THREE ESSAYS ON GLOBALIZATION AND INNOVATION

by

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ABSTRACT OF THE DISSERTATION

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Globalization is a key variable associated with technological change. This dissertation examines not only the correlation between globalization and innovation, but also the interacting effect of globalization with firm-specific variables on innovation and performance.

Essay 1: Why Do Some Countries Hardly Innovate? Evidence from Zero Inflated Negative Binomial Model[1]

The patent data from the United States Patent and Trademark Office (USPTO) indicate that among 175 countries, between 1977 and 2010, about 45% hardly generated any innovations. We argue that this group of countries is systematically different from the others who have been innovative, and that non-innovative countries need to possess a minimum level of ability and incentive in order to progress. By employing a zero-inflated negative binomial model based on the patent data from the USPTO, the results show that

[1] The first chapter is co-authored by Jun Xiang.

the significant determinants *turning* a non-innovative country into an innovative one are active international trade, improved quality of civil liberties, a high level of human capital, and less economic reliance on natural resources.

Essay 2: Two Different Effects of R & D on Innovation in South Korea: Evidence from The Firm Level Data

At the firm level, innovation can be made through two different effects of research and development (R & D), which are the *creative effect* and the *learning effect*. It should be noted that export activities can offer an important source of learning—as important as foreign direct investment (FDI)—and may be exceptionally meaningful for firms in countries with export-oriented economies. Using longitudinal firm-level data for the period of 2000–2009 in South Korea, empirical tests show that the creative effect of R & D is far more important than the learning effects through export and FDI in generating innovation.

Essay 3: The Dynamic Relationship between Female Employment and Firm Profitability: A Three-Stage Sigmoid Curve Model and the Influence of Export

Female workers are sources of competitive and intangible assets that can enhance a firm's profitability. I present arguments that the correlation between gender diversity and organizational performance needs to be investigated in terms of more complex corporate circumstances. Empirical analyses of longitudinal firm-level data from South Korea for 2000–2009 show that a firm's female workers are more positively related to a firm's profitability when the firm actively exports. In addition, the results demonstrate a sigmoid curve relationship between female workers and profitability.

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Essay 1: Why Do Some Countries Hardly Innovate? Evidence from Zero Inflated Negative Binomial Model

1. Introduction

A country's innovations are the key driving forces in improving economic output and thus for their long–term economic growth. Innovation can directly influence productive processes; therefore, a country can gain more outputs out of the same amount, or even less, of inputs (Stokey, 1995). Innovative activities contribute to the growth of not only the host country, but also other neighboring countries and therefore the global economy because new technological knowledge is not exclusive property of the country that discovered it, but rather a public good for every other country with volition to pursue. Active usage of technological knowledge by various actors enhances the original value of ideas. These enhanced ideas are still non-exclusive goods available to everyone and can be upgraded further to drive long-term growth. It is virtuoso cycle. Likewise, Romer (1993) argued that ideas are non-rival goods, and Park (1995) noted that even if the benefits of new technological knowledge are fully appropriated by the inventor and the agent has a monopoly right for the effort, the idea can be still spread across the world through diversified channels (e.g., publications, seminars, personal contacts, reverse engineering, and joint ventures).

This paper used a panel of data to examine which determinants of innovation a country should possess, and at what level, to have the resources and incentives in place to become an innovating country accordingly using a sample of 178 countries for the period of 1977-2010 from the United States Patent and Trademark Office (USPTO). A key asset of this study is to explain the series of zero patents or continuous non-innovating status of

almost half of the sample countries, rather than how much the level of innovation is predicted to change through explanatory variables. We argue that if a country does not possess a certain threshold level of resources (e.g., human capital, GDP) and incentives (e.g., quality of domestic institutions, less reliance on natural resources, and exposure to international market), the country will not turn into an innovating country and thus post zero patents over successive years.

In addition, we emphasize the effects of democracy on the innovation of the countries using all major organizational indexes (i.e. Freedom House, Polity IV Project, and ACLP Political and Economic Database) that measure the level of democracy frequently used by social scientists. Political scientists have analyzed economic growth while focusing on institutional factors that affect economics, such institutional disruptions (e.g., wars or revolutions) or political regimes (e.g., Doucouliagos and Ulubaşoğlu, 2008; Baum and Lake, 2003; Leblang, 1996). However, in spite of the importance of innovation, they scarcely touched on innovation along with these institutional factors, a necessary research area in political science. Currently, innovation is not as popular a subject as economic growth for political scientists, and much research on innovation is actively investigated by economists. However, economists' explanatory variables are based on economic variables, for example, trade, foreign direct investment (FDI), or human capital, and omit important political factors, particularly democracy, which critically affect national innovation rates, too. In this sense, analyses from two different worlds cannot sufficiently explain the true motivation of national innovative activities. The world of political science lacks research on innovation, while the world of

economics should enhance its analyses with additional political variables. Such a deficiency motivates us to work on this research.

Empirical tests show that a country can turn into an innovating country if that country meets a certain threshold level of determinants of innovation. These innovation determinants can offer resources and incentives to potential innovators. The highly significant determinants are improved quality of civil liberties, high level of human capital and economic resources and performance, active international trade, and less economic reliance on natural resources.

The paper is organized as follows. Section 2 reviews the theoretical and empirical literature background of existing papers, which have been examined by economists to show the degree of the effects of several determinants of innovation promotion. Section 3 describes our main research questions and theory. Section 4 summarizes our data and empirical model, and discusses the results of our econometric analysis along with some policy implications. Section 5 concludes the paper.

2. Literature Review

2.1 Trade and FDI

Today, advances in technology occur globally and are induced by various methods. Among the methods, trade and FDI receive the most attention from economists. Particularly, exports have cited as having a significant positive effect on innovation. Due to increased competition and the demands of discerning customers in global markets,

exports increase the demand for newer and more advanced technology and thus result in more investments to create new idea and improve products. Similarly, Pack and Saggi (1997), Alvarez and Robertson (2004), Ciruelos and Wang (2005), and Schneider (2005) argue that facing more rigorous requirements from external clients and competitors in export-oriented markets motivate companies to update existing technologies and boost performance. Verhoogen (2008) shows that exporters in developing countries manufacture high-quality goods to attract consumers in developed countries and the quality of exporting goods is higher than those intended for domestic markets. Additionally, exporters can increase foreign reserves by external consumers paying with foreign currencies; therefore, exporters can purchase more advanced machinery and equipment from abroad to innovate further (Fu, 2008). Alvarez and Robertson (2004) investigate the effect of percentage of production exported on technological activities measured by a survey sent to 541 manufacturing plants in Chile and 5242 in Mexico for the period from 1993 to 1995 and find a significant positive effect on innovation in both countries. Braga and Willmore (1991) show that among 4342 industrial establishments in Brazil, the establishments exporting abroad invest much more in the quality of the plant's output with modern methods. The significant positive effects of export on innovation are not limited to developing countries. Girma (2005) investigates the effect of share of exports in total shipments of manufacturing firms in the UK from 1989 to 1999 and finds it significantly and positively affects the total factor productivity (TFP) of the firms. While examining the effect of Canadian plant exports to the US market from 1984 to 1996, Lileeva and Trefler (2010) suggest that the exports encourage the plants to increase

their labor productivity, and that these plants engage in more product innovation and adoption of advanced manufacturing technologies for the period.

On the other hand, the effect of competition for imports and FDI can be opposite to that of exports because severe competition in local level by cheaper and higher quality goods from abroad may steal "*domestic market share*" and shrink sales. Thus, the firms cannot invest in R & D or other technology-related projects as actively as before.[1] Similarly, Joseph Schumpeter theorizes that competitive markets are not necessarily the most effective environment to promote innovation because lower profits by harsh competition will blunt innovative activities (as cited in Gilbert, 2006, p.6; Bloom et al., 2011, p.7). In addition, local market share is not the only thing stolen by foreign companies; "*local talent"* can be acquired by foreign companies through highly competitive salaries and benefits. Similarly, Blomström and Kokko (1998) note that one of the expected benefits of FDI, technology spillovers through labor turnover between foreign firms and domestic firms, cannot be easily observed in reality. Also, even if many foreign companies' R & D activities are known to be performed in their host countries (Alvarez and Robertson, 2004), exactly what type or the importance of the R & D projects performed in host countries are rarely known (Blomström & Kokko, 1998). According to a recent report by Zhou (2006), more than 80% of R & D labs in China

[1] On the other hand, globally, many host countries have liberalized the policies on foreign investment because they believe in the positive effects of FDI. The expected positive effects of FDI include the following: Firms in the host country can learn more advanced technology through demonstrations by foreign companies, utilize a more expanded global network already constructed by multinational corporations, and raise productivity and efficiency through the relationship between local suppliers and MNCs affiliates requiring high-quality outcomes (Ciruelos and Wang, 2005; Alvarez and Robertson, 2004; Hejazi and Safarian, 1999; and Blomström and Kokko, 1998). However, it should be noted that such spillover effects can be effectively investigated when firm-level data (e.g. the employment share of foreign firms, the share of capital owned by non-residents in a firm) is available.

owned by foreign companies do not have any plans to collaborate with domestic labs, local companies, or local universities.

The negative effects of imports and FDI on domestic market share and innovative activities in host countries have also been shown empirically. Recently, Bloom and others (2011) investigated the effect of imports from China to 12 European countries' establishments after the 1990s. They found that the more a population is exposed to Chinese imports, the more the employment and survival rates of domestic firms that are not competitive in technology fall. Teshima (2008) concludes that import competition (low tariff) does not make local firms in Mexico invest in product R & D between 2000 and 2003. In other words, import competition does not motivate domestic firms to engage in more creative works or to upgrade quality. Based on 308 manufacturers in the United States for the period from 1971 to 1987, Scherer and Huh (1992) find that intensity of high-technology imports reduces domestic firms' R & D/sales ratio and such reduction becomes more exaggerated over the longer run. Cheung and Lin (2004) show that inward FDI has no significant positive effect on technology related patents in 26 different provinces in China for the period from 1995 to 2000. Girma and others (2001) investigate whether FDI (the share of foreign companies' employment and output) affects the productivity and wages of domestic manufacturing firms in the UK, one of the largest hosts for FDI in the world, and do not find an aggregate result of intra-industry spillovers in the UK from 1991 to 1996. They also show that foreign firms may damage domestic firms with large technology gaps. Konings (2001) concludes that the significant negative effects of FDI (shares of foreign investors) dominate the revenue of domestic firms in Bulgaria and finds no positive effects for FDI in Romania either.

2.2 Human Capital

Without doubt, if a country does not have a sufficient level of human capital, it cannot create more valuable technology and thus compete with advanced goods from abroad. Similarly, Dakhli and De Clercq (2004) emphasize the role of human capital in converting various forms of capital or products into more useful resources by tailoring them to local markets and other types of economic benefits. Cheung and Lin (2004) find that the significant and positive effect of local human capital, when measured by R & D inputs (i.e. R & D expenditure and the number of personnel focused on science and technology development), influences the number of patents related to innovation in 26 provinces in China between 1995 and 2000.

Moreover, a country without a sufficient level of human capital cannot take advantage of any benefits from the opportunities created by competition with foreign companies or those available in global markets. Technological advances cannot be planted or delivered automatically from the outside because they are not ordinary physical goods. Host countries are the subjects, and they should equip a sufficient level of local capacity to actively realize technological change from the international economic environment. Although multinational corporations (MNCs) can demonstrate something novel and push local firms to perform to a higher standard; they do not build plants overseas to hand over advanced technological knowledge voluntarily. Similarly, Görg and Greenaway (2004) note that the most important reason for the presence of MNCs is to realize a higher return than in their home countries. Keller (1996) theoretically emphasizes that local human capital is the key factor in absorbing foreign advanced knowledge. He notes that successful implementation of foreign technology and thus

sustained growth is possible only when domestic labor in host countries matches the skills of laborers in foreign countries. Cantwell (1989) shows that the industries in Europe for the period from 1955 to 1975 with the local firms with a strong technological tradition could benefit the most positive effect from the entry and presence of US multinationals.

