Ph. D. Dissertation in Engineering

The Effects of Innovation Strategy and Policy on Product Innovation Performance and Technology Entrepreneurship

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Abstract

The Effects of Innovation Strategy and Policy on Product Innovation Performance and Technology Entrepreneurship

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This dissertation consists of two essays on the effects of innovation strategy and policy on technology commercialization performance. Innovation is regarded as one of the important determinants for national economic growth. Stimulating innovation performance requires not only the implementation of an innovation policy at national level but also an innovation strategy at the firm level.

The first essay assessed the effect of the simultaneous implementation of different intellectual property protection methods (IPPMs) on a firm's product innovation performance. Seven widely used intellectual property protection methods in the

manufacturing industries are grouped into two categories – formal and informal. Complementary effect is then tested within and between the two groups. An additional analysis on the moderating role of the industrial complexity in terms of technology on the complementary effect of intellectual property protection methods on product innovation performance is also conducted. The data of 1297 manufacturing firms analyzed in the first essay is from Korean Innovation Survey (KIS) 2010. Throughout the cross-sectional tobit-regression, 'within group' complementary effects are revealed in both formal and informal groups of IPPMs. On the other hand, the result of testing 'between groups' effects of IPPMs differs by the level of industrial technological complexity. Implementing IPPMs from two different groups are in a relation of complementarity when industrial technology is complex and of substitution when industrial technology is discrete (or simple).

The second essay investigates the relationship among market failure, national culture, government intervention, and technology entrepreneurship. Market failure in entrepreneurship market has been regarded as a justification for government intervention in the shape of policy. It has been also emphasized that the accordance with not only economic aspects, but also national context is important in framing the technology entrepreneurship policy. To find out the effectiveness of the government intervention, direct effect of market failure, national culture, and government intervention on technology entrepreneurial activity is analyzed by using panel data of 49 countries from 2007 to 2013. Indirect effect of government intervention is then tested to reveal the

moderating role of the policy on the effect of market failure and national culture on technology entrepreneurship. By conducting random effect model analysis on panel data of 199 observations, three main findings are obtained. First, information asymmetry affects technology entrepreneurship and its effect varies by the novelty of the technology involved. Second, individualism has a negative effect on technology entrepreneurial activity level. Last, government intervention has both direct and indirect effect on technology entrepreneurship, but the effect varies according to the characteristic of government intervention.

Keywords: intellectual property protection method, product innovation performance, market failure, national culture, government intervention, technology entrepreneurship

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Introduction

Innovation is regarded as one of the important determinants for national economic growth. Rather than inventing technology, it is more important to commercialize the invented technology in terms of economic benefit that is directly connected to economic growth. To stimulate commercialization performance, it is required to shed on not only innovation policy at the national level but also innovation strategy at the firm level simultaneously. At the firm level, the crucial determinants of most manufacturing firms' success in the market is not only the success of introducing innovative products in the market that satisfy or even create market needs, but also the sustainability of the rents from the new products introduced. Allowing competitors to imitate product or processes will result in a loss of market share (Teece, 1986), and Intellectual property protection methods can prevent the competitors from stealing the deserved profit from an innovative activity (Levin et al., 1987).

Some of the previous researcher have emphasized the use of multiple intellectual property protection methods since it is rarely possible to protect all the technologies and the products launched with a single method (Cohen et al., 2000; Levin et al., 1987). However, the effectiveness of the intellectual property protection methods varies according to the complexity of the product in terms of the technology involved. In discrete technological industries, imitation is relatively easier and a single formal method such as patenting is sufficiently powerful to protect the innovative product. In complex technological industries, however, even a single product usually consists of several innovations that need to be protected and preventing imitation by implementing a formal protection method solely is not as effective as in discrete industry.

Technology commercialization performance is also crucial for the national economic growth. For large firms, who find it less difficult to retain technology, human capital, and the resources, commercializing the technologies is much easier than it is for the small- and medium-sized firms, especially for new entrants. Lacking of resources, facing greater uncertainty and risk, and imperfect competitiveness in the market makes it difficult for the inventors or the prospective entrepreneurs to start their own business, resulting in the underperformance of technology entrepreneurship called market failure. Market failure gives the justification for a government to intervene, according to the followers of the institution theory. Government intervention, however, should be implemented with care since the effect on technology entrepreneurship varies according to external factors such as national context, level of economic development, and the characteristic of the technology involved.

In Essay I, the combination effects of intellectual property protection methods on product innovation performance are tested to ascertain whether those effects are complementary or substitutive. The difference in the combination effects due to the technology complexity level of industries is also investigated. Firm-level data for the analysis are obtained from the 2010 Korean Innovation Survey (KIS): The manufacturing Sector, conducted by the Science and Technology Policy Institute (STEPI, 2010). Industry-level data for the technological complexity, 'Triple', which shares the concept of patent-thicket is used to enables a quantitative research on the level of technological complexity of the industries (von Graevenitz, 2011).

In Essay II, the effect of information asymmetry, which is regarded as the most influential factor for underinvestment, and the effect of national culture, which explains the attitudes and the behavior of the members in the society, on technology entrepreneurship are investigated. Government intervention is able to affect technology entrepreneurial activity level both directly and indirectly. To measure the indirect effect of government intervention, interacting terms with information asymmetry and national culture are also tested to find out the moderating roles of government intervention. The annual data related to entrepreneurship are retrieved from the annual survey called Global Entrepreneurship Monitors (GEM) project. Standard deviations of market-adjusted stock returns are calculated for each country and are used as the proxies for information asymmetry. The stock data are obtained from the database called Datastream. The level of economic development is measured by GDP per capita and the data are from the World Bank database.

Essay I　The Complementary effects of intellectual property protection methods on product innovation performance and the moderating role of industrial technological complexity

1. Introduction

One of the crucial determinants of most manufacturing firms' success in the market is the manufacture of innovative products that satisfy or even create market needs. Successfully bringing these products to the market, however, is not sufficient. Market profit earned from a newly launched product must be sustained for a sufficient duration to be called a "real success." The hyena, seeking to scavenge delectable food, always exists in the market. As soon as a firm introduces an innovative product to the market (or sometimes even before the product launch), incumbent firms or prospective competitors begin to imitate. Without the need to invest in Research and Development (R&D), there is a high probability that competitors will price replicas much lower than the original, and it is not difficult to predict a significant loss of market share (Teece, 1986). To prevent scavengers from stealing a firm's deserved profit from an innovative product, the firm must protect the knowledge or technologies related to the product; the tools used to do this are known as intellectual property (IP) protection methods (Levin et al., 1987).

Rapid changes in market needs and in technology have created a situation where few firms are able to respond successfully to shortened product life cycles individually. This fact has led to a paradigm change—from closed innovation to open innovation (Chesbrough, 2003a). Through technological cooperation, firms gain the ability to graft external resources onto their internal capabilities, leading to a reduction in R&D costs, increased diversification of market risk, and quicker response to market needs, enhancing firms' market power and competitiveness (Chesbrough, 2003b), Despite these great advantages of technological cooperation, the effectiveness of open innovation continues to be debated because of a fatal flaw—the knowledge leakage (Chesbrough, 2003b). The more a firm practices open innovation, the higher the chance of unintended outflow of internal knowledge or technology. Again, the importance of Intellectual property protection methods (IPPMs) comes to the forefront. These IPPMs are implemented solely or in combination in accordance with industrial characteristics, firm-specific characteristics, technology or innovation characteristics, and the cost incurred to maximize the product innovation performance (PIP).

The purpose of the present study was to clarify the effect of IP Strategies on a firm's PIP. The moderating influence of inter-industrial differences in terms of technological complexity on the effect of IP strategies was also studied. For the empirical analysis, seven widely-used IPPMs were categorized into two groups: formal and informal and the ‘within groups’ and ‘between groups’ combination effects were tested. Firm-level data for the analysis were obtained from the 2010 Korean Innovation Survey (KIS): The Manufacturing Sector, conducted by the Science and Technology Policy Institute (STEPI) (STEPI, 2010). To examine the inter-industrial difference in technological complexity, this study used “Triple” which enables quantitative research of industrial technological complexity (von Gravenitz et al., 2011). Given that the dependent variable, the percentage of sales from new products, is double-censored, Tobit regression methods were applied for the analysis.

The results showed that the use of multiple IPPMs from the same groups was positively more effective to the firm’s PIP than the use of single or no IPPMs, proving the ‘within groups’ complementary effect. It was also found that the IP protection tools from the two different groups are in a relation of complementarity when industrial technology is complex and of substitution when industrial technology is discrete or simple, confirming the moderating effect of inter-industrial differences in technological complexity.

This paper contributed academically in three ways: first, the combination effects of IPPMs were studied along with the industrial complexity in technology, which enabled the moderating effect of industrial technology complexity on the multi-use of IPPMs to be discovered empirically. Second, Continuous variable for technology complexity of industry has been used for the analysis. This made possible to find the range of the combination effect of IPPMs for all manufacturing industries. Finally, this paper did not focus on the determinants for the selection of IP protection strategies, but tried to show how the firm's IP protection strategies affected their PIP, which is relatively more direct and intuitive to demonstrate the effect of IP protection strategies.

2. Theoretical background

2.1. Single use of intellectual property protection method

An extensive body of literature has analyzed IP protection methods and their effectiveness. A focus on patents, the original statutory means of IP protection, has been dominant in past studies (Levin et al., 1987; Mansfield, 1986). Mansfield (1986) empirically studied the effectiveness of the patent system in 100 randomly selected manufacturing firms. The results demonstrated that although most firms used the patent system, it was not very effective in promoting innovation in most industries. In addition to Mansfield (1986), other previous investigations of the patent system raised suspicion regarding its theoretical role as an innovation motivator, and studies on non-statutory methods such as secrecy followed (Arora, 1997; Arundel, 2001; Cohen et al., 2000; Teece, 1986). Teece (1986) concluded that patents rarely provided sufficient protection because of upholding cost, the industrial aspect, and the modest cost of "inventing around" patents. Teece (1986) also argued that trade secrets could be a suitable alternative to patents in some industries where an innovative product is difficult to be invented around. Cohen et al. (2000) stated that, although patents had become more effective among larger firms since the early 1980s, non-statutory protection methods such as secrecies were emphasized more than patenting by the majority of manufacturing industries. Unsurprisingly, Arundel (2001) showed that a higher percentage of manufacturing firms preferred secrecies to patents. For small and innovative firms that are not capable of using non-statutory methods to sustain their rents, however, patents could be a profitable alternative. Holgersson (2013) also agreed on the effectiveness of patenting systems for small and medium-sized enterprises (SMEs). By conducting interviews on how patenting is used with 26 R&D managers and chief executive officers of SMEs, Holgersson (2013) showed that although patenting is of less importance in terms of protection among SMEs, it still plays crucial alternative roles for the growth and survival by attracting customers and investors. Taken together, these previous work agree that patents are ineffective, with some exceptions based on, for example, firm size and the characteristics of the innovation. Interestingly, most of these previous works have treated statutory and non-statutory methods as mutually exclusive alternatives; the simultaneous use of both types of protection methods has not been studied.

2.2. Multi-use of intellectual property protection methods

While the former researches have focused on the single use of IP protection methods, several articles have studied the use of multiple IP protection methods. Firms typically have more than one invention or new product, and even a single product consists of several IPs to be protected; therefore, it is hardly possible to protect all of them with a single method of protection, so firms tend to use multiple IP protection methods simultaneously (Arora, 1997; Cohen et al., 2000; Levin et al., 1987). By bundling various tools, researchers began to take note of the combination of methods, and especially of their complementary or substitutionary effects (Amara et al., 2008; Gallié and Legros, 2012; Graham and Somaya, 2006). Gallié and Legros (2012) conducted a correlation analysis of the selection of IP protection methods. They categorized seven different IP protection methods as statutory or non-statutory methods and tried to determine whether there was a complementary effect or a substitutionary effect within and between the two groups. They concluded that formal and informal IP protection methods were negatively correlated with each other, whereas there were positive correlations within both groups of methods. This finding showed that manufacturing firms experience a complementary effect when multiple IP protection means within the same group are implemented, but a substitutionary effect when multiple IP protection means between the two groups are implemented. Amara et al. (2008) estimated a multivariate probit model to assess whether there was a complementary effect when IP protection methods were used simultaneously. Similar to Gallié and Legros (2012), Amara et al. (2008) found complementarity within each group of IP protection methods and a relation of independency or substitutionary between the two groups. These two studies, however, focused on the selection of IP protection methods, which relied completely on the strategies of the manufacturing firms. In other words, these studies did not show how the firms' choices of IP protection methods affected their performance, a more direct way of demonstrating whether there is a complementary or substitutionary effect among the protection tools.

2.3. Determinants of intellectual property protection methods

In addition to confirming the effect of IP protection methods and their effects when implemented in combination, several previous studies have analyzed various factors that determine the choice of IP protection methods. Joo (2012) categorized the type of innovation by the level of newness, scope of newness, and lifetime of product innovation and investigated the effects of the characteristics of innovation on the selection of IP protection methods, while many studies have focused on the typical types of innovation: product innovation vs. process innovation. Alexy et al. (2009) proposed that IP strategy and open innovation strategy should be integrated and these strategies should be flexible, depending on the technological environment in which a firm is involved and the knowledge distribution among prospective partners. Laursen and Salter (2014) also focused on the relationship between IP strategy and open innovation strategy and empirically proved not only the existence of the relationship between breadth of external collaboration for innovation and the strength of a firm's IP strategy, but also the difference in strength of the relationship depending on the collaboration types. Manzini and Lazzarotti (2015) proposed that the selection of IP protection mechanisms (IPPM) should be carefully decided concerning different phases of the new product development (NPD), especially when NPD process is collaborative. Amara et al. (2008) stated that knowledge codification and output tangibility affected the selection of IP protection methods. Their study also revealed that firm size mattered for a firm's choice. Gallié and Legros (2012) found that type of innovation, market characteristics (such as a technology push or market pull situation), and firm-level characteristics (such as firm size, level of market share, R&D level, or group membership) influence the IP protection tools used. Porter and Siggelkow (2008) also focused on the firm-specific context, concluding that a firm's optimal IP protection strategies cannot be built without considering the firm's context. Veer et al. (2015) focused on the difference of the firm size, which is also one of the firm-specific contexts, proposing that the reaction to the product imitation differs by the size of the firm. Large firms, who possess sufficient resources to enforce IP rights, will implement more formal IP protection method to react the product imitation than SMEs (Veer et al., 2015). The findings of the studies described here, however, are limited to the selection of IP protection tools, lacking the additional investigation that could only be based on the empirical analysis of a firm's product innovation performance.

2.4. Industrial technological complexity

In addition to firm-specific characteristics, industry-specific characteristics should also have a major influence on the effect of IP protection tools and industrial technological complexity, one of the industry-specific determinants has been studied.

Cohen et al. (2000) defined complex technology industries as industries where a product protected by numerous patents. Discrete technology industries, on the other hands, is defined as industries where a product protected by relatively few patents. The key difference between a complex and a discrete technology is whether a new, commercializable product consists of numerous separately patentable elements or relatively few (Cohen et al., 2000).

The effectiveness of intellectual property protection methods varied by the level of industrial technological complexity has been studied. Harabi (1995) revealed differences in the effectiveness of the patent system by industry characteristics, concluding that variations between industries in terms of technological complexity determine the effectiveness of patents. In other words, the patent system is more effective when "inventing around" the patented innovation is difficult and less effective when “imitating” the patented innovation is difficult (Harabi, 1995). Cohen et al. (2000) also argued that differences in the effectiveness of statutory means of IP protection are caused by differences in technological complexity among industries. Cohen et al. (2000) concluded that patents are more effective when industrial technology is “discrete” or simple, whereas patents are less effective in “complex” industries. Although both Cohen et al. (2000) and Harabi (1995) attended to industrial complexity in technology, they only dealt with changes in the effects of individual IP protection methods; changes in the effects of IP protection methods used in combination have not been studied sufficiently.

3. Research framework

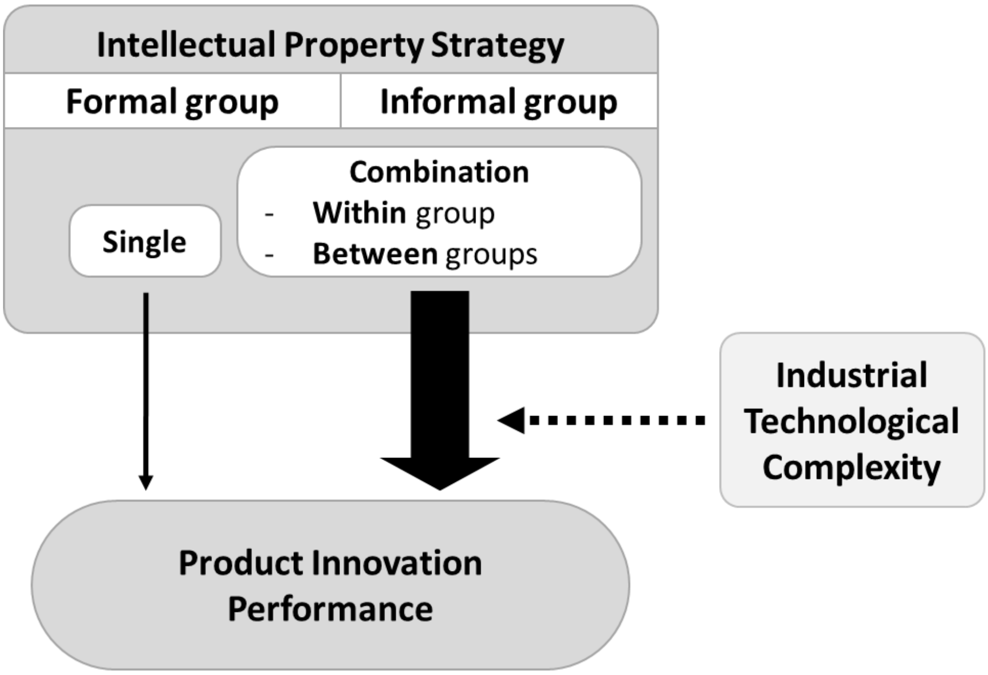

Figure I-1 Conceptual Model

3.1. Complementarity of intellectual property protection mechanisms

Several previous studies have investigated the combination effect of IP protection methods (Amara et al., 2008; Gallié and Legros, 2012; Graham and Somaya, 2006; Hussinger, 2006). Gallié and Legros (2012) showed complementarity within each group of IP protection methods, whereas independency or substitutionary relations exist between groups. Most manufacturing firms, however, have more than one innovative product in the market. Although there is variation by industry, even a single product in the market consists of several instances of IPs to be protected. Protecting all the IPs is rarely possible using a single type of protection method and it is necessary to implement several different types of IP protection means (Arora, 1997; Cohen et al., 2000; Levin et al., 1987). Thus, the use of multiple methods of IP protection will create positive synergy for product innovation performance, as Gallié and Legros (2012) have argued. For computer software, as an example, copyright, trademark, and patent are often used together (Graham and Somaya, 2006).

Although Gallié and Legros (2012) stated that there will be no complementary effect on the firm's product innovation performance, there are some industries where both informal and formal methods of IP protection are needed to sustain their rents. Secrecy can be used before the launching of the innovative product, and formal methods such as patents or trademark can be used after launching to the market (Teece, 1986). Relying on the patenting system to protect their core technology before launching may provide enough information about their new product to competitors to 'invent around'; therefore, implementing non-statutory means of protection before launching a new product can be more effective than statutory means (Teece, 1986).

