0.093		0.290		-0.276	
Reg4	-0.108		-0.018		0.076		0.004	
Reg5	-1.453	**	-0.932		-0.238		0.097	
Constant	1.160		3.891	***	-1.535		3.040	**

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
No_certification	-5.036		0.550		-3.357		4.659	**
Sales	0.655		-3.765		0.523		2.271	
Assets	5.506		4.760		-2.729		-3.090	
Pro4	0.000		0.000		0.000		0.000	
Wage	-3.455		-1.756		2.722		-1.887	
Worker	0.301		-1.310		-3.308		2.013	
Age	1.203		1.054		-1.227		3.026	
ROA	0.124		0.243		0.189		0.038	
ROE	0.005		-0.007		-0.003		0.000	
R&D	-0.948		0.489		0.536	*	-0.044	
Export	-4.016		5.998		5.960		2.062	
Reg2	43.460	***	-8.157		1.094		5.338	
Reg3	3.341		18.114	**	-0.324		5.846	
Reg4	-7.413		3.856		0.871		4.761	
Reg5	-8.326		2.077		7.419		8.121	
Constant	-52.160		2.907		10.548		16.171	

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Appendix 4. Regression results of complementarity effect according to sequential support

Sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Dummy_kibo	0.031		-0.046		-0.001		0.060	
Sales	-0.191	***	-0.265	***	-0.321	***	-0.388	***
Age	-0.025		-0.051	**	-0.055	**	-0.055	**
R&D	-0.006		-0.012	***	-0.012	***	-0.002	
Export	0.251	*	0.126		0.166		0.010	
Reg2	-0.102		-0.212	***	-0.041		0.008	
Reg3	0.035		-0.004		0.013		0.022	
Reg4	0.048		0.050		-0.003		0.034	
Reg5	-0.153		-0.171		-0.284		-0.260	
Di1	0.059		0.047		0.082		0.068	
Di2	0.134	*	0.231	***	0.259	***	0.260	***
Di3	0.023		0.059		0.177	***	0.143	**
constant	2.906	***	4.061	***	4.876	***	5.844	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Asset growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Dummy_kibo	0.102	***	0.156	***	0.226	***	0.249	***
Sales	-0.029	***	-0.053	***	-0.107	***	-0.127	***
Age	-0.018		-0.025		-0.086	***	-0.110	***
R&D	-0.002		-0.006	*	-0.006	*	-0.006	
Export	0.136	*	0.081		0.077		-0.022	
Reg2	-0.012		0.022		0.081		0.145	*
Reg3	0.057		-0.017		0.015		0.129	
Reg4	-0.026		-0.065		-0.095	*	-0.072	
Reg5	-0.028		-0.084		-0.001		0.074	
Di1	0.032		0.116	*	-0.023		-0.050	
Di2	-0.077	**	0.029		0.145	**	0.089	
Di3	0.007		0.109	***	0.146	***	0.145	***
constant	0.702	***	1.134	***	2.020	***	2.355	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Worker growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Dummy_kibo	-0.009		0.156	***	0.066		0.113	*
Sales	0.002		0.010		-0.003		-0.022	
Age	0.000		0.012		0.004		-0.002	
R&D	-0.009	***	-0.006		0.001		-0.007	
Export	0.067		-0.146		0.113		0.123	
Reg2	0.002		0.006		-0.042		0.019	
Reg3	0.098	*	0.072		0.132		0.187	**
Reg4	0.040		0.054		0.021		0.014	
Reg5	-0.057		0.159		-0.125		0.159	
Di1	-0.006		-0.059		-0.034		0.016	
Di2	0.035		-0.002		0.007		0.045	
Di3	-0.030		-0.056		0.006		0.011	
constant	0.104		-0.003		0.222		0.548	**