2.3 Democracy

It may be natural to emphasize the role of domestic institutions to promote national innovation rates because the institutions can build an effective playground for innovative actors to perform actively and freely. Likewise, Taylor (2009) notes that high quality of domestic institutions can lower the costs of information, transactions, and risks and enhance transparency in the markets. Although the extent of domestic institutions is large, democracy is an important factor not to be omitted. Democracy can offer an environment in which innovative ideas can be generated and diffused effectively because of the freedom of circulation and sharing of information and knowledge. Also, in democratic economies, there is the freedom of selection, and, therefore, each agent is continuously motivated to develop unique and valuable products. Despite its critical role, few papers investigate the effect on innovation because, as noted earlier, for political scientists, innovation is not as popular a subject as economic growth, and for economists, democracy is not a frequently used variable versus other economic variables. Among this scarce literature, Knutsen (2009) emphasizes the major effects of democracy (e.g., liberalization of discussion, communication, learning, media, economic activities) on innovation and shows the significantly positive effects of democracy on TFP in more than 100 countries with some time series going back to the 19th century. On the other

hand, Rivera-Batiz (2002) emphasizes the indirectly positive effect of democracy on innovation. He argues that democracy can give the public the freedom to peacefully remove inept and inefficient administration and thus enhance the quality of governance. Such governance may not require unnecessary taxes or bribes for firms engaging in innovative activities, and, eventually, the firms can concentrate on their original duty and stimulate investment in R & D. In his empirical model covering 59 countries between 1960 and 1990, Rivera-Batiz (2002) finds that democracy has a significant and indirect positive effect on TFP through the quality of governance.

2.4 Property Rights

Property rights are another important component of domestic institutions. If an innovator creates something valuable and its exclusive right is well protected and appropriated through an advance property right system, then the innovator will be encouraged to work on further innovation. Chen and Puttitanum (2005) show the significantly positive effects of intellectual property rights on innovation (number of patents) in 64 developing countries from 1975 to 2000. An advanced property rights system can also attract foreign investments, thus, technological spillover can be expected. For example, Lai's model (1998) argue that in the globalized production era, high-quality intellectual property rights in developing countries may result in more production transferred from developed countries to developing countries, thereby inducing a higher rate of innovation in developing countries. However, on the other hand, too stringent property rights may hurt innovative activities because it may increase the cost of imitation, which is an important method to create further innovation. Firms' profit from successfully innovative products that appeal to their competitors, thus, the competitors

begin to heavily invest in R & D to imitate the successful products and subsequently develop more advanced and improved products. Similarly, Helpman (1993) notes that competing manufacturers try to imitate successful innovations made in the markets and adapt those innovations to create their own success. He also suggests that although developed countries prevent the abuse of property rights through patent, trademark, and copyright laws, this legal protection is not perfect and imitation is widespread; sometimes, important knowledge leaks out in the middle of the development process. He models the effects of intellectual property rights on developed countries' innovations and developing countries' imitations and argues that if imitation is the only channel of technology transfer, the strong protection of property rights will not only reduce the rate of innovation in developing countries, but also in developed countries. Glass and Saggi (2002) enhance Helpman's (1993) argument by adding FDI as another channel for technology transfer. Empirically, Taylor (2009) demonstrates that the overall effect of domestic institutions on national innovation rates (number of patents) from 1980 to 1995 is insignificant.

2.5 Additional Determinants: Ethnic Fractionalization, Urbanization, and Dependency on Natural Resources

Although the nuance of "ethnic fractionalization" does not sound promising, it may lead to creativity and innovation because fractionalization can bring diversification of abilities and experiences. Alesina and others (2005) note that New York City and Los Angeles owe its continuous innovative activities in the arts and business to their ethnic mix. Similarly, Lazear (1999) purports that different skills within a production unit may promote overall productivity. On the other hand, he also discusses a trade-off between

increased productivity benefits by diversification and liability risks due to communication difficulties among people from different languages and cultures.

Urbanization can bring more people (potential innovators) and their innovative activities closer to each other; therefore, the collaboration and sharing of knowledge between them and subsequent generation of innovation become much easier in urban areas. Similarly, Rivera-Batiz (2002) suggests that urbanization is assumed to be related to economic agglomeration, which generates new competitive industries, goods, and services, thus increasing the rate of innovation.

On the other hand, natural resources are very important factors in discouraging national innovation rates because the more resources a country can exploit for profit, the less its people are motivated to work in sectors other than natural resource-related sectors. Too much dependency on a highly lucrative industry naturally discourages active investment in other industry and in innovative activities, and skews national economic activities and wealth. Sachs and Warner (1995, 2001) made a major contribution through empirically identifying a significant negative relationship between natural resource abundance (measured by the amount of natural resources exported divided by GDP) and growth per capita from 1970 to 1989 in resource-abundant countries. They suggest that natural resources abundance not only discourages innovative activities, but also usually makes government officials seek bribes, leading to a corruption level. Such corruption may hinder the pro-growth activities of industries and national innovation rates accordingly. According to Ross (1999), in reality, it is easy to observe the better performance of resource-poor countries than resource-abundant counterparts. Such poor performance in resource abundant countries is due to short-sightedness among

policymakers, the bias of sectors, classes, or interest groups related to resource exports, and weakening state institutions through resource booms.

3. Theory

The Patent Technology Monitoring Team (PTMT) in the U.S. Patent and Trademark Office (USPTO) constructs an annual table containing the number of all types of patents granted that require utility, innovative, and novel since 1977 by country and year.[2] According to data covering 178 different countries for the period from 1977 to 2010, more than 45% of the countries generated little innovation during the time. More specifically, as Table 1 shows, 85 out of the 178 countries were granted less than 30 individual patents by the USPTO during that time. That is, on average, less than one patent per year per country. Additionally, 62 out of the 178 countries have a single digit number of total individual patents granted for the period. It should be noted that the number of patents is in aggregate. Therefore, when approached from an industry perspective, the issue here is more obvious. That is, besides the few industries filing less than a single patent per year on average in those 85 countries, the rest can be assumed to have never innovated during that time.

Table 1- Countries with less than total 30 patents granted from the USPTO between 1977 and 2010

[2] For full table, see http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_allh.htm

Due to these low-innovation countries, the data table is composed of excessive zeros, and among those zeros, we find an interesting pattern. In case of Thailand, Turkey or Iceland, for example, the zeros are distributed randomly. In other words, the countries had zero patents granted in a certain year but not over a series of years. However, in case of low-innovation countries in Table 1, their zeros are distributed in series. That is, once a country has no patent in a certain year, then, there are no innovations for several years. Most countries in Table 1 show such a pattern in the series of zeros or continuous non-innovation.

Likewise, although the zeros can be seen as identical numbers, it should be noted that the zero outcomes are made through two different processes. In process 1, a country tried to innovate and could have a patent granted by the USPTO because the country was ready to supply the necessary determinants (e.g., quality of human capital and economic resources) but was not due to internal or external factors, such as a globally depressed economy. If this is the case, the zeros in the patent data table are more likely to be distributed randomly, like the case of Thailand, Turkey or Iceland. The country could have zero patents granted in a certain year but not over a series of years.

In process 2, a country did not even try to innovate due to the lack of important innovation determinants. In such a case, the outcome is "*certain to be zero*", and not by chance. The non-innovating status will continue until the country fills a missing gap and becomes qualified to innovate. In this sense, the series of zero patents or continuous non-innovating status shown in the USPTO dataset is likely due to process 2, and these zeros cannot be explained in the same manner as process 1. Existing literatures implicitly assume that only process 1 creates a zero patents outcome, and their empirical analyses

concentrate on how much the level of innovation is predicted to change through explanatory variables, not whether or not a country can innovate. Therefore, the literatures are insufficient to explain excessive zeros from the USPTO dataset. Such insufficiency motivates us to investigate why almost half of the world rarely innovates for a certain period of time and argue that these low-innovation countries are systematically different from countries that innovate. If a country does not possess a certain threshold level of resources (e.g., human capital, GDP) and incentives (e.g., quality of domestic institutions, less reliance on natural resources, and exposure to international market), the country will not turn into an innovating country and thus post zero patents over successive years[3].

[3] Qatar and Gabon are good real life examples. Although these two countries are from different continents, they share the common problems of decreasing incentives and resources to innovate. The leaders of these countries, and other natural resource abundance countries, have never publicly announced that they do not need innovative activities to build a better country because of abundant natural resources. However, their heavy economic reliance on natural resources and lack of innovation-related activities during a long period time demonstrates their short-sighted policies. For example, both countries have not innovated for a long time. Qatar had no patents granted from the USPTO for 22 years, since 1977, while Gabon had no patents granted for 33 years, since 1977 (except for a single patent in 2007). During this period, according to the World Bank's world development indicator (WDI), economic dependence on natural resources was very heavy: the average revenue of natural resources rents as a percentage of GDP for Qatar and Gabon was very high, 44.57% and 42.32%, respectively. Even though Qatar was ranked as the world's richest country in terms of GDP per capita adjusted for purchasing power parity in 2010 because it has the third largest reserves of natural gas in the world, much of the population in Qatar is actually very poor (Greenfield, 2012). In addition, according to the CIA World Factbook, Qatar and Gabon did not really experience true democracy during of its period of non-innovation due to long-ruling family dynasties, the Al Thani in Qatar and the Bongo in Gabon. Specifically, in Gabon, there were allegations of electoral fraud in local elections between 2002 and 2003 and presidential elections in 2005, thus reflecting the weakness of its domestic institutions. A below average level of human capital is also a common problem in these two countries. While the world population aged 15 and above was estimated to have an average of 5.3 years of schooling in 1980, Qatar and Gabon were measured at 4.817 and 3.332 years, respectively (Barro & Lee, 2010). In fact, inability to innovate due to low incentives and resources as a result of poor human capital, heavy reliance on natural resources, and low-quality domestic institutions are not the only problems these two countries face; they also face the same problem as most of Sub-Saharan African countries. It is not surprising that most countries in the region, such as Mauritania, Ghana, Liberia, Benin, Chad, and Angola, have hardly had any patents granted from the USPTO for several decades. However, a non-innovating country does not necessarily remain as it is, because the increased incentives and resources provided by

We used a panel of data to examine which determinants of innovation a country should possess, and at what level, to have the resources and incentives in place to become an innovating country accordingly using a sample of 178 countries for the period of 1977-2010 from the USPTO.

4. Empirical Analysis

4.1 Variables and Data

As a measure of innovation, we use the total number of patents granted by the U.S. Patent and Trademark Office (USPTO) explained in the previous section in this analysis, because of the following good reasons.

First, following Cantwell and Fai (1999) and Pavitt (1988), we argue that the data is one of the most useful means for an international comparison of technological change at the country level because both U.S. and non-U.S. innovators have strong incentives to file their patents and to thus claim exclusive rights for their innovative achievements in the U.S. Because of Territorial Principle in the Patent Law, which means that the exclusive right for inventions is available only in the state where the patent is granted

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better domestic institutions and efforts to improve human capital and economic structure can transfer the country into an innovating country. Vietnam is a good example. Since North Vietnam conquered the South and reunified Vietnam under communist rule in 1975, political expression has been suppressed by Communist Party leaders, and most parts of its economy have been dominated by state-owned enterprises (Abrami, 2003). However, since implementing its economic renovation policy, called “doi moi” (renovation), in 1986, Vietnam has increased the liberalization of its economic activities and reformed its economic structure to encourage export-driven industries. In addition, Vietnam has hosted several international academic symposia and conferences and developed a bilateral relationship with the United States to promote educational exchanges (Han, 2009). These efforts seem successful. Although Vietnam had no patents granted between since 1977 and 1998, it was and granted a total of 16 patents from the USPTO between 1999 and 2010. The number of patents granted steadily increased every year.

(Hsu, 2009), if innovators do not grant their technological performance protections through patents in the U.S. (which always has been not only the largest technology consumption market in the world during the last few decades [Hsu, 2009], but also the place where globally diversified innovators and corporations have actively pursued their innovative activities), the achievements will be abused freely by rivals without any cost.[4] Similarly, Bertin and Wyatt (1988) note that the United States is the first country for global patentees to register patents, and Hagedoorn and Duysters (2002) suggest that it is almost compulsory for non-U.S. companies to file patents in the U.S.

Second, the patents granted by the USPTO capture the quantity and quality of innovative activities. Since the United States is the largest and most popular single market in the world, the patents registered in the USPTO can be regarded as high quality and significant (Cantwell & Fai, 1999). Likewise, Zander (1999, p.201) notes that "the attractiveness of the U.S. market encourages patenting of inventions that are believed to be of significant commercial importance."

Third, by utilizing patents data from a single institution, the USPTO, the analysis can be free of a bias and does not have to account for each country's propensity to apply for patents (Quintas et al., 2009). Soete (1987) suggests that comparing patents data from one organization to the other can be particularly problematic, because the ratio between the patent applications and patents granted varies widely among countries.

Fourth, since the USPTO determines the origin of a patent according to the nationality of the first-named inventor, the patent granted can be regarded as a true

[4] According to the USPTO data, even USSR has been a top patenting country until the end of the Cold War.

outcome of national efforts. For example, if a U.S. scientist is granted a patent while residing in Mexico, the patent belongs to the United States. The extended coverage of countries and time periods in the USPTO's data is another asset. Lastly, the USPTO patents data give us an important clue in that countries' active innovative activities are not evenly distributed globally and the rates of technological change vary by country. Those data motivates us to examine which determinants of innovation a country should possess, and at what level, to have the resources and incentives to become an innovating country. The question can be most effectively answered by combining the USPTO patent data with a zero-inflated negative binomial regression analysis. More details about the model are explained in following section.