Therefore, the multiple uses of any IP protection methods simultaneously will create complementarity, which has a positive effect on a firm's product innovation performance. The following hypothesis, thus, can be developed:

Hypothesis 1: There is a complementary effect of intellectual property protection methods on a firm's PIP

3.2. Inter-industrial difference in technological complexity

The complementarity of IP protection methods on a firm's product innovation performance varies by industry. In other words, implementing the same combination of IP protection means may give far different results, depending on the industrial characteristic. One of the crucial reasons for this is that each IP protection method plays a different role depending on industrial differences in technological complexity (Amara et al., 2008; Cohen et al., 2000; Harabi, 1995). Most previous researches, for example, showed that statutory means of IP protection are less effective in technologically complex industry but relatively more effective in discrete industry in terms of technology (Cohen et al., 2000;

Harabi, 1995).

The main reason for the difference in the effectiveness of formal IP protection methods is that firms implement IP protection tools for different purposes. In discrete industries, such as chemical or pharmaceutical industries, inventing around is far more difficult than copying (Cohen et al., 2000). In these industries, firms implement IP protection methods simply to prevent the development of substitutes by incumbents, and statutory IP protection tools are very effective by themselves. In this case, using informal IP protection tools, which are effective at preventing inventing around, along with formal tools could be redundant, because the additional protection effect offered by informal methods might be far less than the cost incurred, resulting in a decrease of the overall profit of the firm.

The role of formal IP protection methods is somewhat different in complex industry. In complex industry, the main purpose of implementing formal IP protection methods is not to block the appearance of substitutes, but to force the incumbents into negotiation (Cohen et al., 2000). Most products developed in complex industry are easily exposed to the danger of inventing around, so the protection effect of formal methods is very limited. In this case, additional informal protection methods that are effective at preventing inventing around should be implemented to supplement the limited protection effect of formal methods. In other words, using both formal and informal IP protection methods creates a synergy effect in IP protection.

Therefore, the complementarity effect of the use of multiple intellectual property protection methods from two different groups on a firm's product innovation performance will increase as industrial differences in complexity increases, and the following hypothesis can thus be developed:

Hypothesis 2: The complementarity of implementing both formal and informal IPPMs will be moderated by the technological complexity of the industries

4. Method

4.1. Data

The data used in this study were from the 2010 Korean Innovation Survey (KIS): The Manufacturing Sector (STEPI, 2010). The KIS 2010 was conducted by the Science and Technology Policy Institute (STEPI), which is a research institute funded by Korean government. In addition, the KIS 2010 was certified by Statistics Korea (the Korean official government statistical organization) and the method and types of questions in the survey followed the third edition of Organization for Economic Co-operation and Development's (OECD) Oslo Manual (STEPI, 2010; OECD, 2005). These facts made the KIS 2010 appropriate for the firm-level empirical analysis in Korea.

The KIS 2010 provides information about innovation of manufacturing firms in Korea. The KIS 2010 contains firm-level survey results related to the input and output of innovation activities from 2007 to 2009 (STEPI, 2010). The KIS 2010 subdivides innovation activities into four sections, which are product innovation, process innovation, organization innovation and marketing innovation. This article focused on the firm's product innovation activities, drawing upon several items from the KIS 2010's product innovation section, such as the usage of IPPMs as inputs of product innovation activity and the percentage of sales generated by new products as an output of product innovation activity (STEPI, 2010). The KIS 2010 also provides general information about Korean manufacturing firms, such as firm-year, R&D expenditure, and number of full-time researchers, which were used as control variables in this paper.

The study population of the KIS 2010 was 41,485 manufacturing firms established before 2007 with more than 10 employees. The sample was stratified by both two digits Korean Standard Industry Code (KSIC) and firm size (full-time employee). All firms with more than 300 employees were also extracted and in total, the sample of 7962 firms was extracted from the population. Responses were received from 3,925 sampled firms, yielding a response ratio of 51.03%. Among the firms responding, the present study included only those firms that conducted product innovation activities from 2007 to 2009, regardless of the success of their innovation activities. The number of firms conducted product innovation activities was 2332 firms and after excluding firms with incomplete information on the other variables, 1,297 firms were finally included in this statistical analysis.

4.2. Empirical model

The objective of the present study was to assess the complementarity effect of the use of multiple IPPMs on a firm's PIP and to investigate differences in this effect by the industrial complexity in technology. To achieve this objective, this article first assesses the complementarity of IPPMs using the Tobit regression model (Greene, 2003). For each firm, KIS 2010 provides the percentage of sales generated by new products, which is double-censored. Because of the dependent variable censored, the data causing censoring problems should be omitted to implement the ordinary least squares (OLS) method. In this case, sample selection bias occurs (Heckman, 1979); therefore, Tobit regression model is more suitable than OLS estimation for this analysis. Heteroscedasticity problem often arises with the cross-section data and it was also the case for the data used in this analysis. To work out the problem, the robust standard error was considered for the analysis (Arabmazar and Schimidt, 1981).

4.3. Variables

4.3.1. Intellectual property protection methods and product innovation performance

To measure a firm's PIP as the dependent variable, the percentage of sales generated by new products introduced between 2007 and 2009 was used. The independent variables were IP strategies and industrial complexity in technology. The KIS provides the information about the use of several IPPMs for product innovation: patents, utility models, designs, and trademarks as formal means, as well as trade secrecy, complex design, and leading advantage over competitors as informal means. Because the aim of the study was to examine the combination effect of statutory and non-statutory IPPMs as distinct groups, patents, utility models, designs, and trademarks were grouped together, namely 'formal groups.' Likewise, trade secrecy, complex design, and leading advantage over competitors were grouped together, namely 'informal groups.' To study all the combinations of different IPPM groups, eight different dummy variables were created as shown in Table I-1. Categorizing IPPMs into two groups and configuring eight dummy variables eliminated the necessity of checking all of the different combinations of IPPMs, which might have impaired the analysis result.

4.3.2. Triples as a proxy for technological complexity of industry

In the recent researches, it has been found that patenting increases as industrial technology becomes more complex (Hall, 2005; von Graevenitz et al., 2011), and the terminology ‘patent thicket’, defined as ‘a dense web of patent overlapped’ (Shapiro, 2003), has been emerged representing the technological complexity of industries. The concept of ‘Triple,’ the first method of measuring “patent thicket,” was then introduced in von Graevenitz et al. (2011). In prior works, for instance, technological complexity of industries was identified by bisecting the standard industry classification (Cohen et al., 2000). This classification method may lead to substantial heterogeneity within groups of the industries, and the heterogeneity could severely bias the results (von Graevenitz et al., 2011). ‘Triple’ may solve this problem, as it is a more consistent classification of industry complexity in technology (von Gravenitz et al., 2011). Triple is a measure that identifies the sequence in which each of three firms owns a patent that blocks the patent applications of the other two firms (von Gravenitz et al., 2011). In other words, if three firms forbid each other in terms of patent acquisition, this is counted as one ‘Triple’. The number of Triples is counted for each industry representing the density of patent thickets in an area of technology – another definition of industrial complexity in technology (von Gravenitz et al., 2011).

To prove the validation of triple measurement is suitable for identifying the industrial technological complexity, von Graventiz et al. (2011) provided a figure comparing triple measurement and the conventional classification of industrial technological complexity suggested by Cohen et al. (2000). Figure I-2 shows the average number of triples identified in complex and discrete areas from 1980 to 2003 (von Graventiz et al., 2011). In Figure I-2, technology areas are bisected into complex group and discrete group according to the definition of industrial technological complexity suggested by Cohen et al. (2000). The number of Triples then computed for each group by year. Figure I-2 shows that the number of triples in complex technology industries outnumbered that in discrete technology industries and the difference is widening over years. The result proved the validity of triple measurement of patent thicket for identifying the level of technological complexity of industries.

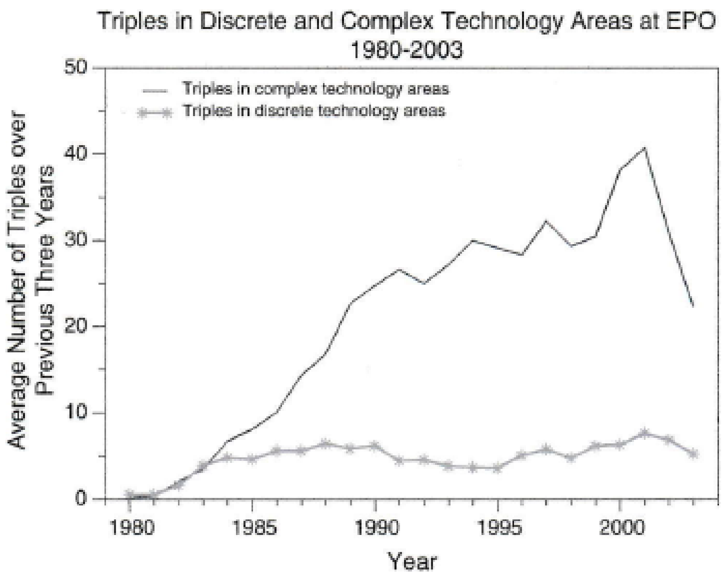

Figure I-2 Average number of triples identified in complex and discrete areas

(source: von Graevenitz et al., 2011)

The most important privilege of triple is that it is allowed to be observed the gradual changes in effectiveness of implementing IPPMs by the level of technological complexity of industries. In the previous literature, inter-industrial difference in technological complexity was previously measured by bisecting all the industries whether complex or discrete and presented in the form of dummy variables (Cohen et al., 2000). By implementing continuous variable for industrial technology complexity, it is able not only to compare the inter-industrial difference within the groups, but also to estimate the effect of industrial technological complexity per unit.

To benefit from the empirical advantage, several studies implemented triple measurement. Hall, Helmers, and von Gravenitz (2015) analyzed the effect of patent thickets on incentives to enter technology areas. By implementing triple measurement as a proxy of patent thicket, it is concluded that patent thickets significantly reduce entry into those technology areas where growing complexity of industrial technology increase the fundamental demand for intellectual property protection (Hall et al., 2015). Harhoff, von Graevenitz, and Wagner (2015) investigated the validity of post grant at patent offices. It is empirically shown that post grant patent review may not constitute an effective correction device for errors in the process of technology patent grants affected by patent thickets (Harhoff et al., 2015).

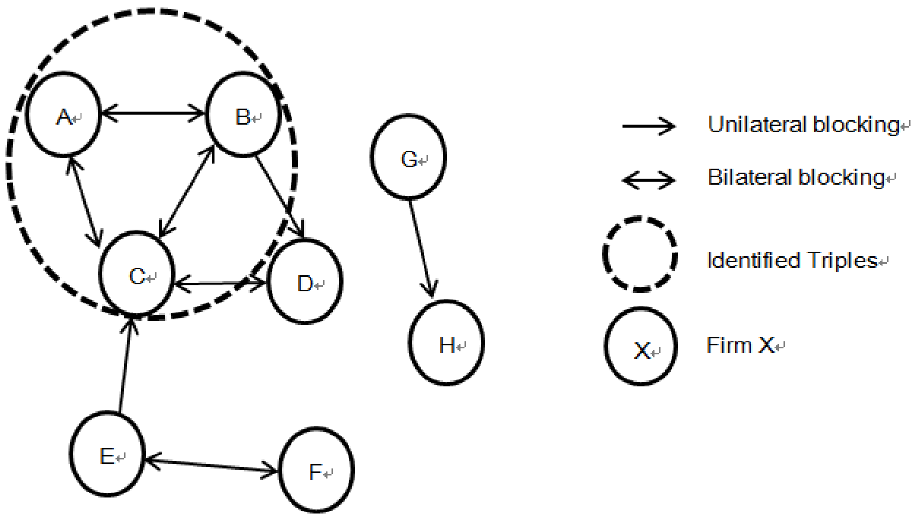

Figure I-3 Structure of Triple (von Gravenitz et al., 2011)

4.3.3. Control variables

Several control variables are implemented to account for the product innovation performance in this empirical analysis. Control variables representing sales potential are included in this analysis and they are years of operation, and whether end-good producer. Years of operation represents how long firms operate in the industries and it is known as one of the determinants for firms' operating performance (Mikkelson, Artch, and Shah, 1997). Control variables accounting for the firm's technological level are included in this analysis and they are the amount of R&D expenditure, whether venture-backed, the existence of R&D labaratory, and the number of high-skilled employees. These variables are regarded as a hint on the firms' technological level. A firm with high technological level has advantages on creating new technology and applying to the new product, both of which will affect the new product performance (Choi, Lee, and Kim, 2012). The relationship between firm size and economic output from R&D has been discussed (Cohen and Klepper, 1996; Schmiedeberg, 2008). Schmiedeberg (2008) maintains that a large firm tends to have wider product range and a higher sale performance is expected in a larger firm rather than a smaller firm. A smaller firm, on the other hands, has relatively narrow product range and the higher sales share of a new product is more likely. Finally, a variable representing a firm conducting both in-house R&D and joint R&D is implemented in terms of dummy variable. Choi, Lee, and Kim (2012) suggested that in-house R&D is complementary to joint R&D, leading to higher innovation performance.

Table I-1 shows the descriptions of the variables, Table I-2 shows the means and standard deviations of the variables. Firms using multiple formal IPPMs and multiple informal IPPMs simultaneously outnumbered the other categories, and about 80% of the firms implemented more than one method. This finding shows that firms applied multiple methods considered to be effective, and it is consistent with previous researches where the use of multiple IPPMs was emphasized (Arora, 1997; Cohen et al., 2000; Levin et al., 1987).

Table I-1 Description of variables

Variable	Definition
Dependent variable	
PIP	Product innovation performance: sales from newly launched products / total sales
Independent variable	
SF&NI	1 if a single formal IPPM and no informal IPPMs were used, else zero
NF&SI	1 if no formal IPPMs and a single informal IPPM were used, else zero
MF&NI	1 if multiple formal IPPMs and no informal IPPMs were used, else zero
NF&MI	1 if no formal IPPMs and multiple informal IPPMs were used, else zero
SF&SI	1 if a single formal IPPM and a single informal IPPM were used, else zero
MF&SI	1 if multiple formal IPPMs and a single informal IPPM were used, else zero
SF&MI	1 if a single formal IPPM and multiple informal IPPMs were used, else zero
MF&MI	1 if multiple formal IPPMs and multiple informal IPPMs were used, else zero
Tr	Logarithm of the number of Triples for each industry
Control variable	
Year	Years of operation
RnDExp	R&D expenditure
SM	1 if firm size is small–medium, else zero
VB	1 if venture-backed, else zero
EGP	1 if end-good producer, else zero
RndLab	1 if R&D Lab exists within the company, else zero
HSE	Number of highly skilled employees*
FTR	Number of full-time researchers
InJoint	1 if in-house R&D and joint R&D are conducted simultaneously, else zero

*A highly skilled employee is defined as any employee with a master’s degree or higher.

Table I-2 Means and standard deviations of variables

Variable	Mean	S.D.
Dependent variable		
PIP	0.323	0.279
Independent variable		
SF&NI	0.057	0.232
NF&SI	0.059	0.236
MF&NI	0.061	0.239
NF&MI	0.095	0.293
SF&SI	0.037	0.189
MF&SI	0.063	0.243
SF&MI	0.088	0.283
MF&MI	0.446	0.497
Tr	5.278	1.678
Control variable		
Year	19.707	13.834
RnDExp	6.915	1.853
SM	0.858	0.349
VB	0.238	0.426
EGP	0.527	0.499
RndLab	0.615	0.486
HSE	9.101	36.828
FTR	16.878	50.797
InJoint	0.257	0.437

4.4. Estimation equations

To reveal the complementarity of IPPMs on a firm's PIP, the percentage of sales from newly launched products was used as the dependent variable, with eight different configurations of IPPMs included as dummy variables. The following is the performance equation:

$$PIP_i = \beta_0 SF\&NI + \beta_1 NF\&SI + \beta_2 MF\&NI + \beta_3 NF\&MI + \beta_4 SF\&SI + \beta_5 \mathrm{MF\&SI} + \beta_6 SF\&MI + \beta_7 MF\&MI + \gamma_i \mathrm{Control}_i + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq(1)}$$

Along with the complementarity of multiple IPPMs, this study also tried to figure out how much more effective is the different IP strategies than the use of no IPPMs on a firm's PIP. It is in this context that the variable representing firms using no IPPMs has been omitted from Eq(1). Without the variable representing the use of no IPPMs, each coefficient of the IP strategies no longer represents an absolute value, but a relative value of the protection effect compared to the no protection effect (Greene, 2003).

To test the moderating effect of industrial complexity in technology, interaction terms between the moderating variable and the independent variables were added to Eq(1) (Bojica et al., 2011; Fey and Birkinshaw, 2005). With six newly included interacting terms between industry technological complexity and multi-use of IPPMs, there were 14 independent variables to be tested, in total. The following is the performance equation being used:

$$PIP_i = \beta_0 SF\&NI + \beta_1 NF\&SI + \beta_2 MF\&NI + \beta_3 NF\&MI + \beta_4 SF\&SI + \beta_5 MF\&SI + \beta_6 \mathrm{SF\&MI} + \beta_7 MF\&MI + \beta_8 MF\&NI * Tr + \beta_9 NF\&MI * Tr + \beta_{10} SF\&SI * Tr + \beta_{11} MF\&SI * Tr + \beta_{12} SF\&MI * Tr + \beta_{13} MF\&MI * Tr + \gamma_i \mathrm{Control}_i + \varepsilon_i \text{ ....Eq(2)}$$

Newly included interaction terms were MF&NI∗Tr, NF&MI∗Tr, SF&SI∗Tr, MF&SI∗Tr, SF&MI∗Tr, and MF&MI∗Tr. To clarify whether the industrial complexity in technology moderates the combination effects of IPPMs on a firm's PIP, Eq(2) could be rearranged as shown in Eq(3):

$$PIP_i = \beta_0 SF\&NI + \beta_1 NF\&SI + (\beta_2 + \beta_8 Tr) MF\&NI + (\beta_3 + \beta_9 Tr) NF\&MI + (\beta_4 + \beta_{10} Tr) SF\&SI + (\beta_5 + \beta_{11} Tr) MF\&SI + (\beta_6 + \beta_{12} Tr) SF\&MI + (\beta_7 + \beta_{13} Tr) MF\&MI + \gamma_i \mathrm{Control}_i + \varepsilon_i \text{ ....Eq(3)}$$

A term (β_4 + β_{10}Tr)SF&SI, for example, explains why the effect of a single formal IPPM and a single informal IPPs on PIP may be no longer constant. As the value of Tr changes, the overall combination effect (β_4 + β_{10}Tr) on SF&SI also changes. In other words, the overall combination effect could be varied, depending on the technological complexity of each industry; therefore, when the coefficient of the interaction term is statistically significant, regardless of its sign, there exists a moderating effect, of which the result tests the Hypothesis 2.

5. Results and discussion

5.1. Complementarity of intellectual property protection methods

Table I-3 shows the results of Eq(1). The coefficients for a single IPPM (SF&NI and NF&SI) were positive but not significant. Because the variable representing firms using no IPPM was omitted, this finding does not mean that the use of any single IPPM was ineffective at all, but not more effective than the use of no IPPM. The coefficients of the variables representing the use of multiple IPPMs (MF&NI, NF&MI, MF&SI, SF&MI, and MF&MI), in contrast, were positive and significant. With the variable representing firms using no IP protection tools omitted, these results clearly show that the combination of IPPMs were more effective than using no IP protection means. Combining the results from a single IPPM that it is no more effective than using no IPPMs, it can be inferred that the multiple IPPMs also had a more positive effect on PIP than did a single IPPMs. This result is consistent with the previous studies where the combination of IPPM provided complementarity rather than substitution effect (Arundel, 2001; Teece, 1986; Hall and Sena 2017).