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D expenditure	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Dummy_kibo	1.237	***	1.351	***	2.134	***	2.596	***
Sales	-0.306	***	-0.264	**	-0.344	***	-0.413	***
Age	0.150		-0.088		0.107		-0.204	
R&D	-0.445	***	-0.576	***	-0.583	***	-0.605	***
Export	1.534	*	2.059	**	1.776	**	1.130	
Reg2	0.334		0.650		1.081	**	1.330	**
Reg3	-0.611		-0.529		-0.584		-0.671	
Reg4	-0.561		-0.882	**	-0.752	*	-0.201	
Reg5	0.191		-0.638		-0.997		-0.270	
Di1	-2.366	***	-3.185	***	-2.241	***	-2.295	***
Di2	-2.357	***	-2.717	***	-3.046	***	-3.006	***
Di3	-1.451	***	-1.323	***	-0.748	**	-0.785	**
constant	9.635	***	11.349	***	12.476	***	14.435	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per worker	1 year after		2 year after		3 year after		4 year after	
growth	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Dummy_kibo	19.654		11.778		-49.298	***	-8.570	
Sales	6.668		-2.996		-2.673		21.223	***
Age	-0.370		-3.225		0.929		-2.699	
R&D	0.458		-1.274		-2.821	*	-4.373	***
Export	4.000		25.875		3.643		-0.539	
Reg2	6.182		18.945		10.498		18.124	
Reg3	3.181		4.232		19.218		16.625	
Reg4	-20.222		21.293		12.033		16.733	
Reg5	15.902		12.253		6.611		65.963	
Di1	9.560		9.388		5.941		-13.455	
Di2	-4.624		-12.128		-14.738		-31.743	*
Di3	14.433		2.783		-16.002		-17.135	
constant	-103.369		46.764		47.061		-265.138	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

R&D per sales growth	1 year after		2 year after		3 year after		4 year after	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Dummy_kibo	-8.471		-41.591	*	-23.478		-8.570	
Sales	-11.797		-6.505		0.621		21.223	***
Age	2.223		-0.526		-1.639		-2.699	
R&D	-3.056		-1.206		-2.022		-4.373	***
Export	7.533		8.960		-4.367		-0.539	
Reg2	-19.507		110.801	***	-13.964		18.124	
Reg3	3.474		-15.623		-32.312		16.625	
Reg4	-9.474		-13.021		-21.959		16.733	
Reg5	-169.091		-7.995		10.083		65.963	
Di1	7.171		-11.756		-5.265		-13.455	
Di2	-4.751		-7.694		35.875		-31.743	*
Di3	14.291		19.472		-2.197		-17.135	
constant	179.251		115.017		25.097		-265.138	***

The ***, ** and * indicate the 1%, 5% and 10% levels of significance

Abstract (Korean)

혁신활동은 기업의 성장에 중요한 요소 중 하나이며, 이러한 기업의 혁신 활동을 지원하기 위해 정부는 다양한 정책을 시행하고 있다. 이처럼 정부가 기업의 혁신활동을 위해 다양한 정책을 시행하는 것에는 다음과 같은 당위성이 있다. 우선 혁신은 spillover의 특성이 있기 때문에 혁신 활동을 시장에만 맡겨놓는다면 당연히 사회적 최적값보다 낮은 혁신이 발생하게 되는데 이러한 문제를 해결하기 위해 정부는 혁신 활동을 지원해야 한다. 또 다른 문제는 투자자와 기업가 사이에 발생하는 정보의 차이로 인해 발생하는 “레몬 시장”의 문제이다. 즉, 자본 시장의 정보의 비대칭성으로 인해 자본의 한계 비용은 더 높아지게 되고, 외부 투자자들이 기업의 혁신활동에 투자하려는 유인은 줄어드는 문제가 발생한다는 것이다. 이러한 spillover 현상과 “레몬 시장”의 문제로 인해 기업은 정상적인 혁신활동을 영위하는 것에 실패할 수 있는데, 이를 해결하기 위해 정부가 시장에 개입하여 정보가 비대칭적인 현상을 바로잡고 시장의 불확실성을 해소할 필요성이 있다. 이러한 정부의 개입이 잘 작동된다면 기업의 혁신 활동이 위축되는 현상을 극복할 수 있다.

이와 같은 이유로 정부는 다양한 혁신 정책을 시행하고 있으며, 이러한 혁신 정책의 지원을 받은 기업들의 성과 평가에 대한 논의가 활발하게 이루어지고 있다. 왜냐하면 정부의 혁신 정책들이 적절한 역할을 수행하고 있는가를 평가하는 것은 매우 중요하기 때문이다. 이러한 정책 평가 연구에는 단일 정책이 그 정책의 목표에 부합하는 효과를 보였는가에 대한 연구뿐 만 아니라

특정 상황에서 어떤 정책이 더 효과적으로 작동할 것인가와 같은 논의들도 포함된다. 하지만 모든 정책이 다른 정책들과의 관계 속에서 차별적이고 배타적으로 역할을 수행하고 있다고 말할 수 없다. 따라서 하나의 정책이 정확하게 평가되기 위해서는 다른 정책들과의 상호작용이 반드시 고려되어야 한다. 하지만 혁신 정책의 분야에 있어서 정책 수단간의 상호 관계에 대한 연구, 즉 여러 정책들이 동시다발적으로 시행되었을 때 나타날 수 있는 상호 보완 효과에 대한 논의가 많이 부족한 편이다. 따라서 본 논문에서는 그 동안 실제 정책 현상에서 차지하는 비중이 충분함에도 불구하고 논의되지 못했던 혁신 정책에서의 policy mix와 상호작용, 그리고 그에 따른 보완 효과에 대한 연구를 수행하였다. 이를 위해서 혁신 정책에서 발생할 수 있는 다양한 정책 간 상호작용에 대한 이론적 분석틀을 기존의 경제학적 개념을 통해 제시하고, 이로부터 발생하는 정책의 보완 효과에 대한 논의를 진행하였다.