All explanatory variables used are summarized in Table 2. To investigate the effects of exposure to foreign markets on the rise of innovation, 6 different indicators are used in the analysis: *EXPORT*, *IMPORT*, *FDI*, *TRADE*, *OPENNESS*, and *International Linkages*. *EXPORT*, *IMPORT*, and *FDI* are measured by the constant value of total merchandise flows of exports, imports, and FDI inflows, respectively, for each country. To make *FDI* more commensurable with *EXPORT* and *IMPORT*, it was measured by FDI inflows, rather than stocks. *TRADE* is the sum of *EXPORT* and *IMPORT*. The data are retrieved from United Nations Conference on Trade and Development (UNCTADstat) and their units are millions of U.S. dollars[5]. The data cover 233 different countries for the period from 1948 to 2010. In addition, we include an index called Freedom to Trade Internationally from the Fraser Institute (Gwartney, Hall, & Lawson, 2011) to capture

[5] Nominal values of export, import and FDI are deflated using the GDP deflator from World Bank Development Indicators database. All values are presented in 2005 constant US dollar currency.

overall effects of exposure to global markets. This index is based on five components (i.e., taxes on international trade, regulatory trade barriers, size of the trade sector relative to expected, black-market exchange rates, and international capital market controls) and is a good exogenous variable, to account for the fact that a single component (e.g. tariff) cannot be a good enough indicator on its own, as Rodriguez & Rodrik (1999, p.262) noted.

> *"Simple tariff averages underweight high tariff rates because the corresponding import levels tend to be low. Such averages are also poor proxies for overall trade restrictions when tariff and nontariff barriers are substitutes. As for the nontariff coverage ratios, they do not do a good job of discriminating between barriers that are highly restrictive and barriers with little effect. And conceptual flaws aside, both indicators are clearly measured with some error (due to smuggling, weaknesses in the underlying data, coding problems, etc.)."*

The index ranges from 0 to 10 with larger values, indicating the higher degree of it, and covers 141 countries for the period from 1970 to 2009. We rename it *OPENNESS* for convenience. This index, and other indexes,[6] from the Fraser Institute are frequently used by many social scientists in comparative institutional analysis (Taylor, 2009); therefore, we can expect to conduct this analysis with relative confidence. As an additional indicator of exposure to foreign markets, we create an index called *International Linkages* based on *EXPORT*, *IMPORT*, *FDI*, and *OPENNESS* through factor analysis.

Barro & Lee's (2010) average years of tertiary schooling among the total population over age 25 in each country—*HK_TER*—are employed to capture the local

[6] For other indexes, refer to http://www.freetheworld.com/release.html

human capital level, since more people with a post-secondary degree can be assumed to generate more innovation and to absorb foreign technology more efficiently. The data covers 146 different countries from 1950 to 2010.

The level of democracy is measured by Freedom House's Civil Liberties Index, not only because the index is one of the most popular indexes to capture the level of democracy, but also because the meaning of the index well meets our emphasis on the effect of democracy on innovation. The Civil Liberties Index ranges from 1 to 7 and covers 197 countries from 1972 to 2010. Interestingly, in contrast to other indexes, Freedom House assigned larger values to indicate a low democratic level (i.e., the value of 7 is given to the country with the lowest quality of democracy). Therefore, to make the empirical results more readable, we rename Civil Liberties to Civil Liberties Restriction (*CL_RES*).

To measure the level of property rights in each country, an index called Legal Structure and Security of Property Rights—*PROP*—from the Fraser Institute is used. The index is based on the following seven components: judicial independence, impartial courts, protection of property rights, military interference in rule of law and the political process, integrity of the legal system, legal enforcement of contracts, and regulatory restrictions on the sale of real property. The index ranges from 0 to 10 with larger values indicating the higher quality of *PROP*. The coverage of the data includes 141 countries for the period from 1970 to 2009.

To measure the level of ethnic fractionalization—*FRACTION*—within a country, Alesina et al.'s (2003) fractionalization index is employed. The dataset only covers a

single year for 215 different countries because ethnic fractionalization does not often change yearly. So the index is extended as necessary as for the analysis[7]. Most of the data[8] that the authors used to compute the index are from the 1990s. The index ranges from 0 to 1 with a higher index indicating higher level of fractionalization.

The percentage of population residing in urban areas is employed to capture urbanization, *URBAN*. The urbanization data of 224 different countries for the period from 1950 to 2010 are found from the most recent version of World Urbanization Prospects built by Department of Economic and Social Affairs, Population Division of United Nations.

To capture individual country's dependency on natural resources, we use each country's annual sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents out of GDP. The data are from the World Bank's world development indicator (WDI) and covers 216 countries from 1970 to 2010.

Lastly, to control the amount of economic resources and performance, we add the constant value of GDP—*KGDP*—and GDP per capita—*KGDPC*—(PPP converted into a thousand dollars) in the analysis. GDP data is from Penn World Table Version 7.0 (Aten, Heston, & Summers, 2011), including data on 189 different countries between 1950 and 2009, which are most widely used in empirical studies examining cross-border

[7] In other words, this is a time-invariant variable, and thus country specific dummies are not included in the analysis.

[8] Encyclopaedia Britannica, CIA's World Factbook, Levinson's Ethnic Groups Worldwide, Minority Rights Group International's World Directory of Minorities, and Mozaffar, S., and J. Scarrit. 1999. "The Specification of Ethnic Cleaveges and Ethnopolitical Groups for the Analysis of Democratic Competition in Contemporary Africa", Nationalism and Ethnic Politics 5(1), 82-117.

differences (Nuxoel, 1994). In addition, to capture aspects of the macroeconomic environment, year dummies are added in each model.

Table 2- Description and source of variables

4.2 Model

For the analysis, a zero-inflated negative binomial regression analysis is employed because our responsive variable is an overly dispersed count variable with excessive zeros and because, most importantly, such a responsive variable with a zero-inflated negative binomial regression model can effectively investigate two different processes and arrive at the outcomes of zero patents.[9]

Zero-inflated negative binomial regression investigates the two different processes by estimating two separate models simultaneously, a negative binomial model and a logit model. A negative binomial model is used for the number of patents model and a logit model is used when the outcome is certain to be zero. In other words, the effects of explanatory variables on the number of patents can be predicted by the former, while the latter can predict which explanatory variables are significant for a country to become an innovating country after ending its series of zero patents.

[9] A standard negative binomial model or zero-inflated Poisson regression can also be appropriate for count variable. However, the former is not appropriate with the excessive zeros in the dependent variable and therefore does not distinguish between two different processes with zero outcomes. In addition, by running the Vuong test in each analysis of this paper, it is revealed that the zero-inflated negative binomial allows for and accommodates our investigation, rather than a standard negative binomial regression. Although zero-inflated Poisson regression can deal with excessive zeros, it is not appropriate with overly dispersed data.

In this analysis, the number of patents model (negative binomial model) is predicted with every explanatory variable, while the certain zeros (logit model) are predicted with every explanatory variable, other than *URBANIZATION* and *FRACTION*, because we assume that the percentage of the population residing in urban areas and the level of ethnic diversification have a greater effect on the degree of innovative activities. Putting it more plainly, a country may still be granted a patent regardless of the percentage of population residing in urban areas and its level of ethnic diversification. Presumably, these variables only affect how many patents a country can make, not whether or not a country can innovate. This results in a baseline model that predicts *PATENTS* using *EXPORT*, *IMPORT*, *FDI*, *HK_TER*, *CL_RES*, *PROP*, *KGDPC*, *KGDP*, *FRACTION*, *URBANIZATION*, and *NATURAL* in the negative binomial; and using *EXPORT*, *IMPORT*, *FDI*, *HK_TER*, *CL_RES*, *PROP*, *KGDPC*, *KGDP*, and *NATURAL* in logit models.

Figure 1- Components of baseline model

4.3 Results

Table 3[10] shows the major results of our regression analyses. To reduce concerns of reverse causality and to avoid simultaneity between explanatory variables and the dependent variable, the analysis is performed with the dependent variable lead by 1 - 2 years. In other words, we test whether the current level of all explanatory variables only

[10] The data from Barro and Lee (2010), the Fraser Institute, and the Population Division of United Nations measure their data on a 5 year basis, not annually. Following other scholars (e.g. Engelbrecht, 1997; Francois and Manchin, 2007; Kurzman et al., 2002; Nickell, 2006), we linearly impute the data to avoid loose observational data, since we assume that these data does not fluctuate annually but change steadily.

affect the future number of patents. Each column in the table reflects the result of a different model. As explained earlier, the analysis simultaneously estimates two separate models, and the predictors in the upper section of the table are used in the negative binomial regression analysis to predict the number of patents granted, while the lower section of the table includes the predictors used in the logit model to predict certain zeros.

Table 3- Zero inflated negative binomial regression of number of patents in 178 countries, 1977-2010

The first and fifth columns, Model 1 and Model 5, in Table 3 report the baseline model. The rest of models show the baseline model abridged by alternative measures of exposure to international markets. For example, in Model 2 and Model 6, *EXPORT* and *IMPORT* are combined into one variable, *TRADE*. Similarly, Model 3 and Model 7 are analyzed with a different proxy, *OPENNESS*, thus capturing the degree of overall effects of exposure to global markets. Finally, Model 4 and Model 8 included a variable called *International Linkages*, which is created by a factor analysis of all the exposure-related variables used for previous models.

By looking at the negative binomial regression results first, the overall picture is supportive of other scholars' findings, as explained in the Literature Review section. The effect of *International Linkages* and *OPENNESS* in Model 3, 4, 7 and 8 shows that if a country are to increase its level of *International Linkages* and *OPENNESS*, its logs of expected number of patents would increase accordingly and the coefficient is significantly different from 0 while holding the other explanatory variables constant in the model. Putting it more plainly, exposure to global markets can remarkably increase

the degree of national innovation. The rest of the models give a more detailed explanation. Models 2 and 6 reveal that the highly significant positive effects of *International Linkages* and *OPENNESS* are driven mainly by *TRADE* rather than *FDI*, and the baseline model shows that *EXPORT* accounts for the effect of *TRADE*, rather than *FDI* and *IMPORT*. In sum, the global economic environment is critical in increasing the level of innovation, and the positive effects primarily come from the potential effects of trade. Above all, exports are the major driving force behind the positive effect of trade. On the other hand, by additional unit-increase on *IMPORT* and *FDI*, the expected log count of the number of patents decreases and their statistical effects are highly significant, suggesting that at overall (country) level the negative effects of *IMPORT* and *FDI* (e.g., domestic market-stealing and the talented-draining effects) supersede the positive effects of *IMPORT* and *FDI* (e.g. vertical integration effect). Thus, the R & D investments of domestic firms decrease and, accordingly, innovation decreases as well.

Additional interesting results are found through the negative binomial regression estimate of other variables. The coefficient value of *CL_RES* and *PROP* shows that a country's innovative activities can be significantly and positively affected by an additional unit-increase in the level of domestic institution. Ethnic fractionalization (*FRACTION*) does lead to creativity and innovation because fractionalization can bring diversification of abilities and experiences. The highly significant and positive coefficient value of *URBANIZATION* suggests that active circulation of ideas and collaboration between innovators made possible by high urbanization puts them closer to each other and remarkably increases the national innovation rate. Finally, heavy economic reliance on the abundance of natural resources (*NATURAL*) consistently hurts innovative activities

and the statistical effect is highly significant. It corresponds with the resource curse hypothesis.

Moving down to the logit regression results, a negative coefficient value of *HK_TER* with statistical significance suggests that the average amount of tertiary schooling of the population remarkably decreases the log odds of successive years without a patent. Put simply, unless a country meets a certain threshold level of human capital, the country may not be able to innovate, but keeps recording zero patents for successive years. In terms of democracy and heavy economic reliance on natural resources, the more restrictions on civil liberties (*CL_RES*) and the more economic reliance on natural resources (*NATURAL*) within a country, the less likely the potential innovating agents will drive technological change, thus, the country will remain a non-innovating country. In other words, additional level of civil restrictions and economic reliance on natural resources significantly increases the log odds of demonstrating successive years with zero patents. On the other hand, the higher economic resource and performance levels are (*KGDP* and *KGDPC*) within a country, the more likely that country will turn into an innovating country.