Table I-3 Complementary effect of IPPMs on PIP

Variable	Coefficient	Robust Standard Error
IP strategy		
SF&NI	0.023	0.036
NF&SI	0.011	0.036
MF&NI	0.082**	0.040
NF&MI	0.100***	0.033
SF&SI	0.047	0.047
MF&SI	0.105***	0.041
SF&MI	0.099***	0.037
MF&MI	0.125***	0.027
Control variable		
Year	0.000	0.001
RnDExp	0.020***	0.004
SM	0.104***	0.022
VB	0.060***	0.021
EGP	0.029*	0.016
RndLab	−0.021	0.019
HSE	0.000	0.000
FTR	0.000	0.000
InJoint	0.020	0.018

***, **, *** represent significance levels of 10%, 5%, and 1%, respectively.**

Either the existence of complementarity when implementing multiple IPPMs from a formal or an informal group (MF&NI and NF&MI) was very clear concluding that there existed “within group” combination effects on PIP. The coefficient of the term

SF&SI, on the other hand, was positive but not significant suggesting that the "between groups" combination effect seemed not to be existed. Even though the coefficients of the terms MF&SI, SF&MI, and MF&MI were positive and significant, their effects consist of two sources – the "within groups" effect and the "between groups" effect. The complementarity of the former was proved to be existed, but that of the latter seemed not to be existed. In accordance with the finding that the coefficients for MF&SI and MF&NI, SF&MI and NF&MI, and MF&MI and the sum of MF&NI and NF&MI were also not statistically different, the "between groups" combination effect still seemed not to be existed. Among the control variables, R&D expenditure, small and medium firm size, venture-backed, and end-good production had positive effects on the PIP, whereas the effects of firm-year, existence of R&D laboratory, number of highly skilled employees, number of full-time researchers, and in-house and joint R&D activities were not statistically significant.

5.2. Moderating effect of technological complexity of industry

Considering differences in the effectiveness of formal and informal methods by the technological complexity of the industries, there might be a possibility of netting problem that blurs the “between groups” combination effect. The use of multiple IPPMs within the same group (MF&NI or NF&MI), for instances, implies the inclusion of two or more methods that play the similar roles, regardless of the industrial technology level. When multiple IPPMs are selected from two different groups, however, their roles and effectiveness may differ by the industry in which they are implemented. In technologically complex industries, formal IPPMs are less effective than they are in discrete industries, and informal IPPMs is less effective in discrete industries than in complex industries (Cohen et al., 2000; Harabi 1995). To determine whether there exists a netting effect blurring the “between groups” complementary effect, inter-industrial difference in technology complexity was considered in the following analysis.

To identify the moderating effect of industrial complexity in technology, interaction terms of the multiple IPPMs and industry technological complexity were added. The results are shown in Table I-4. The coefficient for the interaction term SF&SI*Tr, the moderating effect of Tr, was significantly positive. The following shows the calculation of the overall "between groups" combination effect, $\varkappa$, considering the range of the value of Tr.

$$\varkappa SF\&SI = \beta_4 SF\&SI + \beta_{10} SF\&SI*Tr = SFSI\ (\beta_4 + \beta_{10}Tr)$$

$$= SFSI\ (-0.328 + 0.070Tr) \text{ where } 2.833 \leq Tr \leq 9.669$$

$$\text{Min } \varkappa = \text{Min } (\beta_4 + \beta_{10}Tr) = (-0.328 + 0.070 * 2.833) = -0.130$$

$$\text{Max } \varkappa = \text{Max } (\beta_4 + \beta_{10}Tr) = (-0.328 + 0.070 * 9.669) = 0.349$$

With the value of Tr ranging from 2.833 to 9.669, $\varkappa$ ranged from −0.130 to 0.349. When the value of Tr was large enough, the overall combination effect for SF&SI, $\varkappa$, was positive, demonstrating "between groups" complementarity. When the value of Tr was small, in contrast, $\varkappa$ was negative, demonstrating a substitutionary relation between two groups of IPPMs. Figure I-4 shows the results of the calculation graphically. It is concluded the effects of a formal and an informal IPPMs that industrial complexity not only moderates the complementarity between the two IPPM groups, but also determines whether IPPMs from two different groups are in a relation of complement or substitution. The result is consistent with previous studies (Amara et al., 2008; Cohen et al., 2000;

Table I-4 Moderating effect of industrial complexity on the combination effect of IPPMs

Variable	Coefficient	Robust Standard Error
Configuration of IPPMs		
SF&NI	0.023	0.036
NF&SI	0.010	0.036
MF&NI	0.264*	0.140
NF&MI	0.141	0.104
SF&SI	−0.328***	0.117
MF&SI	−0.133	0.099
SF&MI	−0.077	0.098
MF&MI	0.040	0.047
Interaction between use of multiple IPPMs and technological complexity of industry		
MF&NI*Tr	−0.036	0.024
NF&MI*Tr	−0.008	0.018
SF&SI*Tr	0.070***	0.024
MF&SI*Tr	0.049**	0.021
SF&MI*Tr	0.034**	0.017
MF&MI*Tr	0.016**	0.007
Control variable		
Year	−0.001	0.001
RnDExp	0.019***	0.004
SM	0.106***	0.021
VB	0.054***	0.021
EGP	0.038**	0.016
RndLab	−0.021	0.019
HSE	0.000	0.000
FTR	0.000	0.000
InJoint	0.022	0.018

***, **, *** represent significance levels of 10%, 5%, and 1%, respectively.**

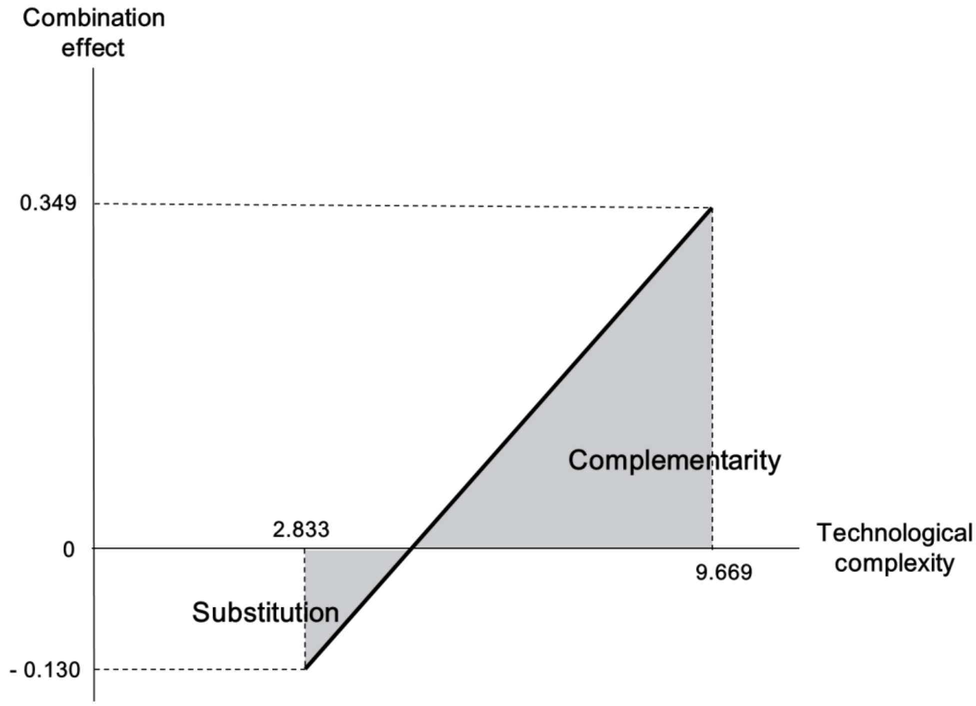

Figure I-4 Moderating effect of industrial technological complexity on the combination of IPPMs

Harabi, 1995) that formal and informal IPPMs play different roles depending on the industry. In discrete industries, the cost to implement informal IPPMs exceeds the benefit to be achieved, causing a reduction in the protective effect from using statutory means.

With the results presented in Table I-4, the combination effects of the different IP strategies dependent on the industrial technology level in terms of the complexity could be also revealed and shown in Figure I-5. The coefficient of MF&NI*Tr was not

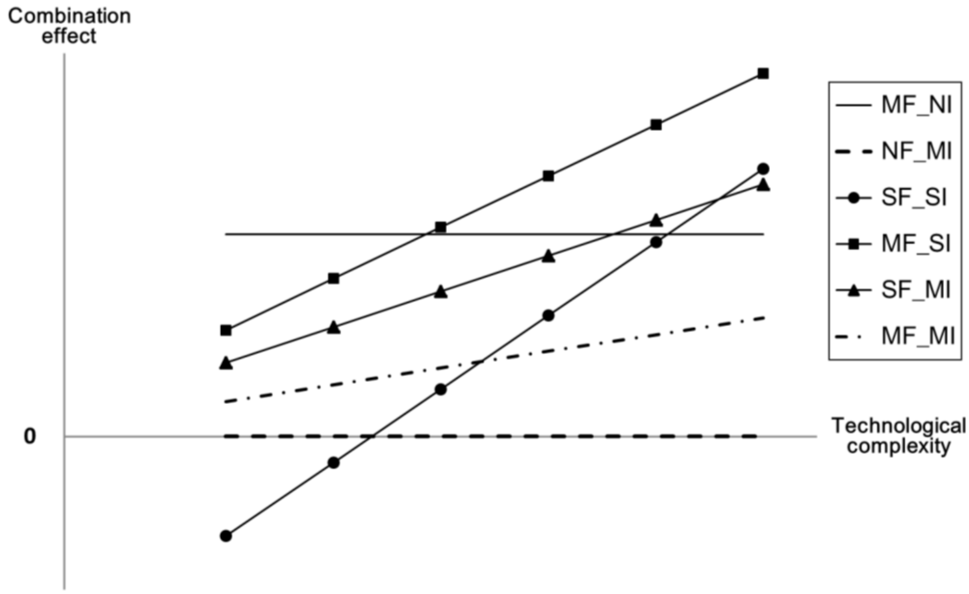

Figure I-5 The combination effect of IP protection strategy dependent on the industrial technology complexity

statistically significant, which showed no moderating effect. With the positive coefficient for MF&NI, it was found that the stable complementary effect exists when implementing IPPMs within the formal group regardless of the industrial difference in technology level shown as a horizontal line in Figure I-5. More strategic implications could be found in Figure I-5. In Figure I-5, MF&SI strategy was always better than SF&SI strategy, regardless of the industrial technology complexity. This finding shows that there exists a positive “within a formal group” effect from the additional multi-use of formal IPPMs under the condition that a firm is already experiencing “between the groups” combination effect. When comparing SF&SI strategy and SF&MI strategy, in addition, SF&MI strategy outperformed SF&SI strategy in most industries except the extreme case of the industry with a high technological complexity level. This finding could be interpreted that it is possible to create an additional positive “within an informal group” effect under the condition that a firm is already implementing the IPPMs from two different groups. It could be inferred the combination effect of informal IPPMs is conditional on the existence of the use of formal IPPM for the reason that this analysis is focused on the product innovation. On the other hands, it is shown in Figure I-5 that MF&MI strategy always underperformed MF&SI strategy and SF&MI strategy. It could be inferred that any additional “within a group” combination will not create positive effect on a firm’s PIP under the condition that all the other combinations of IPPMs are already implemented. This finding could be interpreted that implementing additional IPPM on the MF&SI strategy or SF&MI strategy is redundant in that the additional positive effect on PIP is smaller than the cost incurred. To sum up, a negative effect of “between groups” combination made MF&NI strategy outperformed the other strategies when the value of Tr was small. As the value of Tr increased, however, the effect of “between the groups” combination switched to be positive, resulting that the best IP protection strategy was MF&SI when the value of Tr is big enough.

There are some practical strategic implications from these findings. First, a manufacturing firm should use more than one type of IPPMs. In the data used for the analysis, 122 of 1,297 firms did not use any protection methods for their new products. Most of these (112 of 122) were small- or medium-size firms that might have financial and human resource problems implementing any IPPMs. Based on the results from the analysis, however, most of the firms with no protection strategies could improve their performance by implementing two or more IPPMs. In addition, 151 of 1,297 firms used only one method of IP protection, whose performance could be improved using additional IPPMs.

The managers of the manufacturing firm, however, should be careful when implementing additional IPPMs because the effect of implementing multiple IPPM varies by the difference in industrial technology level. Firms in the technologically discrete industries should be careful when using IPPMs from both groups, because it could be less effective or even harmful to the firms' performance. From the data, 569 of 1297 firms were placed in discrete industries and 355 of those 569 firms in the discrete industries implemented both formal and informal IPPMs. These firms have possibilities to improve their rents from new product sales by modifying their IP strategies. Among the control variables, R&D expenditure, small or medium firm size, venture-backed, and end-good production were positively effective on PIP, while taking the technological complexity of the industry into account.

5.3. Additional analysis

Industrial technological complexity was measured by the number of triples in each industry presenting the extent of patent thicket density. In this article, the purpose of implementing industrial technological complexity was not to observe the direct effect of triple on product innovation performance, but to observe the moderating effect. For this reason, the variable Tr by itself was omitted from the equation (2), but the interaction terms was only included. In previous literature, the effect of industrial technological complexity was illuminated. Gupta and Wilemon (1990) pointed out that there are two factors, which explained the environment for new product development in many technologically complex industries. One was continuous development of new technologies that quickly obsoleted existing products, and the other was changing customer needs and requirements, which truncated product life cycle (Gupta and Wilemon, 1990). These two factors implied that the share of sales from newly launched products might be higher in technologically complex industries compared to that in discrete industries. For this reason, the number of triple for each industry was added to the empirical model and comparison with the model without Triple variable is shown in Table I-A1.

In Table I-A1, Model 1 shows the results of empirical estimation without triple variable, and Model 2 shows the results with triple. As shown in Model 2, the coefficient of Triple is positive and significant. The result shows that the sales from new product is increased, as industrial technology gets more complex. The combination effect of a formal method and an informal method of IP protection appeared in Model 2 is similar to that in Model 1. This finding emphasize the moderating effect of industrial technological complexity. Unlike the result in Model 1, the negative moderating effect of triple on IP strategy of combining formal IPPMs. This finding can be interpreted that ‘within’ group complementary effect of formal IPPMs declines as industrial technology complexity increases. The result is in accordance with the previous literature maintaining that the more complex the industrial technology is the less protection effect of formal IPPM (Cohen et al., 2000; Harabi, 1995).

The proxy for the latent variable, product innovation performance, was the percentage of sales generated by new products. Taking into account that the dependent variable is a firm’s sale, sale and administrative expenditure was added to the analysis and the comparison results are shown in Table I-A2. Model (1) shows the result on the estimation of complementary effects of IP strategies, and model (2) represents the result on the estimation of moderating effects of industrial technological complexity. Model (3) and (4) are similar with model (1) and (2) respectively, but with the control variable of sales and administrative expense. From the results shown in Table I-A2, no difference is found between model (1) and (3), and between model (2) and (4) in terms of statistical significance. The coefficient of sales and administrative expense variables in model (3) and (4) are statistically positive, which means that the more sales and administrative expense, the more sales are expected.

6. Conclusion

In this article, the complementarity of IPPMs on a firm's PIP and the moderating effect of technological complexity of industry were analyzed using Tobit regression method. By using data related to PIP from the KIS 2010 (STEPI, 2010), it was found that there was a complementarity when two or more IPPMs from the same groups are used jointly, concluding that there exists "within groups" complementary effect. The simultaneous use of a single formal IPPM and a single informal IPPM, however, showed no complementarity effect. The "between the groups" combination effect, however, was existed but varied from even negative to positive due to the different roles of each IPPM by the industrial difference of technological complexity. When the industrial technology was discrete, formal IPPMs and informal IPPMs were in a relation of substitution. When technology level of industry was complex, on the other hand, formal IPPMs and informal IPPMs created positive synergy on the innovative product performance. With the finding that implementing multiple formal IPPMs with no informal methods creates a constant complementary effect regardless of the industrial difference in technology, it was concluded that the IP strategy using only multiple formal IPPMs outperforms the other strategies when the industrial technology level is discrete, whereas the use of multi-formal IPPMs and a single informal method creates the greatest positive effect on the performance when the industrial technology is complex enough.

The academic contributions of this paper are as followed. First, the combination effects of IPPMs studied along with the industrial characteristic. Previous studies only focused on either the combination effect of IPPMs (Amara et al., 2008; Gallié and Legros, 2012; Graham and Somaya, 2006) or the inter-industrial difference in terms of technological complexity in the effect of a single IPPM (Harabi, 1995; Cohen et al., 2000). By considering both simultaneously, the moderating effect of industrial technology complexity on the combination effect of IPPMs was empirically discovered.

Second, this paper did not focus on the determinants for the selection of IPPMs, but tried to show how the firm's IP strategies affected their performance. It is a more direct and intuitive method of demonstrating the combination effect among the IPPMs. It was not only the contribution, but also the limitation of the study to use the percentage of sales from newly launched products as a proxy for a firm's PIP. Even though the study focused on a firm’s economic performance, the concept of PIP was expanded from the quantitative aspects such as financial and market performance to the qualitative aspects such as customer and product performance (Hsu and Fang, 2009). This study can be further developed to cover all the aspects of PIP by the case study or even conducting an appropriate survey.

Finally, continuous variable for technology complexity of industry was used for the analysis. In prior works, inter-industrial difference in technological complexity was usually measured by bisecting the standard industry classification and presented in the form of dummy variables: complex technology or discrete technology (Cohen et al., 2000). By implementing continuous variable for industrial technology complexity, the range of the combination effect of IPPMs, of which values are from negative (in relation of substitution) to positive (in relation of complementarity) was able to be empirically analyzed.

In summary, this paper suggests that there exists positive combination effect on a firm’s PIP when two or more IPPMs were implemented simultaneously. This paper also suggests the extent of the combination effect depends on the technological complexity of industry. Although there might be some firm-specific or manager-specific issues, so more space needs to be given to managerial choice, it is expected that the findings from this paper has important implications for the managers and find them useful in the decision making process for IP strategies.

7. Limitation

In this article, intellectual property protection methods were categorized into two groups, formal and informal and it has both advantage and disadvantage. The advantage from the categorization is that it enables to observe the combination effect within groups and between groups empirically. The disadvantage, on the other hand, is that it disables to measure the combination effect of each IPPM on a firm's product innovation performance. Even though the shared characteristic of whether protected by laws made possible to categorize into formal methods group (patents, utility models, designs, and trademarks) and informal methods group (patents, utility models, designs, and trademarks), all methods in the same groups have different characteristics and therefore are implemented for different purposes. It is for sure that it may have more meaningful strategic implications to analyze the combination effect of each IPPM. In this article, however, IPPMs are used only as groups because combination effects of all individual IPPMs and the moderating effect of industrial technological complexity on all the combinations may lead to saturated number of variables that causes the impairment of the empirical results.

Hence, further research should consider implementing modified or even new analytical models, which enables to include each IPPM individually in order to derive relatively more meaningful strategic implications.

Though this article tried to control the determinants, which affect to product innovation performance, the actual process of how implementations of IPPMs affect product innovation performance was not discussed sufficiently. In the process related to product innovation, numerous steps may affect the product innovation performance such as technology development, proto-type, complement assets, financing, launching and so on. Further research should consider subdividing product innovation process into each step, which enables to analyze the effect of IPPMs on each step separately.

Essay II The effects of market failure, national culture, and government intervention on technology entrepreneurship

1. Introduction

Entrepreneurship activity has been being considered as one of the crucial determinants of a country's economic development. Among the various kinds of entrepreneurship, technology entrepreneurship activity, the entrepreneurship involving new technology, has a positive effect on overall economic development by not only providing economic rewards to research and development (R&D) expenditure and creating new jobs, but also leading to the prosperity of the relevant industries. There exist some hindrances, however, to entrepreneurship activity performance, holding back economic development and they are market failure and government failure.