정부의 정책을 평가함에 있어서 다양한 방법이 경제학적 논의를 통해 제시되어 왔는데, 본 논문에서는 이러한 다양한 방법론 중에서 매칭 방법론을 활용하였다. 그 이유는 보완효과를 추정함에 있어서 매칭 방법이 가장 적합했기 때문이다. 특히, 본 논문에서는 성과 평가 시 발생할 수 있는 선택 편이를 해결하기 위해서 propensity score매칭과 multivariate 매칭을 동시에 고려한 모형을 활용하였다.

연구의 결과를 정리해보면 다음과 같다. 우선 정책이 단일 시점에서의 중복 지원이 발생한 경우 중복 지원되고 있는 정책이 서로 다른 특성을 갖는다면 그로 인해 양의 보완효과가 나타난 반면, 유사한 정책이 중복 지원된 경우

에는 음의 보완 효과가 나타나는 것으로 분석되었다. 이러한 결과를 통해 하나의 정책의 지원을 함에 있어서 그 혜택을 받게 될 기업의 현재 어떤 정책을 지원받고 있는가를 고려해야 하며, 성격이 유사한 정책이 중복적으로 지원되는 것은 바람직하지 못하다는 시사점을 얻을 수 있었다. 두 번째로 정책이 반복적으로 지원된 경우에 대한 분석 결과에서는 정책을 반복적으로 지원받은 기업들이 그렇지 않은 기업에 비해 좋은 성과를 보이는 것으로 나타났다. 하지만 그 반복 횟수가 증가함에 따라 그 효과가 정체되거나 감소하는 것으로 나타났다. 즉, 이는 정부가 정책을 지원할 때 지속성을 가지고 지원할 필요성은 있지만 그 반복이 너무 관성화되어 버리는 것은 바람직하지 못하다는 것을 의미하는 결과이며, 정책 입안자들에게는 하나의 정책을 지원하고 난 이후에 어떠한 방향성을 가지고 정책을 지원하는 것이 효율적일 것인가에 대한 시사점을 제시하는 결과이다. 마지막으로 순차 지원의 경우에서는 정부 정책을 순차적으로 지원받은 기업이 그렇지 않은 기업에 비해 자금 조달능력이나 혁신 역량에서 더 우월한 성과를 내고 있는 것으로 나타났다. 이는 서로 다른 정부의 혁신 정책이 잘 구성되어 연계된다면 정책의 효과가 더 커질 수 있음을 보여주는 결과이며, 정책 입안자들이 정책의 지원을 받은 기업을 선정할 때 그 기업이 과거에 어떠한 정책의 지원을 받았는가에 대해 고려할 필요성이 있다는 것을 의미한다. 이처럼 세 분석 결과를 종합해보면 정부가 정책을 고안할 때에는 하나의 정책이 시행되는 시점을 기준으로 과거, 현재, 미래를 모두 감안해야 한다는 당위성을 보여주는 결과라고 할 수 있다.

본 연구는 기존의 문헌들과 다음과 같은 차별성을 가지고 있다. 우선, 단일

정책의 효과에 대한 연구들이 주를 이루고 있던 기존의 연구들과는 달리 기존의 경제학에서 언급되고 있는 policy mix의 개념을 바탕으로 혁신 정책에서도 정책 간 상호작용이 중요하다는 것과 정책의 특성을 분류할 수 있는 새로운 틀을 제시하였다. 두 번째로 기존의 경제학 연구에서 혁신 정책의 성과를 평가하는 다양한 방법론들에 대한 고찰을 통해 정책의 성과 평가에 있어서 더 정확한 결과를 도출할 수 있는 방법론을 정립하였다. 마지막으로 정책의 상호작용이 일어날 수 있는 다양한 경우에 대해 분석을 수행함으로써 일반적인 결론을 도출하였으며, 이러한 결과를 바탕으로 혁신 정책을 시행하고 있는 정책입안자들에게 다양한 시사점을 제시하였다.

주요어 : Policy mix, 보완효과, 매칭, 정책의 중복지원, 정책의 반복지원, 정책의 순차지원

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