With exposure to international markets, just like the negative binomial regression results show, *TRADE* is a critical factor in the logit regression results. An additional unit-increase in *TRADE* decreases the log odds of going successive years without a patent and its statistical effect is significant. Therefore, it can be suggested that the potential effects of international trade (e.g., encouragement to invest more in R & D by increasing market size and competition, direct access to and transfer of advanced technological knowledge and capital, elimination of duplicate research, and reallocation of production resources) is

required to end a non-innovating status. The mere presence of *EXPORT* or *IMPORT* alone does not generate technological change (Models 1 and 5), while the combination between the two, *TRADE*, is far more important[11]. Moreover, once a country begins to innovate, its level of technological change can be continuously promoted by the same method, international trade emphasizing outward-oriented growth. The result can be supported by the historical patenting activities of Asian Tiger countries (i.e., Hong Kong, Singapore, South Korea, and Taiwan) and Latin America's 4 largest GDP countries (i.e., Argentina, Brazil, Mexico, and Venezuela). Although these countries have had patents granted every year for the period from 1977 to 2010, the growth rate in the number of patents between these two groups is exceptionally different from each other, as shown in Figure 2. While the average growth rate of the number of patents in Asian Tiger countries during the period is about 52,800%, the average growth rate in the four Latin American countries for the same period is about 730%.

Figure 2- Annual total number of patents of Asian Tiger countries and Latin America's 4 largest GDP countries between 1977 and 2010

The large difference in the level of innovative activities is due to more incentives by effective economic structure and resources by advanced human capital level in Asian Tigers compared to Latin American countries. Most Latin American countries pursued import substitution industrialization (ISI) until late 1980s, while Asian Tigers pursued export-oriented growth. By avoiding more rigorous clients and competitors in global markets, Latin American countries faced no demands to learn advanced technological

[11] Nevertheless, *EXPORT* is significant at 10% level in Model 1.

knowledge and improve further. Similarly, Bruton (1998) emphasizes learning activities and thus knowledge acquisition as the most important and primary sources for development and notes that ISI in Latin American countries decreased knowledge growth activities. On the other hand, Stiglitz (1996) emphasizes an enormous investment in human capital to explain East Asian countries' growth in innovation. Large numbers of skilled and educated workers were able to transfer advanced technology from abroad more effectively.

Interestingly, the effect of property rights (*PROP*) is not significant in any model in the logit regression results, which is contrary to the results from the negative binomial regression. In this sense, it can be suggested that additional levels of property rights can significantly encourage the level of innovation. However, the quality of property rights is not a critical prerequisite to be an innovating country. Even if a country lacks a quality property right system, the country can still innovate through other determinants. The results partially corroborate Helpman's (1993) and Glass and Saggis' (2002) research, which show that a too stringent level of property rights hurts innovative activities.

In summary, a country can turn into an innovating country if that country meets a certain threshold level of determinants of innovation. These innovation determinants can offer resources and incentives to potential innovators. The highly significant determinants are high level of human capital and economic resources and performance, improved quality of civil liberties, active international trade, and less economic reliance on natural resources.

4.4 Robustness Tests

In order to increase confidence in our results, two different tests are performed. First, we use a non-overlapping, 5-year average of number of patents as the dependent variable and use the initial yearly values for all explanatory variables to check the existence of reverse causation. For example, if a dependent variable is a non-overlapping 5-year average of number of patents from 2000 to 2005, then the corresponding independent variables are from 2000.[12] Table 4 shows the results.

Table 4- Negative binomial regression of number of patents in 178 countries, 1977-2010

Since the dependent variable is now the average of non-overlapping 5-year data, the number of observations contained many gaps and no longer included excessive zeros. However, since the dependent variable is still overly dispersed, a count variable, and according to the likelihood-ratio chi-square test, the test is performed using a negative binomial regression analysis. The results are still very much the same as in Table 3. However, in case of ethnic fractionalization (*FRACTION*), although the sign of the coefficient is always positive, its effect is statistically insignificant in most of models. It could be due to a small number of observations or the tradeoff between the positive effects of variety in terms of abilities, experiences, and cultures on innovation, and the potential costs could be caused by language and cultural barriers. Civil liberties restriction (*CL_RES*) is also insignificant in most of models. However, through additional robustness test using various sets of democracy measurements, we became confident that

[12] See Hasan and Tucci (2010).

democracy and diversification are consistently critical for innovation, and that the insignificant effect in Table 4 is due to a small number of observations.

As a part of robustness tests and to contribute to the very limited extant literature on the effects of democracy on innovation, we test our regression with other commonly-used measures of democracy. Besides the Civil Liberties (CL) Index used in our major regression results, Freedom House also creates another democracy measurement called the Political Rights (PR) Index. Additionally, each country in the indexes is applied to one of three broad categories. Based on the ratings in the CL index and PR index, each country is pigeonholed into three categories, free, partly free and not free, if the CL and PR indexes are rated between 1.0 and 2.5, 3.0 and 5.0, and 5.5 and 7.0, respectively. Therefore, Freedom House offers 4 different measurements of democracy: CL index, PR index, CL category index, and PR category index. Again, since Freedom House assigned larger values to indicate the poorer level of the indexes, for the convenience and readability of the empirical results, we rename those indexes Civil Liberties Restriction Category (*CL_RES_CAT*), Political Rights Restriction (*PR_RES*), and Political Rights Restriction Category (*PR_RES_CAT*).

Polity-index (*DEM_POL2*) is another popular measuring of the degree of democracy according to participation and competition in elections and checks on the executive (Marshall et al., 2010). The index ranges from -10 to 10, and the highest value goes to the country with the highest level of democracy. The polity-index covers 164 countries over the period 1800-2010. Lastly, the regime type variable (*REG*)[13] from

[13] For data download, refer to http://politics.as.nyu.edu/object/AdamPrzeworski.html

ACLP Political and Economic Database is included as a measure of democracy. The data are coded 1 for dictatorships and 0 for democracies. *REG* covers 135 (+) countries for the period from 1946 to 2002.

Table 5- Additional variables for democracy

Table 6 shows the results. Each column in the table reflects a result of a model with different measurements of democracy. Rather than testing six different democracy variables with all models in Table 3, only Model 2 tests each democracy variable since the *TRADE* variable is the most significant among the variables measuring exposure to international markets, which can turn a country into an innovating country and promote the degree of innovation. Democracy is consistently and highly significant, and its effect on innovation is always beneficial in negative binomial regressions, *but not in logit regressions*. In this sense, it can be suggested that additional levels of democracy can significantly encourage the level of innovation. Also, a country may turn into an innovating country if that country meets a certain threshold level of civil liberties. However, democracy in terms of *political freedom* is not a critical prerequisite to be an innovating country. Just like property rights, even if a country lacks a quality democratic system in political terms, the country can still innovate through other determinants (e.g., participating in active international trading, enhancing local human capital, increasing civil liberties, etc.). The case of South Korea well supports the results. For example, the country always had patents granted from the USPTO since 1977, while true democracy began in 1993 (*CIA World Factbook*). Also, the Lee thesis, after former Singaporean Prime Minister Kuan Yew Lee's argument, may corroborate the results. He suggests that

a strong authoritarian leadership generates high investment levels and thus rapid economic developments, which may be hindered by special interest groups within a democracy (Halperin et al., 2005; and Przeworski and Limongi, 1993).

On the other hand, the statistical significance of other variables and the sign of coefficient from Table 3 (our main results) remain the same with any democracy variable.

Table 6- Zero inflated negative binomial regression of number of patents in 178 countries, 1977-2010

4.5 Prediction in Logit Model

Previous sections show the estimated sign and statistical significance of major determinants of innovation through the two separate models simultaneously, a negative binomial model and a logit model. The latter model in a baseline (Model 1) suggests that a country can turn into an innovating country if that country meets a certain threshold level of *EXPORT*[14], *HK_TER*, *NATURAL*, *KGDPC*, and *KGDP*.

Lastly, we employ the logit model to predict the magnitude of each significant variable while holding the rest of the variables at the mean level of the observations.[15] More specifically, we want to suggest a concrete cutoff point for each significant determinant, at which the noninnovating countries shown in Table 1 should surpass to turn into innovating countries. Table 7 shows the specific mean/median values of the variables.

[14] *EXPORT* is significant at 10% level.

[15] In case of CL_RES, it is held at the median level since the variable includes a categorical value.

Table 7- The mean/median level of variables

Table 8 shows the specific value of the range (a minimum value and a maximum value of each variable), an interval value, and a unit of each significant variable to be predicted, while Figure 3 includes the graphs of results.

Table 8- The list of significant variables to be predicted

Figure 3- The graphs of predictions

In the graphs, the Y-axis captures the predicted value of innovation—from 0 (never innovate) to 1 (certain to innovate)—while the X-axis shows the corresponding value of each variable. We simply set 0.5 in the Y-axis as the cutoff point. In this sense, only the country with higher level of a significant variable corresponding to the cutoff point is likely to innovate.

According to the graphs in Figure 3, if a country's average level of export for the period from 1977 to 2010 is greater than about US$3,000 million, the country is likely to innovate. Likewise, in case of human capital, it can be suggested that unless a country's average years of tertiary schooling among the total population over age 25 is greater than about 0.15 years, the country may remain a noninnovating country. In case of constant GDP and constant GDP per capita, a country needs at least an average level of about US$30,000,000 thousand and US$2,500 thousand, respectively. In addition, if a country's

amount of natural resources exported divided by GDP is greater than 11%, the country may not turn into an innovating country and thus post zero patents over successive years.

5. Conclusion

A country's innovations are the key driving forces in improving economic output and thus for their long–term economic growth. Innovation can directly influence productive processes; therefore, a country can gain more outputs out of the same amount, or even less, of inputs. Surprisingly, according to the patents data constructed by the U.S. Patent and Trademark Office (USPTO), among 178 different countries for the period from 1977 to 2010, more than 45% of the countries generated little innovation during the time. We argue this group of countries is systematically different than the other countries that have innovations. If a country does not possess a certain threshold level of resources (e.g., human capital, GDP) and incentives (e.g., quality of domestic institutions, less reliance on natural resources, and exposure to international market), the country will not turn into an innovating country and thus post zero patents over successive years.

However, it should be noted that existing literature has mainly concentrated on how much a country can improve its own level of innovation, rather than on how a less-developed country can become an innovative one. In addition, most of the existing studies investigating innovation have missed political variables (e.g., democracy, ethnic fractionalization) and focused solely on economic variables (e.g., international linkages, human capital). Therefore, existing literature is insufficient to explain excessive zeros from the USPTO dataset.

By employing a zero-inflated negative binomial model based on the patent data from the USPTO, we can examine both the economic and political determinants of the threshold of innovation. The results show that the highly significant determinants improving levels of innovation are more exposure to international markets through trade (mainly through exports), a high level of human capital, improved quality of democracy and property rights, a high level of urbanization, and ethnic diversification. Abundance of natural resources significantly discourages the level of innovation. On the other hand, the highly significant determinants turning a non-innovative country into an innovative one are improved quality of civil liberties, a high level of human capital, active international trade, and less economic reliance on natural resources. In case of democracy, it can significantly encourage the level of innovation. However, democracy is not a critical prerequisite to be an innovating country. Just like property rights, even if a country lacks a quality democratic system, the country can still innovate through other determinants.

Essay 2: Two Different Effects of R & D on Innovation in South Korea Evidence from The Firm Level Data

1. Introduction

Technological capabilities are the key driving forces to increase competitiveness at the state, regional, and firm levels. Particularly, at the firm level, in-house research and development (R & D) activities are the factor directly influencing the generation of such technological capabilities and innovation accordingly. However, looking closely and more deeply, innovation can be made through two different processes or effects of R & D, which are the *creative effect* and the *learning effect*. While such two different effects of R & D have been proposed implicitly by a number of theoretical models (e.g., Allen, 1977; Mowery, 1983), a major contribution was made by Cohen and Levinthal (1989), who first named the two effects as the creative and learning effects. They argued that firms' R & D investments not only generate innovations[1], but also enhance the firms' capacity to assimilate and exploit existing information[2].

[1] For example, a group of seven innovative companies—Compaq, DEC, IBM, Intel, Microsoft, NEC, and Nortel—composed a project team to create a global standardized system to make the connection of external devices (such as keyboards, mice, CD-ROM drives, digital cameras, joysticks, scanners, printers, etc.) to PCs much easier, and they introduced the standard named USB (Universal Serial Bus) in 1996. USB was a truly innovative product which never existed before, and it is attributed to the creative effect of R & D of the joint team. For the detailed information, refer to the news article titled " New PC features offer big leaps in ease, access universal serial bus, intercast are worth investigating," published in *Milwaukee Journal Sentinel* by Brown, J (1996).