Market failure in technology entrepreneurship occurs when there exists information asymmetry, which causes a mismatch between technology supply and demand, technology uncertainty in terms of potential economic value, or both. In other words, market failure will lead to underinvestment, resulting in less technology entrepreneurship activity than social optimal level. Market failure mostly occurs under the liberal market economy model; therefore, it gives legitimacy of government intervention in the form of institutions or policy.

Government intervention can be of two types, direct and indirect (Salmenkaita & Salo, 2002). Direct government intervention could be in the form of a proactive fiscal policy or an institution providing a subsidy or supportive fund to bridge the gap of underinvestment. Indirect government intervention, on the other hands, focuses on the construction of a healthy technology entrepreneurship ecology by amending regulation related to tax, among others, so that it is possible for a new or prospective entrant to compete on equal terms with the incumbents (Giesecke, 2000). The effect of the government intervention on technology entrepreneurship can vary according to its characteristic, direction, or extent; the effect of the intervention, along with market failure, can eventually lead to a negative effect on technology entrepreneurship performance, which is called government failure.

In fact, there is no ‘one size fits for all’ solution in terms of government institution or policy for the activation of technology entrepreneurship. Government intervention should be designed with an understanding of both economic and social situations of the country to which it is applied. In other words, the level of economic development and the extent of public awareness about entrepreneurship should be reflected in the government institution or policy promoting technology entrepreneurship. Yet, few previous studies explored the relationship between technology entrepreneurship and the national social factors, along with the facilitating government institution or policy.

In this research, the effects of information asymmetry, the main reason for market failure and national culture (individualism and uncertainty avoidance), one of the main social factors, on technology entrepreneurship and the role of government intervention on these effects are studied. For the empirical analysis, annual data of 199 observations from 49 countries covering 7 years constitute the panel data. Data on technology entrepreneurship activity are extracted from Global Entrepreneurship Monitor (GEM) – Adult Population Survey, data for control variables are from GEM – National Expert Survey and the World Bank database; data for national culture are from Hofstede (2011), and data on information asymmetry are from Datastream database. By conducting random effect model analysis, several findings are obtained on the relationships among technology entrepreneurship, national culture, and government intervention. First, information asymmetry affects technology entrepreneurship activity and its effect varies by the novelty of the technology involved. Second, individualism – one of the dimensions of national culture – has a negative effect on technology entrepreneurial activity level. Third, government intervention has both direct and indirect effect on technology entrepreneurship activity, but the effect varies according to the characteristic of government intervention. All these findings have implications for government policy making; thus, the government institution or policy should consider not only the economic environment, but also the national social context.

2. Theoretical background

2.1. Technology entrepreneurship

For decades, technology entrepreneurship is at the center of many controversies, including those around regional economic development, inventors and investors, and policy makers. A study on the definitions used for technology entrepreneurship should precede any discussion on the issues surrounding. Table II-1 summarizes the definitions found in the previous literature.

Even though there are slight differences of nuance in these definitions of technology entrepreneurship, the common idea is ‘launching a new venture firm relies on a new technology or technical knowledge.’ In addition to the conventional definition, Bailetti (2012) added economic aspects, such as “investment” and “value creating and capturing” to the definition of technology entrepreneurship. This definition is not only the most appropriate but also the most suitable for this study in that the most crucial factors to be considered for technology entrepreneurship are implementing a new technology, drawing on a necessary resource, and generating economic values.

Table II-1 Definitions of technology entrepreneurship

Literature	Definitions
(Jones-Evans, 1995)	Establishment of a new technology venture
(Nichols & Armstrong, 2003)	Organization, management, and risk bearing of a technology based business
(Liu, Chu, Hung, & Wu, 2005)	Ways in which entrepreneurs draw on resources and structures to exploit emerging technology opportunities
(Garud & Karnøe, 2003)	An agency that is distributed across different kinds of actors, each of which becomes involved with a technology and, in the process, generates inputs that result in the transformation of an emerging technological path
(Bailetti, 2012)	Technology entrepreneurship is an investment in a project that assembles and deploys specialized individuals and heterogeneous assets that are intricately related to advances in scientific and technological knowledge for the purpose of creating and capturing value for a firm

Table II-2 Breakdown of the number of journal articles on technology entrepreneurship by theme (2000-2011)

THEMES	TOTAL	% OF TOTAL
External factors that influence formation of technology firms	**33**	**54.10%**
How, why and when technology entrepreneurship affects the socio-economic development of a region	**8**	**13.11%**
Approaches used by small technology firms to generate revenue and reduce costs	**8**	**13.11%**
Internal practices used to operate and transform small technology firms	**4**	**6.56%**
Overview of technology entrepreneurship	**3**	**4.92%**
Corporate entrepreneurship function in mid-sized and large firms	**3**	**4.92%**
Interdependence between technology path and small technology firm formation and growth	**1**	**1.64%**
Contributions to other fields	**1**	**1.64%**
Number of articles	**61**	**100%**

Source: (Bailetti, 2012)

Table II-2 shows a breakdown of the number of journal articles on technology entrepreneurship by theme from 2000 to 2011 (Bailetti, 2012). Table II-2 suggests that the recent debates on technology entrepreneurship focus on the external factors affecting the technology entrepreneurship activity.

2.2. Market failure

Prior to the discussion of market failure, market theory of mainstream economics should be studied. According to neoclassical economists, the market can realize the most efficient allocation of resources by itself under defined conditions (Zhang, 2015). Among these conditions or assumptions, the three that are usually violated in technology entrepreneurship market are; (i) complete symmetry of information and technology; (ii) perfect rationality of each player; (iii) perfect competition (Zhang, 2015). The violation of these assumptions is the cause of market failure in technology entrepreneurship.

First, information asymmetry occurs in most of the transactions in technology entrepreneurship market. The discovery of information or the opportunity that others miss is the most valuable asset to the inventors or the prospective entrepreneurs for creating and capturing economic value and is called information advantage (Dutta & Folta, 2015). Drawing on external financial assets is also crucial in technology entrepreneurship activity. The problem is that the more valuable the information is, the more hesitant the information holder is to share it fully with the prospective investors or co-workers to avoid unintentional knowledge outflow (Shane & Cable, 2002). This problem makes it difficult for the inventor or prospective entrepreneur to obtain sufficient funds for the formation of a new technology firm.

Second, not every player in technology entrepreneurship market is perfectly rational. In other words, it is more precise to express that instead of being objectively rational, each player in the market is subjectively rational and makes decisions based on his or her actual knowledge. Even though the inventor shares all the information, it is possible that the prospective investor does not fully understand the information (Amit, Glosten, & Muller, 1990). The investor, the financial expert, usually has a background and knowledge bases, which is different from that of the inventor; thus, the investor often has a trouble understanding and evaluating the inventor’s explanations on the information. In such a situation, the investor has no option but add an additional premium for the unknown risks resulting in an increase in the transaction cost (Anonymous, 1993).

Last, the competition between an entrant and the incumbents is not perfect. In the healthy ecology of a perfectly competitive market, all the enterprises in an industry are only price-takers and are unable to influence market prices (Zhang, 2015). In reality, however, there exist some monopolistic or oligopolistic firms playing the roles of price-setters. This imperfect market in terms of competition can be a big obstacle for a prospective entrepreneur trying to enter the market.

2.3. Government intervention

Market failure due to imperfect competition provides a justification for the government to engage in the market. Further, with the main market requirement for entering the market shifting from the traditional factors, such as labor and capital, to knowledge or technology, the government intervention also shifts from the earlier focus on regulating large firms to enabling startups and helping new firms grow (Gilbert, Audretsch, & McDougall, 2004).

In an industry with traditional factors such as labor and capital, a concentrated market structure in shape of monopoly or oligopoly is often observed (Gilbert et al., 2004). As large manufacturing firms with market power gained product efficiency, the problem of contract concentration arose, resulting in a threat to the survival of new and small firms. With the recognition of the importance of the competition and the role of small firms within the market, the government's response was focused on controlling the big players by the means of regulation, antitrust, or public ownership (Gilbert et al., 2004).

As the crucial requirement for production changed from labor and capital to knowledge or technology, the need to amend government policy to accommodate the characteristics of knowledge or technology emerged. Knowledge can be defined as being uncertain and asymmetric(Gilbert et al., 2004). These characteristics make it difficult for the agents to evaluate it objectively. Subjective evaluation of knowledge encourages entrepreneurs to start up new business believing in the value of knowledge. As new and small firms became the vehicle to unlock the economic value of the knowledge or technology, which is the predominant factor of production, government intervention has expanded from the distribution of the wealth to its creation. This entails enabling and growing new and small technology firms (Mazzucato & Semieniuk, 2017). This type of government intervention can be termed as technology entrepreneurship policy (Gilbert et al., 2004).

2.4. National culture

Researchers from various background offer different definitions of “culture.” Table II-3 shows the many definitions of culture offered by comparatively recent researchers from different fields of study. Although these definitions are slightly different, there is agreement that the key features of culture are; “share”, “system”, “distinction”, and “value.” When the label “national” is attached to culture, it can be described as a system of shared values that distinguishes the social character of one country from that of others.

Many empirical studies that have explored the national culture as a determinant of economic performance, including innovation and entrepreneurship activity, are based on Hofstede’s groundbreaking research (Hayton, George, & Zahra, 2002). Hofstede’s work is valuable in that it explains the distinctive patterns or tendencies that are shared among groups of people by presenting a taxonomy of cultural dimensions which is both

Table II-3 Definitions of Culture offered by the researchers

LITERATURE	DEFINITION OF CULTURE
(G. Hofstede, Hofstede, & Minkov, 2010)	The collective programing of the mind which distinguishes the members of one group from another
(Hall & Hall, 1990)	A system for creating, sending, storing, and processing information
(Clark, 1990)	A distinctive, enduring pattern of behavior and/or personality characteristics
(Hill & Hult, 2014)	A system of values and norms that are shared among a group of people and that when taken together constitute a design for living
(House, Hanges, Javidan, Dorfman, & Gupta, 2004)	Shared motives, values, beliefs, identities, and interpretations or meanings of significant events that result from common experiences of members of collectives and are transmitted across age generations
(Namenwirth & Weber, 2016)	System of ideas that has structure, has an identity, and maintains boundaries

comprehensive and concise. The dimensions of national cultures in Hofstede's work are often compared with those in the Global Leadership and Organizational Effectiveness (GLOBE)(House et al., 2004). Although GLOBE has some distinct features such as the subdivision of one of the dimensions and separating values from actual practices (House et al., 2004) it cannot be denied that GLOBE too is stemmed from Hofstede's work and is the most widely used taxonomy of cultural dimensions.

2.5. Market failure, technology entrepreneurship and government intervention

An extensive body of literature has studied market failure and government intervention. Stiglitz (2010) maintains the need for government intervention when markets fail. Even though many economists still call into question the effectiveness of government intervention on market failing situation, the question that needs to be discussed is not whether to intervene or even whether there has been excessive intervention; rather, it is how to design a regulatory system, which is as efficient and equitable as it could be. On the other hand, Zhang (2015) criticizes neoclassical economists for their mathematical approach to solve a constrained optimization problem, which stipulated unnecessary conditions needed for the market to reach optimal efficiency. It is concluded that the market is not a static equilibrium but a dynamic process; so, the assumptions about optimal market are not needed. Further, the justification for government intervention, built upon the unreality of the assumptions, is not reasonable, even though well-designed government intervention is still needed in the market. All these studies, however, only suggest the necessity of well-designed government intervention when market failure occurs; they lack an empirical discussion on the factors that determine an efficient institution or policy design.

The debate on market failure and government failure continues in innovation performance, including technology commercialization and technology entrepreneurship. Following Stiglitz (2010), Giesecke (2000) maintains that the issue is not whether to intervene, but rather how to intervene. By comparing the national science and technology (S&T) policies of the US and Germany, it is concluded that an indirect intervention policy is more successful than a direct intervening policy. Salmenkaita and Salo (2002) criticize some of the studies, which indicate the failure of government in allocating resources optimally. It concluded that government intervention can be justified even in situations in which the benefits from the intervention is questioned because the purpose of the government intervention in technology commercialization market is not only to allocate resources efficiently but also to raise the general awareness about new opportunities

(Salmenkaita & Salo, 2002). It has been also supported by Gilbert, Audretsch, and Mcdougall (2004), who insist that the key factors in market competition have shifted from resource, unskilled labor, and capital to knowledge; therefore, the government policy should also change from direct intervention for regulation of big players to indirect intervention for encouraging new entrants. On the other hands, Mazzucato and Semieniuk (2017) maintain that successful policies that have led to radical innovations have been more about market shaping and creating through direct intervention, rather than market fixing through indirect intervention. Due to the key characteristic of innovation – high uncertainty – direct intervention in shape of public financing is more effective for innovation performance (Mazzucato & Semieniuk, 2017). Summing up, these previous studies mainly support the need for government intervention and emphasize the efficiency of the intervention in terms of policy design, but fail to propose empirical results on the effectiveness of government intervention on innovation activities, including technology entrepreneurship.

2.6. National Culture, technology entrepreneurship and government intervention

As the importance of well-designed innovation policy is emphasized more and more, there have been some attempts to find non-economic determinants, which affect innovation performance. Datta-Chaudhuri (1990) maintains that context-free S&T policies are not efficient enough and a government's policies should reflect the interests of the dominant social groups. Giesecke (2000) also emphasizes the social context in designing S&T policies and concluded that political action can only enhance S&T development if the policies are in line with both social and economic dispositions (Giesecke, 2000). These claims led to the empirical analysis to reveal the relationship between social context and innovation performance.

Several studies have tried to explain the influence of social factors on the performance of technology entrepreneurship. Ostapenko (2016) tries to find an indirect effect of national culture through a comparative analysis of Ukraine and the Slovak Republic. The main finding of the article is that the perceptions about government actions seem to be endogenous to unobservable national culture, and the consistency of government intervention, as well as social values such as national culture and trust affect entrepreneurship performance positively (Ostapenko, 2016). Liñán & Fernandez-Serrano (2014) also try to identify the specific role of national culture as a variable that reinfornces the entrepreneurship performance. By implementing a multidimensional concept of culture, the deep interrelationships between cultural variables, economic elements, and entrepreneurial activity are found (Liñán & Fernandez-Serrano, 2014). Jeong & Ryou (2012) examine the linkage between national culture and entrepreneurial motives. By breaking up entrepreneurial motive into “improvement-driven opportunity motives” and “necessity motives”, it is found that the effect of each dimension of national culture differs by the motive of entrepreneurial activity (Jeong & Ryou, 2012). Morris, Davis, & Allen (1994) also implement a multidimensional concept of national culture to find a factor relavant to entrepreneurial activity and conclude that as the emphasis on collectivism increases, entrepreneurship acitvity declines. All these empirical studies on the relationship between national culture and entrepreneurship, however, fail to include the factors affecting market failure, which is not only the main influence on technology entrepreneurship performance, but also the factor emphasized for justifying government intervention. Besides, most of these empirical results are only based on either organizational analysis in a country or comparative analysis of two or three countries, which makes it difficult to generalize the findings and apply them to other countries. Thus, an empirical study of market failure, innovation activity, and government intervention for a large set of countries is required.

3. Research framework

The purpose of this study is to find out the relationships among market failure, national culture, technology entrepreneurship, and government intervention. Based on the theoretical background of the study, the research framework shown in Figure II-1 below is followed.

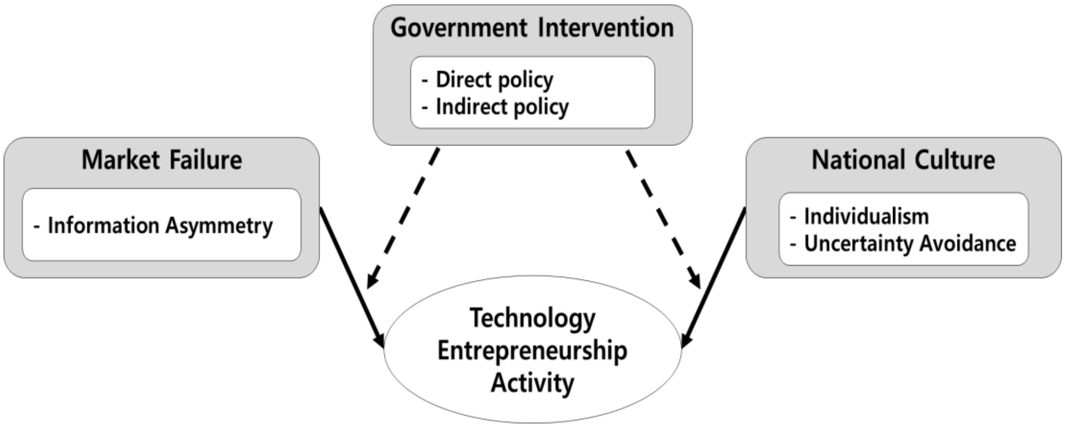

Figure II-1 Conceptual model

3.1. Market failure, technology entrepreneurship, and government intervention

The best technology entrepreneurship market is one where all the demands for finance (to avail the technology opportunity) find sufficient financial supplies with the minimum contract costs. In the real technology entrepreneurship market, however, the number of the matches between demand and supply do not reach the social optimum level and the market fails. One of the most influential factors on the market failure is information asymmetry. Information asymmetry in technology entrepreneurship market usually occurs under two conditions – the risk of imperfect appropriability and the lack of understanding on the technology (Amit et al., 1990; Shane & Cable, 2002).

As the information that an inventor owns for appropriability via technology entrepreneurship is more valuable, it is harder for the investors to share the information fully, the concern about knowledge leakage results in imperfect appropriability (Shane & Cable, 2002). Without full sharing of information, it is merely possible for the inventor or the prospective entrepreneur to obtain sufficient external funding or even to find a suitable investor. Even if the prospective investor is fully informed, he or she may not understand the information and assess economic value objectively due to the lack of background knowledge or the differences in the languages used (Amit et al., 1990). The investor has no option but to add an additional premium for the unknown risks, resulting in an increase of transaction cost (Anonymous, 1993). Therefore, these two problems of information asymmetry will lead to underinvestment, which is another possible definition of market failure in the technology entrepreneurship market.

Market failure, in general, justifies government intervention and it is not unlikely in technology entrepreneurship market (Salmenkaita & Salo, 2002). There exist many kinds of government policies towards technology entrepreneurship and these policies can be categorized by the degree of its involvement. A direct government intervention is a proactive fiscal policy by suppling adequate capital where underinvestment exists, expecting to fill the gap between the demand and the supply in the technology entrepreneurship market. Indirect government intervention, on the other hands, focuses on a construction of a healthy technology entrepreneurship ecology by amending related regulation including tax, so it is possible for a new or prospective entrant to fairly compete with the incumbent (Giesecke, 2000). Although there is the possibility of a difference in the effectiveness, government intervention will moderate the negative impact of market failure on technology entrepreneurship activity.

3.2. National culture, technology entrepreneurship, and government intervention

National culture is a system of shared values that distinguish people’s thinking, attitude, and even behavior (G. Hofstede et al., 2010). Along with the studies that consider entrepreneurial activities as an important source of national economic growth (Birley, 1987), attempts have been made both theoretically and empirically to reveal the existence and the magnitude of the effects of different dimensions of national culture on the level of entrepreneurship activity (Hayton et al., 2002). Most of the previous works, however, focus on the effect of national culture on overall entrepreneurship. Yet, entrepreneurship activities vary by their purposes (e.g., whether necessary or opportunity-driven), means (whether technology is involved) or even number of players involved. With the variation in entrepreneurial activities, it is presumed that the effect of national culture could be different. Among various types of entrepreneurship activities, technology entrepreneurial activity and the effect of national culture on it will be mainly studied in this literature.

The dimension “uncertainty avoidance vs. uncertainty acceptance” indicates the level of anxiety felt by people in an uncertain situation (G. Hofstede et al., 2010). A country with a high level of uncertainty avoidance is relatively less likely to be changed by, and less prepared to take the benefit of, uncertainty (Geert Hofstede, 2011). Technology entrepreneurship can be defined as being new and uncertain; therefore, a society with high uncertainty avoidance witnesses less technology entrepreneurial activity than that with low uncertainty avoidance level.

"Individualism vs. collectivism" is also one of the dimensions of national culture affecting the level of entrepreneurial activity. Individualism as a societal, not an individual characteristic, is the level of integration into a group. In a society with a high level of individualism, the ties between members are relatively loose and everyone cares about himself, herself, and the immediate family only (Geert Hofstede, 2011). Conventional theories of the effect of individualism on entrepreneurship indicate that a high level of individualism encourages entrepreneurship (Shane, 1993). Technology entrepreneurship, however, is distinguished by certain features and the effect of individualism on it can be somewhat different; thus, some studies have concluded that collectivism also has a positive effect on technology entrepreneurial activity (Morris, Davis, & Allen, 1994; Pinillos & Reyes, 2011)

Previous studies have revealed the effect of each dimensions of national culture on entrepreneurial activities and found that some aspects promotes, another aspects have no effect, and the other aspects are proved to hinder the entrepreneurial activities (Hayton et al., 2002). These differences in the effects of national cultural characteristics on entrepreneurship also emphasize the necessity of government intervention. The application of an appropriate government policy can alleviate the negative effect of national culture on the level of entrepreneurial activity where national culture is not supportive, and boost the positive effect of national culture where national culture is supportive. Summing up, government intervention in accordance with national cultural characteristics will increase the level of entrepreneurial activity (Giesecke, 2000).

4. Method

4.1. Data

Data on technology entrepreneurship activity are extracted from Global Entrepreneurship Monitor - Adult Population Survey (GEM-APS) and Data on government intervention and control variables of entrepreneurship educations and infrastructures are from GEM - National Expert Survey (GEM-NES).[1] The GEM project, with more than 120 participating countries, provides rich information on both the entrepreneurial behavior and attitudes of individuals (GEM-APS) and the national context and its impact on entrepreneurship (GEM-NES). The dependent variable, technology entrepreneurship, has been subdivided into three variables based on the newness of the technology involved – from 0 to 1 year (VNTE), from 1 to 5 years (NTE), and from 0 to 5 years (ANTE). The GDP per capita for each country comes from the World Bank. Finally, data for market failure are from Datastream database. Most of the missing information came from GEM, the survey-based data. After the exclusion of missing information, 199 observations from 49 countries covering 7 years (2007 – 2013)

[1] http://www.gemconsortium.org/data

constitute the panel data for analysis.

4.2. Variables

4.2.1. Measuring information asymmetry

Information asymmetry is one of the major determinants for market failure. To measure the information asymmetry for each country, the standard deviation of monthly market-adjusted stock return has been used (Dierkens, 1991; Krishnaswami & Subramaniam, 1999). The volatility in a firm's stock return represents the total amount of uncertainty about the firm. It consists of the firm-specific uncertainty and the market-specific uncertainty. After getting rid of the market uncertainty by calculating the standard deviation of the firm's market-adjusted stock return, only the firm-specific uncertainty caused by the inside information of the firm and the irrationality of the investors is left which can be defined as information asymmetry of the firm (Dierkens, 1991; Krishnaswami & Subramaniam, 1999). For the calculation, each country's major stock index price and the prices of the corresponding stocks on a monthly basis are taken from Datastream provided by Thomson Reuter's. After calculating the returns of each stocks and the stock indexes, market-adjusted stock returns are calculated. Finally, standard deviation of all the market-adjusted stock returns is calculated for each country and year. Information asymmetries calculated are shown in Table II-A1.

4.2.2. National culture

The set of data for national culture is obtained from the research done by Geert Hofstede (G. Hofstede et al., 2010). Among all the attempts to dimensionalize national culture based on empirical studies (Doney, Cannon, & Mullen, 1998), the work of Hofstede is one of the most widely adapted sets of data for both theoretical and empirical studies on innovation and entrepreneurship (Dheer, 2017; Halkos & Tzeremes, 2013; Hayton et al., 2002; Mueller & Thomas, 2001). Since his work first appeared in 1980, Hofstede and his colleagues has tried to make their data more general and sophisticated hoping that it would be adapted in many different field of studies (G. Hofstede et al., 2010). The final version of his data consists of 6 dimensions of national culture – Individualism, Uncertainty Avoidance, Power Distance, Masculinity, Long-term Orientation, and Indulgence (G. Hofstede et al., 2010). Among all the dimensions of national culture proposed by Hofstede, there are two dimensions, which are most frequently studied and proven to be effective on innovation and entrepreneurship –

Individualism and Uncertainty Avoidance (Birley, 1987; Hayton et al., 2002; Hill & Hult, 2014; Liñán & Fernandez-Serrano, 2014; Liñán, Moriano, & Jaén, 2016; McClelland, 1987; Morris et al., 1994; Mueller & Thomas, 2001).

These two dimensions of national culture are also used in this study. Table II-A2 shows the values of the four original dimensions of national culture for the countries used in this analysis.

There exist some critics warning against the implement of Hofstede's work for empirical research. One is that the set of data is out of date. The survey was begun in the 1960s and it is true that the partial set of data is quite old. Of course, there is an alternative which is relatively new called the GLOBE (House et al., 2004). National culture, however, is deeply rooted and the cultural values are formed in the early years of a person's life, tend to be "programmed" and remain stable over time (G. Hofstede et al., 2010). Thus, it can be concluded that there is no problem in using Hofstede's work, which is not out of date, but antique. There was also an attempt to validate Hofstede's national cultural dimension concluding that the score for each dimension is similar to the results presented in 1980's; therefore, there is no problem implementing Hofstede's work (Choi, 2015). Another point that followers of the GLOBE emphasize as a drawback of Hofstede's work is that there is no separation between the actual practices and the values. Again, National culture is deeply rooted and tends to be operated unconsciously (G. Hofstede et al., 2010). By separating the values and the actual practices, there is a possibility of credibility problems since the respondents are already exposed to the consciousness on their cultural behavior (Wennekers, Thurik, van Stel, & Noorderhaven, 2007).

4.2.3. Control variables

Several control variables are implemented to account for the technology entrepreneurship performance. Entrepreneurship education is known as one of the determinants for entrepreneurship performance, so the control variables representing entrepreneurship education are included in this analysis and they are basic-school entrepreneurship education and post-school entrepreneurship education (Maritz, Koch, & Schmidt, 2016). The variable 'basic-school entrepreneurship education' measures how effective the entrepreneurship education is at primary and secondary levels of school. The variable 'post-school entrepreneurship education' also measures the effect of entrepreneurship education, but in higher education institutes, such as vocational, college, business school, etcetera.

The importance of complementary assets, especially infrastructure, on innovation activity has long been emphasized and the control variable ‘physical and service infrastructure’ and the variable ‘commercial and professional infrastructure’ have been added as tangible assets and intangible assets, respectively, for analyzing the role of complementary assets (Mazzucato & Semieniuk, 2017; Salmenkaita & Salo, 2002; Teece, 1986). The variable ‘physical and service infrastructure’ is defined in GEM-NPS as “ease of access to physical resources – communication, utilities, transportation, land or space – at a price that does not discriminate against small and new firms.” The variable ‘commercial and professional infrastructure’ is defined as “The presence of property rights, commercial, accounting and other legal and assessment services and institutions that support or promote new and small firms.”

The control variable ‘Internal market openness’ represents the extent to which new firms are free to enter existing market. Hosts of possible entry barriers, such as monopoly, technological level, rent protection, quality standard, etcetera and their negative effects on innovation have been discussed in numerous previous studies

Table II-4 Descriptions of variables

Variable	Definition	Description
ANTE	All New Technology Entrepreneurship	percentage of 18-64 population those who involved in entrepreneurial activity with technology (0 to 5 years)
VNTE	Very New Technology Entrepreneurship	percentage of 18-64 population those who involved in entrepreneurial activity with technology (0 to 1 year)
NTE	New Technology Entrepreneurship	percentage of 18-64 population those who involved in entrepreneurial activity with technology (1 to 5 year)
IA	Information Asymmetry	the standard deviation of market-adjusted stock returns
IDV	Individualism	the level of individualism
UAI	Uncertainty Avoidance	the level of uncertainty avoidance
GOV	Government Intervention	average of direct government intervention and indirect government intervention
DGI	Direct Government Intervention	The presence and quality of programs including grants and subsidies directly assisting SMEs at all levels of government.
IGI	Indirect Government Intervention	The extent to which public policies including taxation and regulations are either size-neutral or encourage new and SMEs

Table II-4 Descriptions of variables (Cont'd)

Variable	Definition	Description
BSEdu	Basic School Education of Entrepreneurship	The extent to which training in creating or managing SMEs is incorporated within the education and training system at primary and secondary levels
PSEdu	Post School Education of Entrepreneurship	The extent to which training in creating or managing SMEs is incorporated within the education and training system in higher education such as vocational, college, business schools, etc.
PSinfra	Physical and Service infrastructure	Ease of access to physical resources—communication, utilities, transportation, land or space—at a price that does not discriminate against SMEs
Cpinfra	Commercial and professional infrastructure	The presence of property rights, commercial, accounting and other legal and assessment services and institutions that support or promote SMEs
IMO	Internal Market Openness	The extent to which new firms are free to enter existing markets
GDPcap	Gross Domestic Product per capita	natural logarithm of GDP per capita

(Dinopoulos & Syropoulos, 2007; Foxon, 2002; Maxwell, 1998; Stiglitz, 2010); so, the variable controlling entry barrier has been added to the analysis.

Finally, GDP per capita is included in this analysis to control the effect of development level on technology entrepreneurship (Liñán & Fernandez-Serrano, 2014; Pinillos & Reyes, 2011). Table II-4 summarizes the variables and descriptions and Table II-5 shows descriptive statistics.

Table II-5 Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Dependent Variables				
ANTE	2.918	2.670	0.000	23.693
VNTE	1.074	1.442	0.000	16.802
NTE	1.844	1.479	0.000	6.890
Market Failure				
IA	0.410	1.035	0.058	8.620
National Culture				
IDV	48.106	23.860	12.000	91.000
UAI	67.950	22.909	8.000	100.000
Government Intervention				
GOV	2.660	0.435	1.655	3.660
DGI	2.604	0.470	1.590	3.670
IGI	2.717	0.456	1.720	3.710
Control Variable				
BSEdu	2.074	0.345	1.370	3.070
PSEdu	2.856	0.298	2.210	3.580
PSInf	3.805	0.427	2.820	4.700
CPInf	3.078	0.363	2.200	3.990
IMO	2.605	0.323	1.920	3.610
GDPcap	10.161	0.623	7.855	11.406
Observations				199

4.3. Empirical model

There are three possible methods for the analysis, which are pooled ordinary least squares model (OLS), fixed effect model (FE), and random effect model (RE). Pooled OLS can be used on the condition that all the variances across entities are zero. To find out the suitability of pooled OLS method, Breusch-Pagan Lagrange multiplier test (LM test) was conducted, with the conclusion that there are variances across entities; therefore, pooled OLS is not suitable (Breusch & Pagan, 1980). The difference between implementing FE or RE is whether the variances across entities are constant or random, respectively. By conducting the Hausman test (Hausman, 1978), it is concluded that the variances across entities are random; therefore, RE is the more suitable method than FE. Summing up, Random effect panel analysis has been used for the analysis.

To confirm the causal relationship among dependent variables, path analysis using structural equation model is conducted. For the purpose of the analysis, the fundamental assumption on national culture is that it is deeply rooted and hard to be changed over time (Hofstede, 2011; Mueller & Thomas, 2001). The inter-relation between government intervention and market failure, however, was needed to be confirmed, since both variables may interact. As the result of path analysis, it is found that there is no interaction between government intervention and market failure. Rather, it is shown that there exists a casual effect from government intervention to market failure. By conducting confirmatory factor analysis using the sequential equation model, it is also found that all measurement variables successfully represent latent variables, technology entrepreneurship, market failure, national culture, and government intervention. There exists one exception which is ‘NTE’, entrepreneurship activity with technology emerged 1 to 5 years ago. To find out the change in the roles of determinants on technology entrepreneurship varied by the novelty of technology involved, however, it is decided to include NTE in the analysis.

4.4. Estimation equations

4.4.1. Direct effects of market failure, national culture, and government intervention on technology entrepreneurship

Equation (1) is constructed to analyze the direct effect of information asymmetry, national culture, and the following specify government intervention on technology entrepreneurial activity and the model:

$$TE_{it} = \alpha + \beta_1 IA_{it} + \beta_2 IDV_i + \beta_3 UAI_i + \beta_4 GOV_{it} + \gamma_1 BSEdu_{it} + \gamma_2 PSEdu_{it} + \gamma_3 PSInf_{it} + \gamma_4 CPInf_{it} + \gamma_5 IMO_{it} + \gamma_6 GDPcap_{it} + \varepsilon_{it} \quad \text{eq (1)}$$

Where TE_{it} is technology entrepreneurial Activity for country i at time t. IA_{it} is information asymmetry for country i at time t. IDV_i and UAI_i are national culture dimensions of individualism and uncertainty avoidance, respectively, for country i. GOV_{it} is government intervention for country i at time t. $BSEdu_{it}$, $PSEdu_{it}$, $TInf_{it}$, $IInf_{it}$, IMO_{it}, and $GDPcap_{it}$, which are basic-school entrepreneurship education, post-school entrepreneurship education, physical and service infrastructure, commercial and professional infrastructure, internal market openness, and gross domestic production per capita, respectively, for country i at time t, are used as control variables.

To reveal the different roles of direct and indirect governmental intervention, the term GOV_{it} in equation (1) is replaced with two other terms and the modified model is as follows.

$$TE_{it} = \alpha + \beta_1 IA_{it} + \beta_2 IDV_i + \beta_3 UAI_i + \beta_4 DGI_{it} + \beta_5 IGI_{it} + \gamma_1 BSEdu_{it} + \gamma_2 PSEdu_{it} + \gamma_3 PSInf_{it} + \gamma_4 CPInf_{it} + \gamma_5 IMO_{it} + \gamma_6 GDPcap_{it} + \varepsilon_{it} \quad \text{eq(2)}$$

Where TE_{it} is technology entrepreneurial activity for country i at time t; IA_{it} is information asymmetry for country i at time t; IDV_i and UAI_i are national culture dimensions of individualism and uncertainty avoidance, for country i, respectively. DGI_{it} and IGI_{it} are direct government intervention and indirect government intervention, for country i at time t, respectively. $BSEdu_{it}$, $PSEdu_{it}$, $TInf_{it}$, $IInf_{it}$, IMO_{it}, and $GDPcap_{it}$ are used as control variables, which are basic-school entrepreneurship education, post-school entrepreneurship education, physical and service infrastructure, commercial and professional infrastructure, internal market openness, and gross domestic production per capita, for country i at time t, respectively.

4.4.2. Moderating effects of government intervention

Equation (3) accounts for the moderating effect of government intervention. In the model, it is analyzed how government intervention moderates the relationships between information asymmetry and technology entrepreneurship activity and between national culture and technology entrepreneurship activity. Specification of the model is as follows.

$$\mathrm{TE}_{it} = \alpha + \beta_1 IA_{it} + \beta_2 IDV_i + \beta_3 UAI_i + \beta_4 GOV_{it} + \gamma_1 IA * GOV_{it}$$

$$+ \gamma_2 IDV * GOV_{it} + \gamma_3 UAI * GOV_{it} + \delta_1 BSEdu_{it} + \delta_2 PSEdu_{it} + \delta_3 PSInf_{it}$$

$$+ \delta_4 CPInf_{it} + \delta_5 IMO_{it} + \delta_6 GDPcap_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{eq(3)}$$

Where TE_{it} is technology entrepreneurial Activity for country i at time t. IA_{it} is information asymmetry for country i at time t. IDV_i and UAI_i are national culture dimensions, which are individualism and uncertainty avoidance, for country i, respectively. GOV_{it} is government intervention for country i at time t, respectively. $IA * GOV_{it}$ is the interaction term between information asymmetry and government intervention for country i at time t. $IDV * GOV_{it}$ and $UAI * GOV_{it}$ represent interacting terms between national culture and government intervention which are individualism and government intervention for country i at time t and uncertainty avoidance and government intervention for country i at time t. Control variables are $BSEdu_{it}$, $PSEdu_{it}$, $TInf_{it}$, $IInf_{it}$, IMO_{it}, and $GDPcap_{it}$, which are basic-school entrepreneurship education, post-school entrepreneurship education, physical and service infrastructure, commercial and professional infrastructure, internal market openness, and gross domestic production per capita, for country i at time t, respectively.

To reveal the different moderating roles of direct governmental intervention and indirect government intervention, the term GOV_{it} in equation (3) is replaced with two other terms and the modified model is as follows.

$$\begin{aligned}\mathrm{TE}_{it} = {} & \alpha + \beta_1 IA_{it} + \beta_2 IDV_i + \beta_3 UAI_i + \beta_4 DGI_{it} + \beta_5 IGI_{it} + \gamma_1 IA * DGI_{it} \\ & + \gamma_2 IA * IGI_{it} + \gamma_3 IDV * DGI_{it} + \gamma_4 IDV * IGI_{it} + \gamma_5 UAI * DGI_{it} \\ & + \gamma_6 UAI * IGI_{it} + \delta_1 BSEdu_{it} + \delta_2 PSEdu_{it} + \delta_3 PSInf_{it} + \delta_4 CPInf_{it} \\ & + \delta_5 IMO_{it} + \delta_6 GDPcap_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{eq(4)}\end{aligned}$$

Where TE_{it} is technology entrepreneurial Activity for country i at time t. IA_{it} is information asymmetry for country i at time t. IDV_i and UAI_i are national culture dimensions, which are individualism and uncertainty avoidance, for country i, respectively. DGI_{it} and IGI_{it} are government intervention which are direct government intervention and Indirect government intervention, for country i at time t, respectively. $IA * DGI_{it}$ and $IA * IGI_{it}$ are the interaction terms between information asymmetry and direct government intervention for country i at time t and between information asymmetry and indirect government intervention for country i at time t, respectively. $IDV * DGI_{it}$, $IDV * IGI_{it}$, $UAI * DGI_{it}$, and $UAI * IGI_{it}$ represent interacting terms between national culture and government intervention which are individualism and direct government intervention, individualism and indirect government intervention for country, uncertainty avoidance and direct government intervention, and uncertainty avoidance and indirect government intervention, respectively, for country i at time t. Finally, $BSEdu_{it}$, $PSEdu_{it}$, $TInf_{it}$, $IInf_{it}$, IMO_{it}, and $GDPcap_{it}$, which are basic-school entrepreneurship education, post-school entrepreneurship education, physical and service infrastructure, commercial and professional infrastructure, internal market openness, and gross domestic production per capita, for country i at time t, respectively, are used as control variables.

5. Results

5.1. Direct effects of market failure, national culture, and government intervention on technology entrepreneurship

The direct effect of information asymmetry, national culture, and government intervention has been tested and the results are shown in Table II-6. According to the results, only the coefficients of individualism – one of the national culture – are significantly negative, regardless of the newness of the technology involved in entrepreneurial activities. The coefficients for information asymmetry, uncertainty avoidance, and government intervention are not statistically significant. In other words, it is shown that the direct effect of individualism is observed while the others are not observed. Among the control variables, basic-school education of entrepreneurship is shown to be positively effective on the level of technology entrepreneurial activity.