[2] For example, in 1972, German Brazilian Andreas Pavel first invented a portable personal stereo audio cassette player, Stereobelt, and filed a patent for it in Italy, the U.S., Germany, the United Kingdom, and Japan. Upon the invention of Pavel's innovative product, a Japanese company, Sony, exerted its learning effect of R & D, improved the existing product by adding more advanced features and design improvements, and began selling the popular Walkman in 1979. See the news article titled "Farewell to the Sony Walkman - you gave us the soundtrack to our lives," by Nolan, P. (2010) published in *Daily Mail*;

This paper uses a panel of firm-level data to examine two such different effects of R & D using a sample of the top 100 most innovative South Korean companies for the period of 2000–2009, and offers right implications for the firms as to which effect of R & D is more critical to promote technological change. The list of the firms is based on the most recently published ranking by the Korean Intellectual Property Office (KIPO) according to the accumulated number of patent applications for the period. Empirical tests show that the creative effect of R & D is far more important than the learning effect in generating innovation of firms in South Korea. Surprisingly, not only the learning effect of R & D but also the individual variable of sources of learning, export and FDI, turned out to be insignificant. The results suggest that since many of the firms in South Korea have been in the leading group of the technological frontier *during the sample period*, they hardly had something new to learn from other competitors. In other words, the effort to create something unique by themselves has resulted in more innovation, rather than the effort to exploit others. In addition, the number of employees is significantly and positively associated with the number of patents of the firms, while an additional unit increase in product diversification significantly decreases the level of innovation. Lastly, no matter if it is a large company or a small-medium enterprise in terms of innovative activities, the results show that the major driving force to generate innovation is through the creative effect of R & D or active R & D investment.

The paper is organized as follows. Section 2 reviews the existing literatures regarding to the two different effects of R & D, and demonstrates the motivation for the

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and the news article titled "A sound move [consumer electronics industry]," by Conti, J.P. (2009) published in *Engineering & Technology*.

paper and its contribution. Section 3 describes the circumstance of FDI and export and their possible role in influencing technological change in South Korea. Section 4 summarizes the data and empirical model, and discusses the results of the econometric analysis. Section 5 concludes the paper along with some policy implications.

2. Literature Review

After the major contribution of Cohen and Levinthal (1989), various scholars investigated the two effects along with foreign direct investment (FDI) as a major source of learning in their empirical analysis, where the interaction term between R & D intensity capturing absorptive capacity and the FDI variable, the source of learning, served as a proxy of the learning effect of R & D. A positive and significant coefficient value of the interaction term implies the higher the R & D intensity and, thus, the greater ability to assimilate and exploit FDI, the greater the effect of FDI on a firm's innovation. Simply, the learning effect of R & D is a critical factor influencing a firm's technological change. On the other hand, the sole R & D variable captures the creative effect. For example, Fu (2008) investigates the effect of FDI (measured by the proportion of net fixed assets of foreign firms) on the number of patents of 31 provinces in China from 1998 to 2004 and shows that both creative and learning effects of R & D are highly significant in generating regional innovations. Based on a large data set of China's large- and medium-size enterprises from 1995 to 1999, Hu and others (2005) also show the highly significant and positive effects of both effects of in-house R & D through FDI on the firms' productivity. Griffith and others (2004) examine the two effects of R & D

influencing the productivity convergence of 12 OECD countries between 1974 and 1990 and find creative and learning R & D equally critical. Kinoshita's unpublished work (2000), "R & D and Technology Spillovers via FDI: Innovation and Absorptive Capacity", investigates the effect of local R & D expenditures and the foreign share within the industry (employment share of foreign firms) on productivity in the Czech manufacturing industry from 1995 to 1998 and shows that the interaction between the two variables is significantly positive for the productivity growth of the firms, whereas their separately individual values are not significant. She interprets the result that the mere presence of local or foreign capacity alone does not generate technological change, while the interaction between the two, the local and foreign capacity, is far more important.

Depending on the availability of data, some scholars use another type of variable to measure the proxy of absorptive capacity and show the significance of Cohen and Levinthal's (1989) learning effect from FDI. That is, besides R & D intensity, they employ a total factor productivity (TFP) gap measuring the technological distance between domestic and foreign companies. Both a small TFP gap and high R & D intensity capture a high level of absorptive capacity. A small TFP gap means that the technological level of domestic firms is already close to that of foreign firms. Therefore, the domestic firms may already have sufficient capacity to create something valuable or exploit and assimilate from the foreign firms more effectively. For example, by dividing the sample of 159 Uruguayan manufacturing plants into two groups according to the TFP gap, Kokko and others (1996) show that FDI (measured by the foreign plants' share of the total output in an industry) is significantly positive in only the subgroup with the

small TFP gap. The result implies a lesser technological distance from the foreign companies, and thus, the more effective the ability to learn advanced knowledge from them, the more positive the effect of FDI or the learning effect is on local productivity. In addition, Kokko (1994) paradoxically shows the significance of the learning effect of the small TFP gap through FDI (measured by the foreign plants' share of the total employment in an industry) to increase the labor productivity based on the Mexican manufacturing industry in 1970. He finds that the interaction term between the TFP gap and FDI is significantly negative. The result suggests that the larger the TFP gap and, thus, the less ability to assimilate and exploit FDI, the more the presence of the foreign firms significantly decreases the local labor productivity level. In other words, without the learning efficiency of the local absorptive capacity, the local firms cannot benefit the spillovers from advanced machines or management practices of the foreign firms, and thus, there cannot be any technological change. Instead, there can be a significantly negative effect of FDI, such as that the advanced foreign companies may steal the market share of domestic firms which lag behind and, thus, discourage the innovative activities of local firms. Similarly, Cantwell (1989) notes that the industries composed of the local firms with a strong technological tradition could take advantage of the most positive effects from the entry and presence of U.S. multinationals in Europe for the period from 1955 to 1975.

On the other hand, some authors' ideas on the TFP gap are quite the opposite. If a sponge is dry and, therefore, has more rooms within the structure, it can absorb a lot more water than the already-wet one. The dryness or rooms and water describe the potential of absorptive capacity and the source of learning (e.g., FDI), respectively. Likewise, their

literatures suggest that the larger the productivity gap or technological distance between local and foreign firms, the larger the potential for productivity spillovers from the foreign companies to the host country or less-developed firms, and thus, the learning effect of potential absorptive capacity is significantly positive for local innovation. Similarly, Castellani and Zanfei (2003) label the assumption as the "catching up hypothesis." They examine the impact of foreign presence at a sector level (measured by number of workers employed by foreign firms within an industry) and TFP gap on domestic firms' productivity in France, Spain, and Italy from 1992 to 1997 and show that the learning effect (the interaction between FDI and TFP gap) is significantly positive in the pooled sample countries. Griffith and others (2002) investigate the effect of FDI (measured by the share of employment of foreign firms) on the productivity growth of the UK manufacturing establishments over the period 1980 to 1992 and show the same results as the Castellani and Zanfei (2003) study. Based on the UK manufacturing industry between 1989 and 1999, Girma (2005) finds that a local firm's TFP gap significantly and positively interacted with the foreign firms existing in the same region.

Based on the literature, it can be noticed that FDI has been regarded as a critical method through which local absorptive capacity (R & D or TFP gap) exerts its learning effect and promotes technological change, and actually, the learning effect significantly influenced the dependent variable in various host countries. The positive effect of FDI is that by demonstrating more advanced products and increasing competition by multinational corporations (MNCs), local firms can have more motivation to learn from them, upgrade existing technologies, and boost performance. Similarly, Griffith and others (2002) suggest that as a result of greater competitive pressure from FDI, (less-

developed) domestic firms can have more incentives to make technological improvements. However, it should be noted that such demonstration and competition effects do not come from FDI only. Exports can also offer increased competition and demonstration of more advanced goods in global markets and, therefore, inspire the exporting firms to learn newer and more improved technology harder. Moreover, through export, a firm should face increased demands from discerning customers worldwide and, thus, pickier requests from them. Such an environment is also an essential factor in inspiring the exporting firms toward more innovation. In this sense, exports are also an important source of learning through which local firms' R & D activities can exert their learning effects that result in new ideas and upgrade products accordingly. In a similar vein, Falvey and others (2004) suggest that a facing the technological frontier countries in the international market is an important means of imitation for an exporting country.

Exports may be exceptionally meaningful for export-oriented economic countries, such as South Korea, Japan, Taiwan, Malaysia, etc., which have strongly regulated FDI in their domestic market and promoted exports for the growth. However, to my best knowledge, there have hardly been literatures concentrated on outward-oriented countries to investigate the two different effects of R & D, and thus, the literatures have missed the alternative learning effect of R & D in a unified framework. More specifically, there has been a lack of analysis including the interaction term between R & D and *export at the firm level*. Most of the literature has implicitly assumed that FDI is the most important factor through which R & D exerts its learning effect to generate innovation. However, I argue that without including the interaction term between R & D and *export at the firm level* in a unified framework, the two true different effects of R & D cannot be examined

accurately and, thus, cannot offer right implications for firms as to which effect of R & D is more critical to promote technological change, particularly for the firms in export-oriented countries[3]. Besides including the alternative learning effect variable of R & D and export, this study has other features.

Using longitudinal firm-level data, especially export data, is a key asset of this analysis. Due to the data availability, it has been difficult for other papers to employ export data at the firm level[4]. However, thanks to the general characteristic of financial statements issued by Korean firms, which discloses the realized value of export annually, the rich information of the continuity of export amount at firm level could be used. Effective controlling for unobservable or immeasurable firm-specific factors can be possible through the continuity of the data at the firm level in addition to including sector and year dummies. Branstetter (2001) notes that within an industry, there is a considerable technological heterogeneity, and Gorg and Strobl (2001) argue that panels using firm-level data are the most appropriate estimating framework to investigate the spillover effect from the foreign presence. In addition, a firm's innovating capacity in the past influences their future capacity. In other words, generating innovation is a path-dependent process. According to Redding (2002, p. 1215), "The historical pattern of technological development plays a central role in determining the pace of future technological change." Therefore, using longitudinal firm-level data can very well capture such a process in the econometric analysis.

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[3] In addition, buying technology (licensing) is also well-known strategy to learn among Korean firms (Pack and Saggi, 1997). However, due to the data unavailability, the variable is not covered in this analysis.

[4] Even the link between export at the firm level and a company's profitability has been investigated in a limited number of studies. Refer to Wagner (2012) and Grazzi (2011).

Also, this study concentrates on the most innovative companies in South Korea during the last decade. The economic and innovative performance of South Korean firms has received a great deal of attention due to its exceptional speed of growth. Although the nation's strong emphasis on the level of human capital and, thus, absorptive capacity has been regarded as an important ingredient for the rapid growth (Page, 1994), there have not been many case studies that have examined its innovative capacity along with international linkages.

3. Export and FDI in South Korea

Export has brought South Korean innovative firms not only the effect of competition and demonstration of advanced goods in the global market, but also increased demands of discerning customers worldwide so that the firms could have incentives to learn and develop unique ideas and products. Similarly, Ciruelos and Wang (2005), Schneider (2005), Alvarez and Robertson (2004), and Pack and Saggi (1997) argue that facing more rigorous requirements from external clients and various competitors in export-oriented markets motivate firms to increase technological changes and performance accordingly. Verhoogen (2008) shows a theoretical framework wherein southern exporters manufacture high-quality goods to attract northern consumers, and the quality of exporting goods is higher than the one for domestic markets. Additionally, in South Korea, since the beginning of its industrialization, export has been an important means to increase foreign reserves by external consumers paying with foreign currencies so that they could purchase more advanced machinery and equipment from abroad to innovate.

An interesting point is that the firms in South Korea have always regarded active exporting as a destiny. Such an export-oriented strategy has not been driven by any other factor, but by the very small size of the given domestic market. The firms always insist that such a small local territory cannot satisfy their supply and, therefore, have looked to the international market. Similarly, Lu and Beamish (2001) and Grant and others (1988) note that the most obvious benefit from exporting is gaining larger volumes of sales and production in geographically extended markets and therefore achieve scale and scope of economies. In addition, the peninsula, surrounded by sea, makes the firms export and behave in an outward-oriented policy more easily[5].

The government in South Korea has been on the same page to emphasize such an export-oriented strategy with local innovative firms. The government has worked hard on the stage of global politics to help South Korean firms increase their exporting level by intervening in trade agreements with partner countries so that the products with a strong advantage could be exported as much as possible, while the same type of products built by competitors could be imported as little as possible[6]. In fact, according to the database

[5] How seriously South Korean firms pursue exporting activities in a natural manner can be well explained by an example—when Hyundai Motor Group acquired Kia Motors, which just entered Chapter 11 bankruptcy protection in 1998. As soon as the acquisition was made, Mongkoo Chung, the chairman of Hyundai Motor Group, argued that the concentration on export was the foremost important strategy to revive Kia and, thus, build a successful global company along with Hyundai because the tiny domestic market in South Korea could not give any chance or a good lesson to improve the existing status of Kia. Looking at the current shape of Kia in terms of its technological level and global market share, no one may deny that Chung's decision was the right one. For the detailed information, see the news article titled "정몽구 회장의 수출보국론," published in *The Aju Business* by Kim, H. in 2010.