Table II-6 Direct effects of market failure, national culture, and government intervention on technology entrepreneurship

	ANTE		VNTE		NTE	
Market Failure						
IA	-0.001	(0.046)	-0.011	(0.032)	0.01	(0.018)
National Culture						
IDV	**-0.051****	**(0.025)**	**-0.041****	**(0.019)**	**-0.016***	**(0.009)**
UAI	-0.019	(0.020)	-0.015	(0.015)	-0.005	(0.007)
Governmental Intervention						
GOV	0.944	(0.749)	0.340	(0.260)	0.437	(0.488)
Control Variable						
BSEdu	**1.347****	**(0.577)**	0.576	(0.357)	**0.709****	**(0.290)**
PSEdu	-0.712	(0.532)	-0.312	(0.244)	-0.25	(0.308)
PSInf	0.257	(0.537)	-0.037	(0.277)	0.341	(0.274)
CPInf	-0.083	(0.630)	-0.02	(0.314)	-0.219	(0.361)
IMO	-0.752	(0.688)	-0.099	(0.282)	-0.454	(0.451)
GDPcap	-0.932	(0.704)	0.119	(0.438)	**-0.758****	**(0.350)**
Constant	**14.449***	**(7.529)**	2.359	(4.787)	**9.366*****	**(3.512)**

Standard errors in parentheses　　*, **, *** represent 0.1, 0.05, 0.01 significance, respectively

The direct effect of information asymmetry, national culture, and government intervention has been analyzed. To figure out the different roles and the effects on technology entrepreneurship, government intervention has been subdivided into direct intervention and indirect intervention, assuming that these two interventions affect technology entrepreneurial activity differently. The empirical results are shown in Table II-7.

The results in Table II-7 are not much different from results in Table II-6. The coefficients of individualism remain significantly negative throughout for all types of technology entrepreneurial activities, showing that individualism gives negative effect on technology entrepreneurial activity level. All other factors including information asymmetry, uncertainty avoidance, and both direct and indirect government intervention are shown to have no effect on technology entrepreneurship. Basic-school entrepreneurial education, again, is observed to be positively effective.

Table II-7 Direct effects of market failure, national culture, and direct and indirect government interventions on technology entrepreneurship

	ANTE		VNTE		NTE	
Market Failure						
IA	0.004	(0.045)	-0.009	(0.032)	0.012	(0.019)
National Culture						
IDV	**-0.051****	**(0.025)**	**-0.041****	**(0.02)**	**-0.016***	**(0.009)**
UAI	-0.020	(0.020)	-0.015	(0.015)	-0.005	(0.007)
Governmental Intervention						
DGI	0.207	(0.624)	0.039	(0.315)	0.068	(0.358)
IGI	0.655	(0.669)	0.259	(0.268)	0.328	(0.429)
Control Variable						
BSEdu	**1.287****	**(0.554)**	0.546	(0.364)	**0.678****	**(0.268)**
PSEdu	-0.635	(0.586)	-0.273	(0.279)	-0.209	(0.324)
PSInf	0.243	(0.546)	-0.044	(0.283)	0.336	(0.277)
CPInf	-0.107	(0.642)	-0.033	(0.309)	-0.226	(0.369)
IMO	-0.721	(0.659)	-0.082	(0.27)	-0.443	(0.439)
GDPcap	-0.868	(0.734)	0.155	(0.455)	**-0.725****	**(0.359)**
constant	**14.024***	**(7.641)**	2.11	(4.861)	**9.132*****	**(3.538)**

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

5.2. Moderating effects of government intervention

The moderating effects of government intervention on the relationship between market failure and technology entrepreneurship and between national culture and technology entrepreneurship are tested. By adding the interaction term between information asymmetry and governmental intervention, as well as that between national culture and government intervention, the indirect effect of government intervention can be analyzed and the results are shown in Table II-8.

For the overall technology entrepreneurship, the coefficient of information asymmetry is negative and that of the interacting term between information asymmetry and government intervention is positive and statistically significant in Table II-8. The results are about the same for the entrepreneurship with the latest technology that the coefficient of information asymmetry and that of the interacting term with government intervention are also observed to be significant. These findings show that information asymmetry negatively affects technology entrepreneurship and the government intervention alleviates that negative effect of information asymmetry on technology entrepreneurship. Neither direct nor indirect effect of national culture on technology entrepreneurship is observed. Basic-school education on entrepreneurship continues to be effective positively on the technology entrepreneurial activity.

Table II-8 Moderating effect of government intervention

	ANTE		VNTE		NTE	
Market Failure						
IA	**-0.428***	**(0.253)**	**-0.304****	**(0.120)**	-0.095	(0.126)
National Culture						
IDV	-0.012	(0.068)	-0.027	(0.033)	0.009	(0.036)
UAI	-0.058	(0.067)	-0.037	(0.033)	-0.018	(0.034)
Governmental Intervention						
GOV	0.474	(2.298)	-0.100	(0.965)	0.486	(1.185)
Market Failure X Government intervention						
IA*GOV	**0.156***	**(0.082)**	**0.108*****	**(0.039)**	0.038	(0.043)
National Culture X Government intervention						
IDV*GOV	-0.015	(0.024)	-0.005	(0.009)	-0.010	(0.014)
UAI*GOV	0.014	(0.020)	0.008	(0.008)	0.005	(0.012)
Control Variable						
BSEdu	**1.456****	**(0.609)**	**0.632***	**(0.374)**	**0.749****	**(0.309)**
PSEdu	-0.733	(0.546)	-0.318	(0.249)	-0.276	(0.321)
PSInf	0.331	(0.513)	-0.004	(0.276)	0.367	(0.273)
CPInf	-0.019	(0.601)	0.02)	(0.299)	-0.179	(0.362)
IMO	-0.784	(0.679)	-0.141	(0.273)	-0.449	(0.454)
GDPcap	-0.950	(0.723)	0.062	(0.433)	**-0.745***	**(0.382)**
constant	15.461	(10.281)	3.918	(5.950)	**8.913****	**(4.333)**

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

Government intervention is segmented into direct intervention and indirect intervention, and their moderating effects on technology entrepreneurial activity are tested and the results are as shown in Table II-9.

First, the coefficient of information asymmetry is significantly negative for the overall technology entrepreneurial activity, showing that there is a negative effect of information asymmetry on technology entrepreneurship. The coefficient of direct government intervention is significantly negative while that of indirect government intervention is significantly positive proving that there exists direct effect of both types of government interventions on technology entrepreneurship but in opposing directions. Moderating effect of direct intervention on uncertainty avoidance is positive, while indirect effect of indirect intervention is not observed. Among the control variables, basic-school entrepreneurial education is observed to have a positive effect.

The coefficient of information asymmetry is still negative for the entrepreneurial activity with the latest technology involved. The coefficient of the interacting term of direct government intervention with information asymmetry and that of indirect intervention with information asymmetry are significantly positive and negative, respectively. The coefficient of interaction between uncertainty avoidance and direct government intervention is positive and statistically significant.

When entrepreneurial activity with relatively less new technology is the dependent variable, neither the direct effect nor the indirect effect of information asymmetry is observed, while direct effects of both direct intervention and indirect intervention are shown to be significant, but with the different signs. Once again, it is proved that there is a moderating effect of direct intervention on uncertainty avoidance.

Table II-9 Moderating effects of direct and indirect government interventions

	ANTE		VNTE		NTE	
Market Failure						
IA	**-0.412****	**(0.196)**	**-0.308*****	**(0.071)**	-0.071	(0.147)
National Culture						
IDV	-0.032	(0.071)	-0.032	(0.037)	-0.005	(0.035)
UAI	-0.089	(0.069)	-0.050	(0.035)	-0.035	(0.037)
Governmental Intervention						
DGI	**-4.005***	**(2.372)**	-1.534	(1.420)	**-2.437****	**(1.143)**
IGI	**3.288***	**(1.986)**	1.023	(0.911)	**2.210****	**(1.074)**
Market Failure X Government intervention						
IA*DGI	0.166	(0.106)	**0.179*****	**(0.043)**	-0.042	(0.078)
IA*IGI	-0.030	(0.133)	**-0.091***	**(0.053)**	0.082	(0.091)
National Culture X Government intervention						
IDV*DGI	0.017	(0.024)	0.005	(0.015)	0.012	(0.012)
UAI*DGI	**0.045****	**(0.018)**	**0.018***	**(0.010)**	**0.026****	**(0.013)**
IDV*IGI	-0.026	(0.021)	-0.008	(0.009)	-0.018	(0.014)
UAI*IGI	-0.021	(0.019)	-0.005	(0.008)	-0.015	(0.011)
Control Variable						
BSEdu	**1.429****	**(0.591)**	0.614	(0.385)	**0.759*****	**(0.287)**
PSEdu	-0.673	(0.614)	-0.317	(0.297)	-0.223	(0.337)
PSInf	0.441	(0.486)	0.039	(0.266)	**0.427***	**(0.258)**
CPInf	0.046	(0.625)	0.050	(0.293)	-0.145	(0.381)
IMO	-0.821	(0.631)	-0.167	(0.246)	-0.462	(0.452)
GDPcap	-0.685	(0.737)	0.131	(0.447)	-0.553	(0.393)
constant	15.780	(10.604)	4.327	(6.038)	**8.685***	**(4.453)**

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

6. Discussion

The relationships among market failure, national culture, government intervention, and technology entrepreneurial activity are analyzed in several different models, which vary according to the differences in the level of technology novelty, in the level of economic development, and in the directness of government intervention. Throughout the analysis, findings about the determinants are discovered.

6.1. Information asymmetry and technology entrepreneurship

As hypothesized in the previous chapter, it is found that information asymmetry negatively affects technology entrepreneurship. This finding provides strong evidence that information asymmetry is a major factor for underinvestment in the market, resulting in underperformance of technology entrepreneurship.

An interesting finding from the empirical analysis of the effect of information asymmetry on technology entrepreneurship is that the role of the novelty of the technology involved in entrepreneurial activity. It is found that the negative effects of information asymmetry on technology entrepreneurship vary by the newness of the technology involved in the entrepreneurial activities. It is found that information asymmetry affects negatively on the entrepreneurship with the technology appeared in the market less than a year ago, whereas there exists no effect of information asymmetry on the entrepreneurial activity with the technology emerged 1 to 5 years ago. This finding is reasonable and acceptable in that technology itself is a type of information. The latest technology is relatively newer, and therefore more uncertain. This makes it difficult for both inventors and investors; the former find it more difficult to disclose all the information to the investors and the latter find it more difficult to assess the value of the latest technology and its economic potential without any reference on that technology (Amit et al., 1990; Anonymous, 1993; Shane & Cable, 2002). Therefore, entrepreneurship using latest technology suffers more from information asymmetry.

6.2. National culture and technology entrepreneurship

Individualism – one of the national cultural dimensions – has a direct negative effect on technology entrepreneurial activity. This finding is in conflict with the conventional theory that posits a relationship between individualism and entrepreneurship (McClelland, 1987; Mueller & Thomas, 2001). The reasons for the difference between the conventional theory and the findings in this study can be explained by the unique features of technology entrepreneurship that distinguish it from ordinary entrepreneurship. The key feature is that the technology entrepreneurship activities face higher risk than the ordinary entrepreneurship. Collectivist countries, compared to individualist countries, tend to place a higher value on risk-sharing (Autio, Pathak, & Wennberg, 2013). The higher the level of societal risk sharing, the more technology entrepreneurial activity will be witnessed. The other feature is that technology entrepreneurial activities tend to be occurred in a corporate environment where the group or team is more important for accomplishing entrepreneurship than it is in other types of entrepreneurships. Collective societies value 'we' or 'group' more than 'I' or 'individual'; therefore, collective culture is more suitable for technology entrepreneurship than individualistic culture. Summing up, technology entrepreneurship can be characterized by its higher risk, and corporate setting, and these features made individualism less favorable to collectivism for technology entrepreneurial activity.

6.3. Market failure, national culture and government intervention

The results from the empirical analysis show that no direct effect of government intervention on technology entrepreneurship is found but there is an indirect effect interacting with information asymmetry. In accordance with the theoretical works on the justification of the need of government intervention (Anonymous, 1993; Dodgson, Hughes, Foster, & Metcalfe, 2011; Salmenkaita & Salo, 2002), this finding proves empirically that the government intervention is justified when a market failure occurs. Government intervention has been subdivided into direct intervention and indirect intervention and both direct and indirect effects on technology entrepreneurship are tested. The result shows that direct government policy brings negative effect and indirect government policy gives positive effect on technology entrepreneurial activity. From the results of indirect intervention, it is proved that indirect government intervention on technology entrepreneurship is effective by constructing a healthy technology entrepreneurship ecology such that the prospective entrants are able to freely compete with the incumbents (Giesecke, 2000).

The overall effectiveness of the direct intervention, however, should be assessed with the consideration of both direct and indirect effects on technology entrepreneurial activity. The interacting term between uncertainty avoidance and direct government intervention is shown to be positive. It implies that the overall effectiveness of the direct government intervention varies by the level of uncertainty avoidance. By considering the coefficient of both direct and indirect effects of direct intervention on technology entrepreneurship, the following shows the calculation of the overall effectiveness of the direct government intervention, μ, on technology entrepreneurship numerically.

$$\mu DGI = \beta_4 DGI + \gamma_5 UAI * DGI = (\beta_4 + \gamma_5 UAI) DGI$$

$$\mu = (\beta_4 + \gamma_5 UAI) \quad where\ \beta_4 = -4.005, \gamma_5 = 0.045, 8 \leq \mathrm{UAI} \leq 100$$

$$\mathrm{Min}\ \mu = \mathrm{Min}\ (\beta_4 + \gamma_5 UAI) = (-4.005 + 0.045 * 8) = -3.645$$

$$\mathrm{Max}\ \mu = \mathrm{Max}\ (\beta_4 + \gamma_5 UAI) = (-4.005 + 0.045 * 100) = 0.495$$

$$-3.645 \leq \mu \leq 0.495$$

With the value of UAI ranging from 8 to 100, the value of μ, the overall effectiveness of the direct government intervention ranges from -3.645 to 0.495. This implies that the direct government intervention has a positive effect on technology entrepreneurship when uncertainty avoidance level is high, whereas a negative effect is expected in countries with low level of uncertainty avoidance. In other words, the overall effectiveness of the direct government intervention varies from negative to even positive, based on the level of uncertainty avoidance. This finding gives a policy implication in that the level of uncertainty avoidance should be considered when implementing direct government intervention. Figure II-2 shows the level of uncertainty avoidance for each country. The score of 89 for uncertainty avoidance represents the indifference to direct government intervention. Countries with uncertainty avoidance higher than 89 can enjoy the advantage from implementing direct government policy; thus, their governments should allocate more resources to direct government policy on technology entrepreneurship. On the other hand, those with an uncertainty avoidance level lower than 89 can be harmed if they implement a direct government policy; thus, their governments should lower the expenses on direct government intervention.

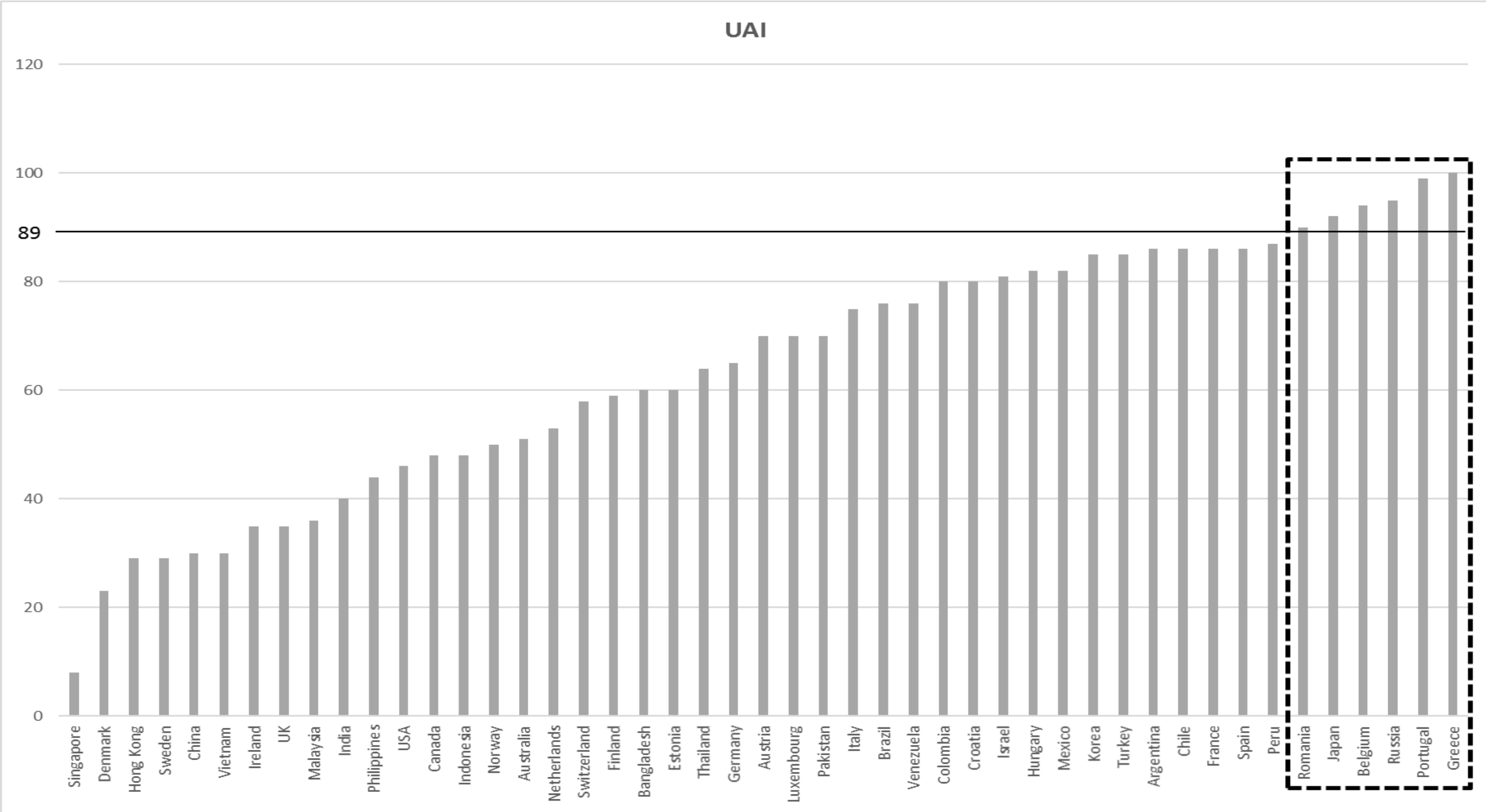

Figure II-2 Uncertainty avoidance level of the countries

The most important factor found from the result above is that the direct government intervention moderates the effect of uncertainty avoidance – one of the national cultural dimension – on technology entrepreneurial activity level, whereas indirect government intervention is not effective in moderating the relationship between uncertainty avoidance and technology entrepreneurship. Shane (1993) argues that the government intervention can change the values of people in a way that encourages entrepreneurship. Hofstede (1980), on the other hand, maintains that culture is deeply rooted and hard to be changed over time (Mueller & Thomas, 2001). This finding is in accordance with the previous literature that the more effective method to improve technology entrepreneurship performance in a society with high level of uncertainty avoidance is not by constructing a favorable ecology system via implementation of indirect policies, expecting a change in the values of the society towards entrepreneurship. Instead, it can be done by sharing the risk with direct policies that help the prospective entrepreneurs to lower the uncertainty level (Giesecke, 2000; Mueller & Thomas, 2001).

The difference of the moderating effects of direct and indirect government intervention on the relationship between information asymmetry and technology entrepreneurship is also tested empirically. The results show that the direct government intervention positively moderates the effect of information asymmetry while the indirect government intervention negatively moderates the effect of information asymmetry on entrepreneurship with the latest technology. This finding implies that the direct government intervention is more effective in alleviating the market failure, especially when the technology involved in the entrepreneurial activity is more recent. This finding has implications for designing innovation policy in that it gives a hint for evaluating the allocation of resources to direct and indirect policies of technology entrepreneurship. By considering the coefficients of both direct intervention and indirect intervention, the following shows the calculation of the overall effectiveness of information asymmetry, ω, on entrepreneurial activity with the latest technology.

$$\omega IA = \beta_1 IA + \gamma_1 IA * DGI + \gamma_2 IA * IGI = (\beta_1 + \gamma_1 DGI + \gamma_2 IGI) IA$$

$$\omega = (\beta_1 + \gamma_1 DGI + \gamma_2 IGI)$$

$$where\ \beta_1 = -0.308, \gamma_1 = 0.179, \gamma_2 = -0.091, 1.82 \leq DGI \leq 3.67, 1.89 \leq \mathrm{I}GI \leq 3.65$$

$$\mathrm{Min}\ \omega = \mathrm{Min}\ (\beta_1 + \gamma_1 DGI + \gamma_2 IGI) = (-0.308 + 0.179DGI - 0.091IGI) = -0.314$$

$$\mathrm{Max}\ \omega = \mathrm{Max}\ (\beta_1 + \gamma_1 DGI + \gamma_2 IGI) = (-0.308 + 0.179DGI - 0.091IGI) = 0.176$$

$$-0.314 \leq \omega \leq 0.176$$

The value of ω – the overall effectiveness of information asymmetry – is ranged from -0.314 to 0.176. This implies that the overall effectiveness of information asymmetry on entrepreneurship activity with the latest technology varies from negative to even positive by the moderating effects of direct and indirect government interventions. Figure II-3 shows the overall effects of a unit of information asymmetry on entrepreneurial activity with the latest technology for each country. According to Figure II-3, countries in the box successfully moderate the negative effect of market failure by the suitable allocation of resources on direct and indirect policies. The other countries, however, suffer from the negative effects of market failure in technology entrepreneurship market, and the resources should be allocated more to direct policy and less to indirect policy.

As discussed earlier, the effectiveness of direct government intervention, and indirect government intervention varies according to the novelty of the technologies involved in technology entrepreneurship. This finding gives policy implication in that the technology level of each country should be taken into account when designing a government institution or policy. Firms in the countries with relatively higher level of technology can be termed as 'early adaptors' or 'leaders', and face negative effect of market failure due to information asymmetry. It is recommended that the governments of these countries intervene more directly. For the countries with relatively lower level of technology termed as 'followers’, indirect intervention is recommended but direct intervention should be implemented with the consideration of the uncertainty avoidance level.

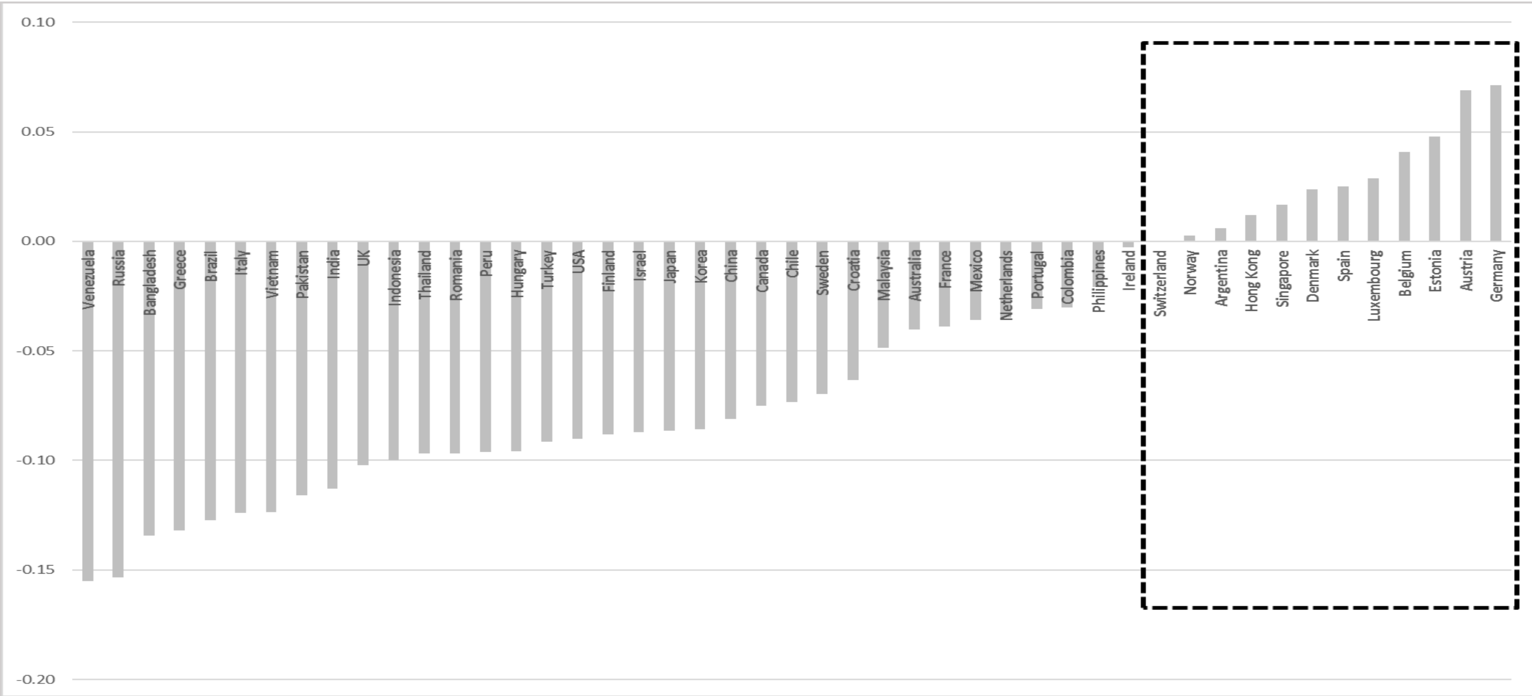

Figure II-3 Overall effect of a unit of information asymmetry on entrepreneurship with the latest technology

6.4. Additional analysis

In econometric terms, the number of observation seems to be insufficient to cover all the variables to be tested, which might cause the impairment of the empirical results in terms of credibility. To find out the robustness of the empirical results, two alternative analytic methods are additionally tested. One method is to reduce the control variables. By conducting correlation analysis of the control variables, it is found that the variable IMO is highly correlated with BSEdu and CPInfra. IMO is then omitted from the analysis, and the comparison of the results obtained before and after omission is shown in Table II-A3. In Table II-A3, Model (1) is the result with IMO, and Model (2) is the result without IMO. As shown in Table II-A3, most of the coefficient are similar in both models. Although there is one exception of the coefficient of IA on ANTEA, it is still in line with the finding that the effects of information asymmetry on technology entrepreneurship vary by the novelty of technology involved in entrepreneurship activity.

The other method is to test the moderating effects of direct government intervention and indirect government intervention in two separate models and the results of the comparison are shown in Table II-A4. In Table II-A4, model (1) shows the result of the analysis with both direct and indirect government interventions, model (2) shows the result with only direct intervention, and model (3) shows the result with only in direct intervention. As shown in Table II-A4, the results from all the models are similar in terms of statistical significance. As an additional analysis, the distributions of dependent variables has been checked, since the number of observation is small, which may impair the results of hypothesis testing when the distributions of dependent variables are not normal. The histograms of the three dependent variables are presented in Figure II-A1, Figure II-A2, and Figure II-A3. It is shown that all the dependent variables are very skewed, which may cause inference problems. To not only solve this problem, but also test the robustness, the three dependent variables are transformed into square root forms, and the empirical analysis is conducted. Table II-A5 shows the comparison results. Model (1) represents the results before the transformation of the dependent variables, and Model (2) shows the results after the transformation. In Table II-A5, the statistical significances of most coefficients remains the same although the absolute values of the coefficients decreased due to the transformation of the dependent variables. Unlike the results in model (1), the moderating effect of indirect government intervention on uncertainty avoidance is found, which is statistically negative. The finding is in line with the previous discussion that the more effective method to improve technology entrepreneurship performance in a society with high level of uncertainty avoidance is not the construction of a favorable ecology system by implementing indirect policies expecting the change in the values of the society towards entrepreneurship. Instead, the solution lies in implementing direct policies that help the prospective entrepreneurs to lower the uncertainty level they face by sharing the risk.

7. Conclusion

In this study, the relationships among market failure, national culture, government intervention, and technology entrepreneurship are analyzed using a set of panel data of 49 countries for 7 years, from 2007 to 2013. Several noteworthy findings are observed from the results of the empirical analysis. First, information asymmetry affects technology entrepreneurship negatively. This finding proves empirically that information asymmetry is a major factor for underinvestment in the market resulting in the underperformance of technology entrepreneurship. Second, the effect of information asymmetry varies by the novelty of technology involved in the entrepreneurial activity. Entrepreneurial activity involving latest technology suffers more from information asymmetry. Third, individualism – one of the national cultural dimensions – has a negative effect on technology entrepreneurship. Technology entrepreneurship requires risk-sharing and corporate environments, which is more suitable in a collective society. Fourth, indirect government intervention gives a positive effect on technology entrepreneurship proving that indirect government intervention supports the construction of a healthier ecology system in the technology entrepreneurship market. Last, direct government intervention is positively effective in moderating the negative effect of uncertainty avoidance on technology entrepreneurial activity level. This finding proves that lowering the level of uncertainty for the prospective entrepreneur by sharing their risk through direct policies such as grants or subsidies is effective in improving the technology entrepreneurship performance.

The academic contributions of this paper are as followed. First, the variable representing market failure has been used as a determinant of technology entrepreneurship performance. Most of the previous discussions are based only on either theoretical analysis or case studies (Dodgson, Hughes, Foster, & Metcalfe, 2011; Giesecke, 2000; Salmenkaita & Salo, 2002), but this article introduces an empirical analysis of market failure by implementing the measurement of information asymmetry, one of the key factors explaining market failure (Dierkens, 1991; Krishnaswami & Subramaniam, 1999; Shane & Cable, 2002).

Second, the effects of market failure, national culture, and government intervention on technology entrepreneurship have been studied simultaneously. Previous studies only focused on either the effect of market failure and the government intervention on innovation or that of the social context and the government intervention on innovation performance (Dodgson et al., 2011; Giesecke, 2000; Hayton et al., 2002; Mueller & Thomas, 2001; Salmenkaita & Salo, 2002). By considering all determinants of technology entrepreneurship simultaneously, it becomes possible for the governments to help evaluate their technology entrepreneurship policies or institutions under various conditions, such as economic, social-contextual, and technological level.

In summary, the effect of market failure, national culture, and both the direct effect and the moderating effects of government interventions on technology entrepreneurship have been analyzed empirically. As Mueller and Thomas (2001) state, conventional theories are not suitable for the explanation of the behaviors observed in a society when differences exist in culture or in economic systems interacting with the environmental conditions. It is strongly suggested from the findings of the study that all three factors of market, technology, and societal context should be taken into account simultaneously when establishing technology entrepreneurship policies.

8. Limitations

One of the limitations of this study is that only individualism and uncertainty avoidance are tested to find out the effectiveness on technology entrepreneurship. Even though previous studies emphasize the importance of those two national cultural dimensions on innovation performance, expanding the empirical model to include the other national cultural dimensions will enrich the implications to a great extent.

Another limitation of the study is that the size of the data set was not sufficient to test all the variables; thus, the countries or years with lots of missing information (some countries began to participate in the middle of the project, and some countries did not respond during some of the years in GEM survey data) were not omitted. In the further research, it is believed that the shortage of the data problem can be solved by expanding the duration of the sample collection.

The other limitation of the study is that only the control variables at national level are included for the empirical analysis. By implementing industry-level control variables such as technology level of the industry, not only the policy implications, but also the organization-level of implications can be derived.

Conclusion

The effects of innovation strategy and policy on technology commercialization performance are analyzed in this dissertation. The dissertation involves two essays attempting to provide implications at both firm level and national level. In the first essay, the combination effects of intellectual property methods on product innovation performance and the moderating role of the technological complexity of industry on the combination effects are investigated by using firm-level survey data. The results from the cross-section empirical analysis show that complementary effects exist when intellectual property protection methods are implemented simultaneously. The results also show that the combination effect of formal and informal intellectual property protection methods is varied by the complexity of industrial technology level. These findings provide several implications for the managers of the manufacturing firms. First, implementing two or more protection methods from the same group is more effective for product innovation performance than implementing no method or just one method of intellectual property protection. Second, in discrete industries, additional implementation of informal protection methods is found to be ineffective, or even harmful for economic performance. Last, in complex industries, implementation of an additional informal protection method is suggested because of the synergy expected when both formal and informal protection methods of intellectual property are implemented together.

In the second essay, the effects of information asymmetry, one of the major determinants for market failure; national culture, which represents the values of those people belonging to the society; and government intervention on technology entrepreneurship are studied. The implications from the results of the random-effect panel analysis are as follows. First, information asymmetry affects technology entrepreneurship negatively, which justifies government intervention. Second, entrepreneurial activity with the latest technology suffers more from information asymmetry. Third, indirect government intervention is positively effective in improving technology entrepreneurship performance, while direct government policy is effective for alleviating the problem of market failure. Fourth, individualism – one of the national cultural dimensions – gives a negative effect on technology entrepreneurship. Last, direct government intervention has a positively effect in moderating the negative effect of uncertainty avoidance on technology entrepreneurial activity. These findings suggest to the policy makers that government intervention on technology entrepreneurship should be instituted in accordance with both market situations and societal values, which, in turn, has a close connection with the national economic growth.

Appendix

Table I-A1 Comparison of moderating effects for the presence of Tr

	Model 1		Model 2	
Variable	**Coefficient**	**Robust SE**	**Coefficient**	**Robust SE**
Configuration of IPPMs				
SF&NI	0.023	0.036	0.023	0.037
NF&SI	0.010	0.036	0.012	0.036
MF&NI	**0.264***	0.140	**0.340****	0.141
NF&MI	0.141	0.104	**0.204****	0.101
SF&SI	**−0.328*****	0.117	**−0.220***	0.129
MF&SI	−0.133	0.099	−0.074	0.099
SF&MI	−0.077	0.098	0.015	0.099
MF&MI	0.040	0.047	**0.128****	0.053
Interaction between use of multiple IPPMs and technological complexity of industry				
MF&NI*Tr	−0.036	0.024	**−0.051****	0.025
NF&MI*Tr	−0.008	0.018	−0.020	0.017
SF&SI*Tr	**0.070*****	0.024	**0.049***	0.027
MF&SI*Tr	**0.049****	0.021	**0.037***	0.021
SF&MI*Tr	**0.034****	0.017	0.015	0.018
MF&MI*Tr	**0.016****	0.007	−0.002	0.009

***, **, *** represent significance levels of 10%, 5%, and 1%, respectively.**

Table I-A1 Comparison of moderating effects for the presence of Tr (Cont'd)

	Model 1		Model 2	
Variable	**Coefficient**	**Robust SE**	**Coefficient**	**Robust SE**
Control variable				
Tr			**0.000*** **	0.000
Year	−0.001	0.001	−0.001	0.001
RnDExp	**0.019*** **	0.004	**.018*** **	0.004
SM	**0.106*** **	0.021	**.103*** **	0.021
VB	**0.054*** **	0.021	**0.050** **	0.021
EGP	**0.038** **	0.016	**0.034** **	0.016
RndLab	−0.021	0.019	−0.025	0.019
HSE	0.000	0.000	0.000	0.000
FTR	0.000	0.000	0.000	0.000
InJoint	0.022	0.018	0.025	0.018

***, **, *** represent significance levels of 10%, 5%, and 1%, respectively.**

Table I-A2 Comparison of the results with and without sales and administrative expense

Variable	(1a)	(1b)	(2a)	(2b)
	coefficient	coefficient	coefficient	coefficient
Configuration of IPPMs				
SF&NI	0.023	0.023	0.027	0.027
NF&SI	0.011	0.010	0.014	0.012
MF&NI	**0.082****	**0.264***	**0.084****	**0.271***
NF&MI	**0.100*****	0.141	**0.103*****	0.147
SF&SI	0.047	**−0.328*****	0.051	**−0.306****
MF&SI	**0.105*****	−0.133	**0.109*****	−0.127
SF&MI	**0.099*****	−0.077	**0.103*****	−0.067
MF&MI	**0.125*****	0.040	**0.127*****	0.059
Interaction between use of multiple IPPMs and technological complexity of industry				
MF&NI*Tr		−0.036		−0.037
NF&MI*Tr		−0.008		−0.008
SF&SI*Tr		**0.070*****		**0.067*****
MF&SI*Tr		**0.049****		**0.048****
SF&MI*Tr		**0.034****		**0.032***
MF&MI*Tr		**0.016****		**0.013***
Control variable				
Year	0.000	−0.001	−0.001	−0.001
RnDExp	**0.020*****	**0.019*****	**0.018*****	**0.018*****
SM	**0.104*****	**0.106*****	**0.104*****	**0.106*****
VB	**0.060*****	**0.054*****	**0.060*****	**0.054*****
EGP	**0.029***	**0.038****	**0.027***	**0.034****
RndLab	−0.021	−0.021	−0.023	−0.022
HSE	0.000	0.000	0.000	0.000
FTR	0.000	0.000	0.000	0.000
InJoint	0.020	0.022	0.021	0.023
SAExp	0.000		**0.001*****	**0.001****

***, **, *** represent significance levels of 10%, 5%, and 1%, respectively.**

Table II-A1 Information asymmetry for 47 countries

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
Argentina	0.126	0.130	0.157	0.120	0.114	0.114	0.139	0.163	0.158
Australia	0.220	0.327	0.309	0.255	0.218	0.224	0.279	0.289	0.846
Austria	0.147	0.146	0.201	0.162	0.126	0.753	0.138	0.124	0.197
Bangladesh	0.175	0.376	0.282	0.230	0.932	0.111	0.139	0.103	0.101
Belgium	0.188	0.523	2.238	0.336	3.043	0.473	0.150	0.701	0.147
Brazil	1.902	8.620	0.352	1.506	0.192	0.139	0.121	0.133	0.241
Canada	0.148	0.206	0.275	0.170	0.187	1.124	0.159	0.249	0.533
Chile	0.078	0.087	0.109	0.665	0.134	0.099	0.919	0.114	0.077
China	0.231	0.139	0.145	0.105	0.095	0.101	0.108	0.147	0.208
Colombia	1.674	0.423	0.094	0.466	0.097	0.104	0.097	0.085	0.073
Croatia	0.267	0.198	0.202	0.157	0.218	0.140	0.167	0.154	0.159
Denmark	0.088	0.184	0.196	0.132	0.319	0.125	0.205	0.130	0.123
Estonia	0.103	0.120	0.181	0.117	0.073	0.069	0.058	0.054	0.062
Finland	0.090	0.126	0.130	0.093	0.105	0.105	0.107	0.095	0.115
France	0.214	0.215	0.460	0.248	0.193	0.949	0.150	0.171	0.173
Germany	0.239	0.520	2.279	1.596	0.913	8.481	0.655	0.365	0.202
Greece	0.204	0.147	0.158	0.158	0.225	0.299	0.289	0.203	0.224
Hong Kong	0.380	0.238	0.256	0.173	0.215	0.157	0.190	0.215	0.245
Hungary	0.352	0.230	0.429	0.104	0.173	0.300	0.257	0.136	0.170
India	0.834	0.201	0.187	0.128	0.311	0.142	0.413	0.168	0.175
Indonesia	0.260	0.172	0.196	0.212	0.177	0.214	0.195	0.131	0.129
Ireland	0.107	0.173	0.252	0.159	0.203	0.238	0.197	0.186	0.130
Israel	0.157	0.154	0.403	1.550	0.171	0.312	0.308	2.701	0.570
Malaysia	0.158	0.134	0.212	0.172	0.134	0.202	0.138	0.114	0.113
Italy	0.086	0.111	0.144	0.107	0.124	0.688	0.133	0.107	0.100
Japan	0.103	0.140	0.148	0.109	0.124	0.115	0.151	0.116	0.104
Korea	0.190	0.160	0.188	0.148	0.165	0.150	0.131	0.127	0.163
Luxembourg	0.078	0.132	0.128	0.110	0.119	0.072	0.086	0.084	0.099
Mexico	0.103	0.110	0.144	0.099	0.100	0.077	0.092	0.078	0.070