[6] Particularly, the U.S. automotive industry has always complained such intervention of the government, and U.S. politicians have reacted sensitively to the intervention of the South Korean government. Recently, U.S. president Barack Obama noted that he "signed bipartisan trade agreements [free trade agreements between the U.S. and South Korea] into law because [he wants] to see more cars on the road in places like

of the Ministry of Knowledge Economy (MKE) in South Korea (http://www.mke.go.kr/info/main.jsp), between 2000 and 2010, major importing goods accounting for more than 50 percent of total imports have been raw materials, while consumer goods accounted for less than 10 percent. In this sense, Yanikkaya (2003) points out that although South Korea is a country pursuing active global trade, it does not necessarily mean that South Korea is pursuing a truly open economy.

However, the recent global financial crisis that began in 2007 reflected that export dependence may influence innovative activities in unexpected directions. Although the small domestic market size led the local firms to pursue an outward-oriented strategy, great sources of learning, and thus may result in technological change of the firms, on the other hand, the small domestic market could not make up for the decreased demands overseas, especially during the globally depressed period. Anemic consumer demand worldwide may cause the exporting firms to cut jobs and manufacturing levels and accordingly affect the R & D activities negatively. In fact, in South Korea, export accounts for more than one-third of GDP, and it dropped by 34 percent in 2009 from the previous year due to the global financial crisis. "South Korea is now suffering from a double whammy—sluggish domestic demand and sinking overseas demand," said analyst Yu Byoung-Gyu of the Hyundai Research Institute in Seoul[7].

South Korea imported from Detroit and Toledo and Chicago" (as cited in *the Hill*'s news article, "Obama touts auto bailout as new car model year begins", in 2012).

[7] Refer to the news article titled "Asia's export-reliant economies feel pain of slowdown," published in *Agence France-Presse* in 2009.

Not only South Korea but also other East Asian nations with similar characteristics (export-oriented with a small domestic market size) suffered during the same time period in the same manner. For example, the export level in Taiwan, including major semiconductor makers, decreased by 44 percent in January from the last quarter of 2008. In the case of Hong Kong and Singapore, the decrease was at 22 percent and 35 percent, respectively. Actually, the number in Singapore was the biggest drop over the last 30 years. The electronic industry in Malaysia, another heavy export-dependent emerging country in East Asia, generates 40 percent of sales overseas, and the industry has also been hit hard during the financial crisis[8]. To these countries, the only hope which could replace the demands from Western markets is China. However, the financial crisis depressed the demand of China too[9].

On the other hand, little can be assumed in the case of FDI, South Korean firms' R & D activities—which exerted their learning effect through foreign investment—and the effect of FDI itself since the amount of FDI has been minimal among other emerging countries in East Asia. In fact, the most recent data of FDI per GDP from the United Nations Conference on Trade and Development (UNCTAD) for the period from 2000 to 2010 shows that among the major emerging countries in Asia, South Korea has been the country which invited the lowest amount of FDI, the average being 0.83 percent. If the period is expanded to between 1970 and 2010, the number becomes even smaller, 0.59 percent. An even more interesting point is that, according to the database of the MKE,

[8] Ibid

[9] According to the news article titled "Asia trade suffers as Chinese imports fall," published in the *Financial Times* in 2009, exports from Taiwan and South Korea to China decreased by 50 percent and 33 percent year-on-year, respectively.

among the few amounts of FDI, investments related to the service industry (e.g., insurance, financial, business services, etc.) accounted for 63 percent from 2000 to 2009. In other words, there have hardly been chances that South Korean technology-oriented firms faced foreign companies from similar industry types, even before their R & D activities exerted the learning effect through the inward FDI[10].

Figure 4- Average of FDI per GDP from 2000 to 2009 in major emerging countries in Asia

The Korean government's strong regulations and intervention on FDI may answer the poor amount of FDI in South Korea. Based on the four types of measures—(i) foreign equity restrictions, (ii) screening and prior approval requirements, (iii) rules for key personnel, and (iv) other restrictions on the operation of foreign enterprises—Kalinova and others (2010) measure FDI restrictiveness of OECD member countries. According to the report, the restrictiveness of South Korea on FDI is the sixth highest and foreign equity restriction accounted for the most important reason for the result. In fact, among the 100 most innovative firms ranked by the KIPO, only five of them are joint

[10] Conversely, China, Thailand, and the Philippines have actively pursued FDI to generate positive spillover effects from it (Hu et al., 2005). The expected positive effects of FDI include that firms in a host country can learn more advanced technology through demonstration by foreign companies, utilize a more expanded global network already constructed by multinational corporations, or raise productivity and efficiency through the relationship between local suppliers and MNCs' affiliates requiring high-quality outcomes (Blomström and Kokko, 1998). In fact, many other host countries have liberalized the policies regarding foreign investment. For example, according to Görg and Greenaway (2004), 145 regulatory changes related to FDI were made by 60 countries in 1998, and 94 percent of them created more favorable conditions for foreign investors (e.g., subsidies of salary payment or tax incentives to relocate foreign companies' new plants in host countries).

venture companies. In other words, only five companies include foreign investors from a similar industry owning more than 5 percent in shares[11].

The prevalence of negative impressions about FDI among the local population may also enhance the Korean government's regulations and intervention on FDI. Such a negative image has risen since the period of Asian financial crisis in 1997. Many of the financially weak South Korean firms were exposed to the crisis; and continuous bankruptcy and, thus, fire sales of them have brought much of the FDI. However, most of the private foreign investors were actually from financial industries, not technology-oriented industries. Therefore, they took into account only the current returns in the country and did not take account of future prospects (Chung, 2008). In other words, as soon as the foreign investors realized reasonable returns, they pulled out the invested capital. There was not remarkable technological assistance or transfer from the foreign firms to the local firms. Additionally, Chung (2008) notes that the society of South Korea regards FDI as an entity stealing the local talent and building its technology in secret. In fact, Blomström and Kokko (1998) suggest that one of the expected benefits of FDI, which is technology spillovers through labor turnover between foreign firms and domestic firms, cannot be easily observed in reality because the local talent can be taken

[11] The recent case of the conflict between Mahindra & Mahindra Ltd., the owner of Ssangyong Motor Company, and the South Korean government also corroborates how strong regulation and intervention on FDI exists in the country and how inconsistent the attitude of the government on the foreign investors is. Ssangyong is a local auto company specializing in sports utility vehicles (SUVs). After being under court protection due to bankruptcy, an Indian multinational automaker, Mahindra, acquired the company. Faced with a severe liquidity crunch, Mahindra had no choice but fired 2,600 workers (37 percent of its workforce) in August 2009. Even though the layoff followed transparent and ethical procedures and the requirements set under Korean law, the South Korean parliament recently raised a concern about the layoff. They are now seeking the way to prove the layoff was illegal so that the 2,600 workers can be reemployed. For the detailed information, refer to the news article titled "Mahindra worried about reignited ssangyong motor controversy," published in the *Korea Times* in 2012.

away by foreign companies enchanting them with higher benefits. Similarly, even if many foreign companies' R & D activities are known to be performed in their host countries (Alvarez and Robertson, 2004), exactly what kind or how important R & D projects are performed in host countries is rarely known (Blomström and Kokko, 1998).

4. Empirical Analysis

4.1 Model and Data

The econometric analysis of the two effects of R & D on innovation through export at the firm level in South Korea starts from the following base model, where subscripts *i* and *t* denote firm and time period, respectively:

$$\mathbf{Patent_{it}=\beta_0+\beta_1 Export_{it}+\beta_2 Creative_{it}+\beta_3 Learning_{it}+\beta_4 Capital_{it}+\beta_5 Labor_{it}+\varepsilon_{it}}$$

As the measure of innovation (the dependent variable), the number of *Patent* data of each firm retrieved from the most recent publication by the KIPO is used, and the data covers the period from 2000 to 2009. The variable is transformed into a logarithm to reduce the skew of the data[12].

Using patent data from the KIPO as a proxy of innovation is viable because of the following reasons: First, according to Article 29 of the Patent Act of South Korea, the

[12] All other variables are also transformed into a logarithm for the same reason, except *Export* and *Diverse*. In addition, all annual nominal values (e.g., R & D expenditure, revenue, the realized value of export and FDI, net equity value, etc.) are deflated using the GDP deflator from World Development Indicators database. All values are presented in 2005 constant currency.

requirement of a patent includes commerciality, novelty, and progressivity so that the patents can encourage further invention and contribute to the development of the industry. Also, generating unique and valuable patents has been regarded as a core strategy of building competitiveness among firms in South Korea. For example, Jongyong Yoon, the former CEO of Samsung Electronics and the president of the Presidential Committee on Intellectual Property, has pursued its patent-valued management under the slogan of "No patent, no future". In this sense, the patents' data can not only capture just the quantity of innovations, but can also be regarded as a true outcome of serious innovative efforts of the firms. Actually, emphasizing patenting activities for innovative outcomes and a promising future are not limited within the industry of South Korea, but other globally innovative firms' top managers[13].

"For the era to come when only some companies, strong in patents, will cooperate with each other and survive."
—Keizo Yamajo, former CEO, Canon
"CEOs will not be successful unless they begin to look at IP as critical to the success of their business."
—Mel Sharp, former IP consultant, Texas Instruments

In addition, Griliches and Pakes (1980) note that patent data are not contaminated by other unobservable factors and are perhaps the most easily accessible indicator of the number of inventions made at the firm level. On the other hand, by utilizing patent data from a single institution, the KIPO, the analysis can be free of biased

[13] See Koh, J's presentation in 2010, "Evolving Role of IP Offices in Policy Formulation, IP Administration, and Coordination with Stakeholders involved in the Innovation Process", at WIPO High Level Forum on the Global Intellectual Property Infrastructure for Promotion of Innovation. (downloaded on 04 December 2012 from http://www.wipo.int/meetings/en/doc_details.jsp?doc_id=140716)

matter to account for the fact that each firm could have a different propensity of defining innovative outcomes.

Export is each firm's annual export intensity measured by the ratio of net amount of realized export to total revenue in millions of South Korean currency. Such measure is by far the most popular variable in empirical international business research, and also, its objective measurement is another benefit (Pla-Barber and Alegre, 2007). The export data is retrieved from the Data Analysis Retrieval and Transfer System (DART, http://englishdart.fss.or.kr/) operated by the Financial Supervisory Service (Korean version of the U.S. Securities and Exchange Commission). All publicly listed companies in stock markets in South Korea are required to release major financial statements quarterly and annually through the DART, and the information submitted is always open to the public. The first year of available data is from 1999.

Creative and *Learning* capture the two different effects of in-house R & D, the creative effect and learning effect, respectively. Following other papers in section 2, *creative* is measured by each firm's annual R & D expenditure in millions of South Korean currency and is retrieved from the DART. On the other hand, the interaction term between absorptive capacity variable and the source of learning captures the learning effect. Therefore, the effect is measured by the product of each firm's annual R & D and export data in this analysis.

Capital is served as a proxy of each firm's capital stock, while *Labor* is served as a proxy of labor input and size of the firm. These are controlled as firm-specific factors influencing the number of patents other than the major explanatory variables. *Capital* is

measured by net equity value, and *Labor* is measured by the number of total employees in each firm. The data are retrieved from the DART as well.

In order to increase the reliability of the two different effects of R & D through export, more explanatory variables, which have potential influences on the number of patents, are added to the base model, and thus, it extends to the following:

$$\mathbf{Patent_{ijkt} = \beta_0 + \beta_1 Export_{it} + \beta_2 FDI_{jt} + \beta_3 Creative_{it} + \beta_4 Learning_{it} + \beta_5 Learning2_{jt} + \beta_6 University_{kt} + \beta_7 Diverse_{it} + \beta_8 Capital_{it} + \beta_9 Labor_{it} + \beta D + \varepsilon}$$

Although the presence of FDI has been minimal—as shown in section 3 and, therefore, it is assumed that it hardly influences the innovative activities of the firms in South Korea—it is still necessary to control the variable in a unified model to show accurately which effect of in-house R & D is more significant to innovation and to suggest the right direction the firms in South Korea should pursue. Therefore, the panel of FDI at sector-level data from 2000 to 2009 drawn from the Ministry of Knowledge Economy (MKE) website is included in the analysis. Among the sample firms, only five of them are joint venture companies. In other words, only five companies include foreign investors from a similar industry owning more than 5 percent in shares. Therefore, the majority of the sample has not benefited from the foreign investors through *the direct relationship* (e.g., utilizing a more expanded global network already constructed by the investing company, or raising productivity and efficiency through advanced technology transfers from the direct and unique relationship with the investing company). In this sense, I argue that in the case of measuring the spillover effect of FDI among innovative

firms in South Korea, the data at sector level is more appropriate than at firm level. FDI_{jt} refers to the realized value of FDI in millions of U.S. dollars at sector *j* and time *t*. Based on the sectors classified by the MKE, each firm in the sample is categorized into one of 13 different sectors. That is, metals, machinery, electronics, communication, software, energy, construction, motor vehicles, motor vehicle parts, container ships, other transport equipment, rubber and plastic, and chemicals. *Learning2* captures the alternative learning effect of in-house R & D through FDI and is measured by the interaction term between R & D and FDI data.