Table II-A1 Information asymmetry for 47 countries (Cont'd)

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015
Netherlands	0.091	0.139	0.186	0.155	0.172	0.141	0.113	0.117	0.106
Norway	0.092	0.152	0.166	0.127	0.131	0.143	0.171	0.128	0.139
Pakistan	0.261	3.218	0.481	0.415	0.153	0.245	0.160	0.228	0.127
Peru	0.685	0.306	0.198	0.217	0.436	0.220	0.147	0.069	0.074
Philippines	0.237	2.879	0.572	0.336	0.346	0.249	0.123	0.154	0.292
Portugal	0.190	0.125	0.103	0.083	0.139	0.176	0.148	0.157	0.148
Romania	0.425	0.364	3.251	1.251	0.294	0.204	0.323	0.197	0.282
Russia	0.195	0.201	0.300	0.193	0.961	0.170	0.155	0.170	0.203
Singapore	0.184	0.171	0.206	0.125	0.129	0.160	0.160	0.147	0.242
Spain	0.163	0.108	0.108	0.084	0.065	0.094	0.084	0.058	0.091
Sweden	0.104	0.243	0.196	0.176	0.134	0.169	0.159	0.109	0.142
Switzerland	0.085	0.096	0.112	0.078	0.086	0.105	0.069	0.148	0.092
Thailand	0.146	0.152	0.148	0.123	0.365	0.141	0.391	0.226	2.361
Turkey	0.146	0.157	0.164	0.203	0.144	0.148	0.150	0.126	0.135
UK	0.144	0.238	0.339	0.221	0.205	0.159	0.291	0.186	0.187
USA	0.160	1.265	5.916	1.632	0.860	4.966	0.249	0.164	0.198
Venezuela	0.130	0.139	0.098	0.070	0.361	0.676	1.827	4.834	1.910
Vietnam	0.158	0.150	0.150	0.113	0.115	0.150	0.136	0.124	0.114

Table II-A2 Values of national culture dimensions

Country	PDI	IDV	MAS	UAI	Country	PDI	IDV	MAS	UAI
Argentina	49	46	56	86	**Japan**	54	46	95	92
Australia	38	90	61	51	**Korea**	60	18	39	85
Austria	11	55	79	70	**Luxembourg**	40	60	50	70
Bangladesh	80	20	55	60	**Malaysia**	100	26	50	36
Belgium	65	75	54	94	**Mexico**	81	30	69	82
Brazil	69	38	49	76	**Netherlands**	38	80	14	53
Canada	39	80	52	48	**Norway**	31	69	8	50
Chile	63	23	28	86	**Pakistan**	55	14	50	70
China	80	20	66	30	**Peru**	64	16	42	87
Colombia	67	13	64	80	**Philippines**	94	32	64	44
Croatia	73	33	40	80	**Portugal**	63	27	31	99
Denmark	18	74	16	23	**Romania**	90	30	42	90
Estonia	40	60	30	60	**Russia**	93	39	36	95
Finland	33	63	26	59	**Singapore**	74	20	48	8
France	68	71	43	86	**Spain**	57	51	42	86
Germany	35	67	66	65	**Sweden**	31	71	5	29
Greece	60	35	57	100	**Switzerland**	34	68	70	58
Hong Kong	68	25	57	29	**Thailand**	64	20	34	64
Hungary	46	80	88	82	**Turkey**	66	37	45	85
India	77	48	56	40	**UK**	35	89	66	35
Indonesia	78	14	46	48	**USA**	40	91	62	46
Ireland	28	70	68	35	**Venezuela**	81	12	73	76
Israel	13	54	47	81	**Vietnam**	70	20	40	30

Source: (Geert Hofstede, 2011)

Table II-A3 Comparison of the results with and without the variable, IMO

	(1)			(2)		
	ANTE	**VNTE**	**NTE**	**ANTE**	**VNTE**	**NTE**
Market Failure						
IA	**-0.412****	**-0.308*****	-0.071	-0.279	**-0.281*****	0.003
National Culture						
IDV	-0.032	-0.032	-0.005	-0.027	-0.03	-0.002
UAI	-0.089	-0.050	-0.035	-0.08	-0.048	-0.031
Governmental Intervention						
DGI	**-4.005***	-1.534	**-2.437****	**-4.011***	-1.54	**-2.427****
IGI	**3.288***	1.023	**2.210****	**3.369***	1.043	**2.216****
Market Failure X Government intervention						
IA*DGI	0.166	**0.179*****	-0.042	0.122	**0.170*****	-0.066
IA*IGI	-0.030	**-0.091***	0.082	-0.025	**-0.090***	0.084
National Culture X Government intervention						
IDV*DGI	0.017	0.005	0.012	0.02	0.005	0.013
UAI*DGI	**0.045****	**0.018***	**0.026****	**0.041****	**0.017***	**0.024***
IDV*IGI	-0.026	-0.008	-0.018	-0.03	-0.009	-0.02
UAI*IGI	-0.021	-0.005	-0.015	-0.019	-0.005	-0.014
Control Variable						
BSEdu	**1.429****	0.614	**0.759*****	**1.331****	0.595	0.703**
PSEdu	-0.673	-0.317	-0.223	-0.606	-0.303	-0.194
PSInf	0.441	0.039	**0.427***	0.407	0.031	0.409
CPInf	0.046	0.050	-0.145	-0.378	-0.038	-0.374
IMO	-0.821	-0.167	-0.462			
GDPcap	-0.685	0.131	-0.553	-0.678	0.123	-0.543
constant	15.780	4.327	**8.685***	14.638	4.176	**8.060***

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

Table II-A4 Comparison of the results with both DGI and IGI, with DGI, and with IGI

	(1)			(2)			(3)		
	ANTE	**VNTE**	**NTE**	**ANTE**	**VNTE**	**NTE**	**ANTE**	**VNTE**	**NTE**
Market Failure									
IA	**-0.412****	**-0.308*****	-0.071	**-0.500****	**-0.366*****	-0.084	-0.287	**-0.194***	-0.088
National Culture									
IDV	-0.032	-0.032	-0.005	-0.035	-0.034	-0.005	-0.005	-0.025	0.012
UAI	-0.089	-0.050	-0.035	-0.108	-0.057	-0.043	-0.021	-0.02	-0.001
Governmental Intervention									
DGI	**-4.005***	-1.534	**-2.437****	-1.291	-0.75	-0.444			
IGI	**3.288***	1.023	**2.210****				1.375	0.356	0.888
Market Failure X Government intervention									
IA*DGI	0.166	**0.179*****	-0.042	**0.165*****	**0.120*****	0.029			
IA*IGI	-0.030	**-0.091***	0.082				0.118	**0.075***	0.041

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

Table II-A4 Comparison of the results with both DGI and IGI, with DGI, and with IGI (Cont'd)

	(1)			(2)			(3)		
	ANTE	**VNTE**	**NTE**	**ANTE**	**VNTE**	**NTE**	**ANTE**	**VNTE**	**NTE**
National Culture X Government intervention									
IDV*DGI	0.017	0.005	0.012	-0.007	-0.002	-0.005			
UAI*DGI	**0.045****	**0.018***	**0.026****	0.031	**0.015***	0.014			
IDV*IGI	-0.026	-0.008	-0.018				-0.018	-0.006	-0.011
UAI*IGI	-0.021	-0.005	-0.015				0.001	0.002	-0.001
Control Variable									
BSEdu	**1.429****	0.614	**0.759*****	**1.680****	**0.709***	**0.864****	**1.326****	0.582	**0.675****
PSEdu	-0.673	-0.317	-0.223	-0.804	-0.349	-0.295	-0.61	-0.276	-0.212
PSInf	0.441	0.039	**0.427***	0.334	0.001	0.357	0.366	0.019	0.38
CPInf	0.046	0.050	-0.145	0.076	0.069	-0.165	-0.096	-0.018	-0.196
IMO	-0.821	-0.167	-0.462	-0.876	-0.193	-0.467	-0.617	-0.077	-0.382
GDPcap	-0.685	0.131	-0.553	-0.903	0.046	**-0.684***	-0.825	0.161	**-0.720****
constant	15.780	4.327	**8.685***	**19.773****	5.841	**10.868*****	11.249	1.528	**7.302***

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

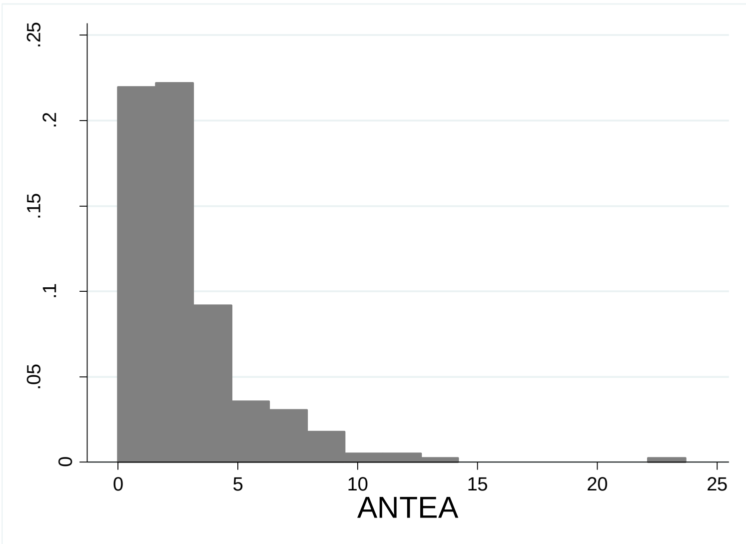

Figure II-A1 Distribution of the dependent variable, ANTEA

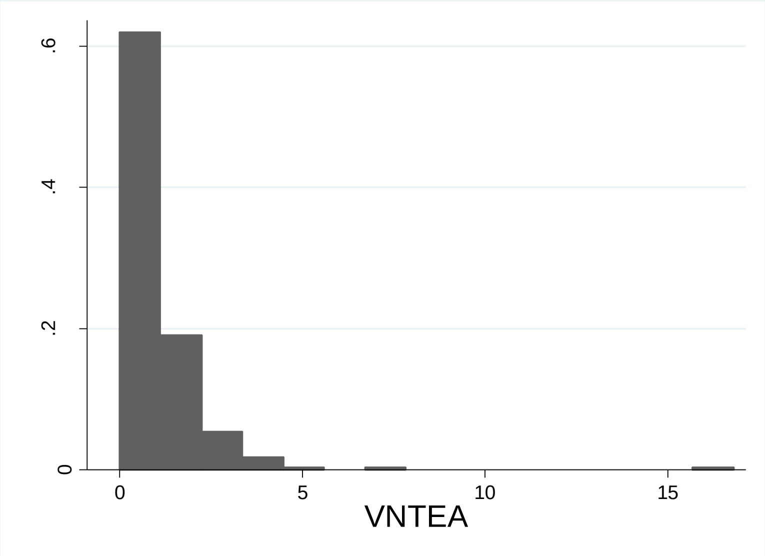

Figure II-A2 Distribution of the dependent variable, VNTEA

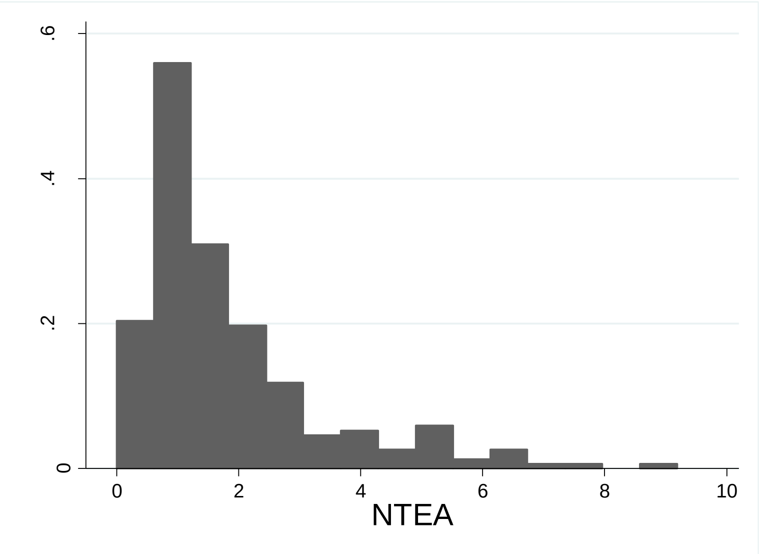

Figure II-A3 Distribution of the dependent variable, NTEA

Table II-A5 Comparison of the empirical results before and after the transformations of the dependent variables

	(1)			(2)		
	ANTE	**VNTE**	**NTE**	**ANTE**	**VNTE**	**NTE**
Market Failure						
IA	**-0.412****	**-0.308*****	-0.071	**-0.110***	**-0.215*****	0.01
National Culture						
IDV	-0.032	-0.032	-0.005	-0.007	-0.008	-0.003
UAI	-0.089	-0.050	-0.035	-0.023	-0.021	-0.012
Governmental Intervention						
DGI	**-4.005***	-1.534	**-2.437****	**-1.230***	-0.781	**-0.906****
IGI	**3.288***	1.023	**2.210****	0.903	0.457	**0.733***
Market Failure X Government intervention						
IA*DGI	0.166	**0.179*****	-0.042	0.042	**0.084*****	-0.015
IA*IGI	-0.030	**-0.091***	0.082	0.001	-0.014	0.019
National Culture X Government intervention						
IDV*DGI	0.017	0.005	0.012	0.003	0.000	0.003
UAI*DGI	**0.045****	**0.018***	**0.026****	**0.017*****	**0.012****	**0.012****
IDV*IGI	-0.026	-0.008	-0.018	-0.004	-0.001	-0.004
UAI*IGI	-0.021	-0.005	-0.015	**-0.010***	-0.005	**-0.008***
Control Variable						
BSEdu	**1.429****	0.614	**0.759*****	**0.373****	0.207	**0.283*****
PSEdu	-0.673	-0.317	-0.223	-0.162	-0.125	-0.08
PSInf	0.441	0.039	**0.427***	0.226	0.086	**0.217***
CPInf	0.046	0.050	-0.145	0.07	0.096	-0.024
IMO	-0.821	-0.167	-0.462	-0.211	-0.09	-0.15
GDPcap	-0.685	0.131	-0.553	-0.202	-0.089	-0.185
constant	15.780	4.327	**8.685***	**4.606****	**3.061***	**3.394*****

standard errors in parentheses *, **, *** represent 0.1, 0.05, and 0.01 significance, respectively

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Abstract (Korean)

본 학위논문은 혁신 전략과 정책이 기술사업화 활성화에 미치는 영향을 분석하였다. 혁신의 국가의 경제적 발전에 가장 중요한 결정 요소 중 하나로 꼽히고 있으며, 혁신 성과를 극대화하기 위해선 기업 혹은 산업 수준의 혁신 전략과 국가 수준의 혁신 정책에 대한 동시적 조명이 필요하다. 이에 본 논문에서는 혁신 전략 중 지식재산권 보호 수단의 활용 전략이 제품혁신성과에 미치는 영향과, 기술창업시장에서의 시장실패와 이에 대한 정부 정책의 영향을 함께 살펴 보았다.

첫번째 에세이에서는 다양한 지식재산보호수단의 동시적인 활용이 제품혁신성과에 가져오는 효과를 분석하였다. 2010 한국혁신조사의 자료를 바탕으로 가장 많이 활용되는 지식재산보호수단들을 제도적 보호 수단과 비제도적 보호수단으로 나누고, 그룹 내 혹은 그룹간의 조합에서 오는 보완 효과를 확인하였다. 또한, 지신재산보호수단의 보완 효과가 산업 마다 차이가 있을 것으로 예상되는 바, 지식재산 보호 수단이 제품혁신성과에 미치는 보완성에 대한 조절 효과를 추가로 검증하였다. 기존 연구의 경우, 산업의 기술복잡성을 산업 코드에 따라 2분화하여 더미 변수로 활용하거나, 특정 산업을 선별하여 비교분석을 시행하였으나, 본 연구에서는 산업기술복잡성을 적용함에 있어서 특허 덤불의 개념을 활용한 연속 변인의 형태로 분석에 도입함으로서 모든 제조산업들을 분석대상으로 삼았을 뿐만 아니라, 지식재산 보호수단들의 보완성에 미치는 조절효과까지 확인할 수 있었다. 연구 결과, 같은 그룹 내의 지식재산 보호 수단이 동시적으로 활용될 경우, 제품혁신성과에 미치는 보완성

을 확인 할 수 있었으며, 그룹 간의 지식재산 보호 수단이 동시적으로 활용될 경우, 산업의 기술수준이 복잡해질수록 제품혁신성과에 미치는 보완 효과가 증가함을 확인 할 수 있었다. 이와 같은 결과를 통하여 지식재산 보호 수단의 활용, 즉 지식재산 전략에 있어서 다양화의 중요성과 산업의 기술수준이 함께 고려되어야 한다는 전략적 함의를 도출할 수 있었다.

두번째 에세이에서는 정보비대칭에서 야기되는 기술창업 시장실패와 이에 대한 정책 형태의 정부 개입이 기술창업활동에 미치는 영향을 분석하였다. 또한, 기술창업 시장과 정부 정책을 연구함에 있어서 비경제적 혹은 사회적 요소 또한 함께 고려되어야 하기에 국가문화차원 중 개인주의와 위험회피성이 기술 창업에 미치는 영향을 분석에 추가하였다. 2007년부터 2013년까지 49개국의 패널데이터를 분석한 결과, 정보비대칭과 개인주의는 기술 창업에 부정적인 영향을 미치는 것으로 나타났으며, 정보비대칭의 부정적인 영향은 기술의 신규성이 높은 경우 더욱 크게 나타났다. 정부개입의 경우, 간접적인 정부의 개입은 기술 창업에 긍정적인 영향을 주는 것으로 나타났으며, 정부의 직접적인 개입이 위험회피성이 기술 창업에 미치는 부정적인 영향을 조절해 줌은 물론, 정보비대칭이 최신기술창업에 미치는 부정적인 영향을 감쇄해 주는 것으로 나타났다. 이와 같은 결과를 통하여, 혁신 정책을 수립함에 있어서 경제적 요소들은 물론, 국가의 기술수준과 국가 문화적 요소들이 함께 고려되어야 한다는 정책적 함의를 도출할 수 있었다.

주요어: 지식재산보호수단, 제품혁신성과, 시장실패, 국가문화, 정부개입, 기술창업

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