On the other hand, the research outcomes of a local university can be a significant factor influencing the firms' innovative activities and are therefore controlled in this analysis. A university has a group of talented graduate students and faculty. Their research activities are supported by the high-quality facilities and libraries containing a tremendous amount of various and valuable knowledge. Most importantly, the newly developed ideas and information in the university are public goods, and therefore, the information and knowledge can be diffused through various channels (e.g., conferences, publications, patent applications, and formal and informal interactions among researchers in firms and universities) without much cost. In fact, generally, ideas are regarded as nonrival goods (Romer, 1993), and Park (1995) notes that even if the benefits of new technological knowledge are fully appropriated by the first inventor and the agent has a monopoly right for the effort, the idea can still be spread across the world through diversified channels, like publications, seminars, personal contacts, reverse engineering, joint ventures, and other means. Jaffe (1989) suggests that university researchers have less incentive to keep their research outcomes a secret, and thus, there should be

spillovers from universities to firms. He also points out that Silicon Valley near San Jose, California, and Route 128 around Boston could be named as the centers of commercial innovation and entrepreneurship due to the near existence of the great research-oriented universities such as Stanford and MIT[14].

The spillover effect by university research has been empirically investigated by several scholars (e.g., Hicks et al., 2001; Saxenian, 1996), and Jaffe (1989) made a major contribution and revealed the effect on firms' innovation. Based on 29 U.S. states accounting for the majority of economic and innovative activities in the U.S. for the period from 1972 to 1977 and 1979 and 1981, he shows that the number of university patents significantly increases the number of patents of the firms within the same state.

The most recent report by the KIPO also presented the annual number of patent data by all local universities in South Korea from 2000 to 2009 and categorized them depending on the type of technology. The patent data is classified into five different types of technology (i.e., chemicals, electronics, energy, machinery, and other technologies). Therefore, I matched the university patent data with the patent data of sample firms according to the each university patent technology type and each firm's core business area. For example, the electronics patents data by local universities in 2000 was matched

[14] In South Korea, there are also several cases in which the firms understand the value of top national universities' research efforts and try to benefit from the spillovers through explicit collaboration. For example, in 2011, Samsung Electronics built a joint research center called the Center for Intelligent Computing (CIC, http://cic.snu.ac.kr/cx/) with Seoul National University (arguably the number one local university in Korea) to enhance the firm's software product quality. Samsung supports infrastructure and budget for the center, while the university is in charge of research efforts.

with the patent data of Samsung Electronics, LG Electronics, and other companies in the industry of electronics in the same year[15].

The diversification of product lines is another potential explanatory variable affecting the innovative activities at the firm level. As the number of product lines increases, it becomes quite difficult for top managers to understand day-to-day operations of whole product divisions. Also, the top managers are lacking in sufficient knowledge regarding every individual product's current industry trend and related prospective technology. Naturally, the criteria to evaluate the performance of each product division become based on financial results, such as net profit or the rate of return of investment. As a result, the firm begins to avoid risky R & D investments while taking into account only the current returns and discourages the efforts of in-house innovators. Similarly, Baysinger and Hoskisson (1989) and Hoskisson and Hitt (1988) showe that the firms with less diversified product lines (dominant business firms) have significantly higher R & D intensity based on *Fortune*'s 971 industrial firms between 1980 and 1982 and *Fortune*'s 124 major U.S. firms, respectively. Also, Rappaport (1978) notes that the lack of emphasis on R & D investment in the 1970s by U.S. firms, compared to other foreign firms, was caused by an emphasis on short-term financial results.

However, it should be noted that innovative products are something to be generated with a long-term perspective and willingness to take some risks. In fact, only

[15] Although Jaffe's (1989) work emphasized geographically mediated spillovers using state-level time series data on corporate patents, this paper used technology-level time series data. Since South Korea is very tiny country, which size is about 1/100 that of the U.S. (100,210 km^2/9,826,675 km^2), there is rarely a case in which geographical distance affects the spillover effect of university research on a firm's innovative activity.

about half of the R & D projects are successful on average (Scherer, 1999). Therefore, a large diversification of product lines within a company and risk-averse behavior toward innovation accordingly may decrease the level of technological change. In this study, the diversification is measured by $1-\sum S_p^2$, where S_p is the proportion of annual sales of the p^{th} product in each firm, and therefore, the greater number captures the greater level of the diversification of product lines. The proportion data is retrieved from the DART.

Lastly, *D* is a vector of dummies of the 13 sectors and the sample years. It is included in each model. To account for the fact that the level of FDI may be higher (or lower) in a certain sector due to, for example, the government's promotion policy, etc.; and to control common macroeconomic effects, controlling time-invariant sector characteristics and year dummies are essential in this analysis.

Notably, in the sample, the data are not continuous for all firms. Due to the restructuring of ownership or a merger and acquisition (M&A), the entry and exit of firms happen in the middle of the sample period. In addition, only the firms which are publicly listed in stock markets are required to offer their major financial data (e.g., revenue, R & D expenditure, net equity, etc.) to the DART. Among 100 firms listed by the KIPO, 29 of them are not publicly listed companies. In this sense, the specific number of firms used in this analysis is 71, and some of the firms in the data set cannot be tracked over the full 10-year period.

Table 1- The list of variables

4.2 Results

Table 2 shows the first results of major regression analyses. Each column in the table reflects the result of a different model. The first two columns, Model 1 and Model 2 in Table 2, report the baseline model analyzing the two effects of in-house R & D on a number of patents through export at the firm level in South Korea. Models 3 through 5 show the baseline model extended by additional explanatory variables influencing the innovation. For example, in Model 3 and Model 4, the *University* and *Diverse* variables are added, respectively, and Model 5 includes the both variables.

Table 2- Linear regression of the number of patents from major innovative companies in South Korea, 2000–2009

According to the results, interestingly, the learning effect of R & D (*Learning*) is not significant. However, the creative effect of R & D (*Creative*) is consistently critical to generate innovation. Statistically, a 1 percent increase in R & D expenditure is associated with about a 0.6 percent increase in the number of patents. Putting it plainly, it can be suggested that the in-house R & D activities at Korean firms generate a lot more patents through creating them themselves, rather than from learning from competition with other advanced products or imitating from demonstrations by other competitors in the global export market. Both the learning effect of R & D (*Learning*) and the effect of export (*Export*) are not significant. This phenomenon may be explained by accounting for the fact that since the firms in South Korea have already been at the technological frontier in the world *during the sample period 2000–2009*, they hardly had anything new to learn from global competitors. In a similar vein, Girma and Wakelin (2001) find that the highly

skilled establishments in the UK electronics sector with a high TFP level between 1980 and 1992 are not affected by FDI. They reason the result is because the establishments are probably the nearest to MNCs in terms of technology and market share. Some data indicating South Korea's high level of technological capacity and human capital can support the same interpretation. For example, the Patent Technology Monitoring Team (PTMT) of the U.S. Patent and Trademark Office (USPTO) constructs an annual table containing the number of patents granted, of all types and from each country, that require utility, innovativeness, and novelty. Since the U.S. is the largest and most popular single market in the world, the patents registered in the USPTO can be regarded as high quality and significant and, thus, a good indicator of technological capacity (Cantwell & Fai, 1999). According to data, during the sample period from 2000 to 2009 (for the sample period), South Korea was the fifth highest country in terms of the number of accumulated patents granted by the USPTO, following the U.S., Japan, Germany, and Taiwan.

Table 3- Accumulated number of patents granted by the USPTO for the period from 2000 to 2009

The level of human capital in South Korea can also support the conjecture. The local population of highly educated people often serves as a proxy of the level of human capital, and Barro and Lee's (2010) data are one of the most popular sets frequently used by many social scientists. According to the data, in terms of average years of tertiary schooling among the total population over age 25 between 2000 and 2010 (for the sample period), South Korea was the seventh highest country among OECD countries, following the U.S., New Zealand, Israel, Canada, Japan, and Australia. More specifically, the

number of South Korea was 0.962, while the number of the world during the same period was 0.392. Simply, it can be suggested that, in South Korea between 2000 and 2010, there had been a lot of the adult population educated above the college level (145.95 percent more than the world), and the population enhanced the technological capacity of local firms to generate innovations on their own.

Table 4- Average years of tertiary schooling among the total population over age 25 in OECD countries from 2000 to 2010

Additional interesting results are found through other explanatory variables. That is, university research activities (*University*), number of employees (*Labor*), and diversification of product lines (*Diverse*) significantly influence technological change in the firms in South Korea. In the case of university research (*University*), a 1 percent increase in the number of patents by local universities is associated with about 0.6 percent increase in the number of patents by the firms. Also, a 1 percent increase in the number of employees (*Labor*) is associated with about 0.3 percent increase in the number of patents by the firms, which means that the size of a firm matters for innovation. On the other hand, an additional unit increase in product diversification (*Diverse*) significantly decreases the level of innovation. Therefore, a firm needs to concentrate on a limited number of products; what the firm can do the best and what the products are can generate a synergy effect among them.

In order to increase the reliability of the results of two different effects of R & D through export, the models in Table 2 are extended by adding the *FDI* variable and its learning effect variable (*Learning2*). The results are shown in Table 5.

Table 5- Linear regression of number of patents by major innovative companies, 2000–2009, with FDI variables

Most importantly, the additional variables do not change the results from the previous models. Still, the creative effect of R & D (*Creative*) is a lot more important to increase the level of innovation, while the learning effect through export (*Learning*) is not significant. As expected, the effect of *FDI* on the number of patents is not significant, nor is the learning effect of R & D (*Learning2*) through it. In this sense, it still can be suggested that since the firms in South Korea have already been in a group at the technological frontier in the world *during the sample period*, they hardly had anything new to learn from their external environment (i.e., export and FDI).

Lastly, to reduce concerns of reverse causality and to avoid simultaneity between explanatory variables and the dependent variable, the analysis is performed again with the dependent variable lead by one year. In other words, I test whether the current level of all explanatory variables only affect the future number of patents.

Table 6- Linear regression of number of patents by major innovative companies, 2000–2009, with FDI variables, Dependent variable lead by 1 year

As Table 6 shows, major findings from previous tables do not change, except the *University* variable. By leading the dependent variable, the *University* variable lost its significance, although the sign of the coefficient remained the same. The conjecture of the change is that since a firm’s research activity is generally more in applied science area and is time sensitive due to the fast-running global competitive market than the activity at

a university, generating innovation at the firm always requires the most recently updated information.

4.3 Advanced Firms vs. Less Advanced Firms

In section 4.2, the results suggest that the sample firms hardly had something new or advanced to learn through either export or FDI because, presumably, they have been within a group at the technological frontier in the world *during the sample period*. If the conjecture is correct, then the effect of export or FDI on the firms, which has a relatively low level of technological capacity among the sample, may be significant. In other words, relatively less-advanced companies among the sample may have learned something new through the external environment and contributed to generating innovation during the sample period because the firms may have not been within a group at the technological frontier.

According to Girma (2005), as an alternative to the usage of a linearly interacting term between a proxy of absorptive capacity (e.g., R & D or TFP gap) and the source of spillovers (e.g., FDI), others (e.g., Girma and Wakelin, 2001; Kokko et al., 1996) divide the sample according to the level of absorptive capacity and compare the degrees of the source of spillovers across the subsamples to explore the idea of Cohen and Levinthal (1989). Following this approach, the sample in this study is divided into two groups according to some perceived proxies of absorptive capacity (i.e., the number of accumulated patents and the average of R & D intensity during the sample period) to

examine whether there is a remarkable difference between two subgroups regarding the effect of export and FDI[16]. Table 7 shows the results.

Table 7- Negative binomial regression of the number of patents by major innovative companies, 2000–2009, dividing the sample into two different groups, top 50 and below 50

Models 1 and 2 report the regression results of advanced companies. Model 1 shows the results of the top 50 patenting companies, while Model 2 reports the results of the top 50 R & D intensity (R & D expenditure out of total sales) companies. In a similar manner, Model 3 shows the results of the below 50 patenting companies, while Model 4 reports the results of the below 50 R & D intensity companies.

Looking at the advanced group (Models 1–2) first, the overall results remain same as the results from the pooled sample. The effect of export (*Export*) and *FDI* on the level of innovation is still insignificant for advanced companies. Therefore, the conjecture made in section 4.2 that the learning effect of in-house R & D through export and FDI is not a critical factor to generate innovation due to the already high level of technological capacity can be viable.

On the other hand, the creative effect of R & D (*Creative*) is consistently highly significant in not only the advanced group, but also the less-advanced group. Thus, technology-oriented firms in South Korea need to concentrate on active R & D

[16] Although Girma (2005) notes that such exogenous sample splitting may run into some inference problems, the method can still suggest such a difference exists. Refer to Xu (2000).

investment, no matter if they are large or small or no matter if they are new or old, because it is a major driving force to generate innovation[17].

Looking at the less-advanced group (Models 3–4), as expected, the effect of export (*Export*) and *FDI* becomes significant in some models. Moreover, the coefficient of *FDI* is positive. In contrast, some scholars (e.g., Cheung and Lin, 2004; Girma et al., 2001; Konings, 2001; Blomström and Kokko, 1998) emphasize the significantly negative or insignificant effect of FDI on local technological change due to severe competition in a host country by cheaper and higher-quality goods from abroad and, thus, stealing of the domestic market share and shrinking investment in R & D or other technology-related projects. However, it seems like that it is not the case for South Korean firms. Due to a large population educated at a tertiary level, rather than losing the domestic market, local firms (less-advanced companies) can enhance a capacity to assimilate and exploit existing information from the foreign firms in South Korea and generate technological changes.

Interestingly, in Model 3, additional unit increases in capital (*Capital*) decrease the level of innovation in less-advanced companies. The model indicates that a 1 percent

[17] The result, suggesting emphasizing on R & D investment, corroborates well with the recent case of LG Electronics. By the mid-2000s, the company had been named as one of the top global mobile phone manufacturers. However, following continuously successful years, LG made a ridiculous decision. That is, the company carried out heavy investments in advertising and marketing, in turn reducing the budget for R & D investment for the mobile phone division. Unfortunately, it cost them tragic results. Because of depressed in-house R & D activities at the company, LG could not react to the newly emerging era of smartphones effectively and, thus, had fallen behind other global competitors. Their mobile phone division is still performing poorly. As of 2011, there have been operating losses for six consecutive quarters in the division. In this sense, a lack of R & D activities may lead a firm not only to decrease innovative outputs, but also to misjudge upcoming technological trends. For the detailed information, see the news article titled "부풀려진 외국계 컨설팅 짐 싸!," published in *Weekly Dong-A* by Son (2010); and the news article titled "LG fails to craft a narrative for its smartphone drama," published in the *Financial Times* in 2011.

increase in *Capital* is associated with about a 0.2 percent decrease in the number of patents, and the effect is statistically significant. The result echoes the cases of natural resource–abundant countries. Natural resources are important factors discouraging national innovation rates because the more resources a country has to make a lot of money from, the less motivated people are to work in other sectors, except for natural resources–related sectors[18]. Very similar things can happen in a firm with a not-yet-advanced technological capacity, but a high amount of given capital. The more capital a firm has, the less its top managers are motivated to innovate hard, or they will not even feel any pressure for it. Also, even though the firm had not introduced any of the innovative products in a market yet, top managers may have paid higher salaries and may have already recruited more employees than necessary. In a longitudinal study of new ventures in the U.S. semiconductor industry, Schoonhoven and others (1990) find that the more financial resources a firm has, the longer it takes to introduce the first product in a market. They note that just throwing money at a new venture is not a viable approach because of a lack of time pressure, and they also mention the case of Trilogy Systems, which achieved one of the largest initial capitalizations in the venture history of computer system manufacturing and never materialized any products in the market, but the company was sold off in pieces. Not only Trilogy Systems, but also Geocast, General Magic, MicroUnity, and HAL went through a same experience.

[18] Sachs and Warner (2001) made a major contribution through the empirical finding of a significant negative relationship between natural resource abundance (measured by the amount of natural resources exported divided by GDP) and growth per capita from 1970 to 1989 in resource-abundant countries. In addition, Ross (1999) notes that poor performance in resource-abundant countries is due to shortsightedness among policy makers concentrating only on the immediate return by natural resources.

5. Conclusion

Technological capabilities are the key driving forces to increase competitiveness at the state, regional, and firm levels. Particularly, at the firm level, in-house research and development (R & D) activities are the factor directly influencing the generation of such technological capabilities and innovation accordingly. However, looking closely and more deeply, innovation can be made through two different processes or effects of R & D, which are the creative effect and the learning effect: firms' R & D investments not only generate innovations, but also enhance the firms' capacity to assimilate and exploit existing information. The existing literatures have regarded FDI as a critical method through which local absorptive capacity (R & D or TFP gap) exerts its learning effect and promotes technological. The positive effect of FDI is that by demonstrating more advanced products and increasing competition by multinational corporations (MNCs), local firms can have more motivation to learn from them, upgrade existing technologies, and boost performance.

However, it should be noted that such demonstration and competition effects do not come from FDI only. Exports can also offer increased competition and demonstration of more advanced goods in global markets and, therefore, inspire the exporting firms to learn newer and more improved technology harder. Moreover, through export, a firm should face increased demands from discerning customers worldwide and, thus, pickier requests from them. Such an environment is also an essential factor in inspiring the exporting firms toward more innovation. In this sense, exports are also an important source of learning through which local firms' R & D activities can exert their learning

effects that result in new ideas and upgrade products accordingly, and may be exceptionally meaningful for export-oriented economic countries, such as South Korea.

Including the alternative learning effect of R & D (the interaction term between R & D and export at the firm level) in a unified framework, this paper uses a panel of firm-level data to examine two such different effects of R & D based on a sample of the top 100 most innovative South Korean companies for the period of 2000–2009.

The results suggest that to increase technological capabilities and, thus, to generate competitiveness at the firm level in South Korea, emphasizing R & D investment is beneficial for the firms. Concentrating on active R & D investment and invigorating in-house innovators is a critical driving force to generate innovation, no matter if a company is large or small or no matter if a company is new or old. On the other hand, surprisingly, not only the learning effect of R & D but also the individual variable of export and FDI turn out to be insignificant for the firms in the pooled sample. The conjecture is that since many of the firms in South Korea have been in the leading group of the technological frontier during the sample period, they hardly had something new to learn from other competitors. In this sense, the creative effect of R & D is far more important than the learning effect in generating innovation of firms in South Korea for the period of 2000–2009. In addition, number of employees significantly and positively influences technological change in the firms in South Korea. On the other hand, the diversification of product lines significantly and negatively affects the number of innovations in the firms. Likewise, a firm should concentrate on a limited number of products; what the firm can do the best and what the products are can generate a synergy effect among them.

It can be assumed that relatively less-advanced companies among the sample may have learned something new through the external environment and contributed to generating innovation because the firms may have not been within a group at the technological frontier. In other words, the effect of export or FDI on the firms may be significant for less-advanced companies. Therefore, the sample in this study is divided into two groups according to some perceived proxies of absorptive capacity (i.e., the number of accumulated patents during the sample period and R & D intensity) to examine whether there is a remarkable difference between two subgroups regarding the effect of export and FDI. The results show that, as expected, the effect of export and FDI on the number of patents of the less-advanced group is significant in some models. Moreover, the coefficient of FDI is positive. Due to a large population educated at a tertiary level, local firms (less-advanced companies) can enhance a capacity to assimilate and exploit existing information from the foreign firms in South Korea and generate technological changes. Therefore, the government of South Korea needs to lessen the existing regulation on FDIs so that small- and medium-sized local companies can take advantage of foreign advanced technologies to improve further.

Although the results show that advanced companies' R & D has no effect on learning from the external environment, it should be noted that the result is only based on the 2000s due to the data availability. In fact, export has been a critical factor resulting in the dramatic growth of South Korea. By accepting more rigorous clients and competitors in global markets, the country has demanded to learn advanced technological knowledge and improve further. Similarly, Bruton (1998) emphasizes learning activities and, thus, knowledge acquisition as the most important and primary sources for development.

Therefore, technologically advanced firms should not make any arrogant decisions—such as neglecting external factors for good—but they should concentrate on an outward-oriented strategy as well along with an active R & D investment.

Essay 3: The Dynamic Relationship between Female Employment and Firm Profitability: A Three-Stage Sigmoid Curve Model and the Influence of Export

1. Introduction

It is frequently observed that many corporations emphasize the diversity of employment in their career websites. They introduce how diversified work environments are offered to potential employees and how respectful they are of women and minority groups. An increase in worker diversity is parallel to an increase in competitive advantage. The diversified employees can bring more various kinds of skills and knowledge to an organization. Utilizing and sharing such diversified ideas effectively can result in more innovative and creative achievement and can help improve an individual's insufficient knowledge level. Similarly, Cohen and Levinthal (1990) suggest that the enhanced ability for further innovation can be done through interactions among individuals possessing various kinds of knowledge, and such an ability can supersede what any single individual can do. Boland and Tenkasi (1995) also note that the synergistic collaboration of different and diverse knowledge can create a form of competitiveness in product success. Moreover, a company's effective identifying of skills and knowledge of such diversified human capital is a competitive and intangible asset. Therefore, such competitiveness cannot be easily imitated by rival firms. Likewise, Pfeffer (1996) points out that unlike technology or machinery, an organization's human resources cannot be readily duplicated.

By using a panel of firm-level data from the top 100 most innovative South Korean firms, based on the most recently published ranking by the Korean Intellectual

Property Office (KIPO) and according to the accumulated number of patent applications for the period 2000–2009, this paper concentrates on the effect of female workers—a critical factor enhancing the diversity of a firm's human resources in the country—on the firm's profitability. Empirical tests demonstrate that a firm's female workers are more positively related to a firm's profitability when the firm actively exports. It can thus be assumed that female workers have a particularly significant positive effect in increasing market understanding, which benefits company performance. The results also demonstrate a sigmoid curve relationship between female workers and profitability. That is, the effect of female employees is negative at first until a certain moderate level (threshold level) is reached. But after this, as the organization adds more females, a positive effect becomes noticeable. Unfortunately, this upward trend does not last; once it reaches its optimal level, the effect turns negative again. In addition, a firm's innovative activities are positively and significantly associated with its profitability. On the other hand, the effects of exports and the number of employees on performance are significantly negative because of an appreciated local currency value and increased organizational costs, respectively.

The paper is organized as follows: Section 2 reviews the existing literature regarding the effects of worker diversity on a firm's performance and discusses the purpose and contributions of this paper. Section 3 summarizes the data and empirical model and discusses the results of the econometric analysis along with some policy implications. Section 4 concludes the paper.

2. Literature Review

Focusing on a certain aspect of worker diversity—gender diversity—both researchers and practitioners around the world emphasize the positive effect of diversity on a firm's performance (Richard et al., 2006) largely because of three possible positive influences. One of them is enhanced creativity and innovation upon more diversified and different knowledge and ideas added within an organization. There is absolutely something that each gender knows more about and understands better, and such unique ideas can dilate the scope of thinking and result in a quite innovative product, strategy, planning, etc. Similarly, Taylor and Greve (2006) suggest that the higher levels of creativity and innovation can be generated by the combination of different knowledge and skills[1].

A firm can also enhance the understanding of the marketplace by increasing gender diversity. As time passes, the line between major and minor customer groups that depend on gender becomes thinner and thinner. For example, the automotive industry, one of the most traditionally male industries, does not target only male groups anymore. Every critical component of a vehicle (such as car design, features, color, marketing strategy, product planning, advertising, etc.) is created taking into consideration the taste of both male and female customers. In this sense, if a company does not have a sufficient level of gender diversity, the firm cannot come up with an effective plan and thus product

[1] Actually, in the real world, there are many different kinds of goods from various industries created by such an interaction. For example, the birth control pill is a good example of innovative products created with the distinctive idea of female scientists. According to Ranga and Etzkowitz (2010), the product is widely recognized as one of the most exceptional achievements of the 20th century. DeLong and Brookshire (2007) note that PepsiCo attributed about $250 million of its 2003 revenue to its diversified workers who created innovative goods like guacamole-flavored Doritos chips, Gatorade Xtremo, and Mountain Dew Code Red.

to satisfy its customer groups. In a similar manner, Richard (2000) argues that an organization with racially diversified workers can better serve racially diversified customers. Nkomo and Cox (1999) suggest that each gender's diverse experiences may provide a better understanding of the different needs of male and female customers. Cox and Blake (1991) note that customers' tastes are getting more diversified, and thus, a firm needs to be as diversified as they are.

In addition, an organization with gender diversity, thus including more female workers, can solve internal problems more efficiently and smoothly than an organization without such diversity because women are inherently good listeners with patience and are thus consensus builders. Dezső and Ross (2008) note that women tend to manage their tasks in a more interactive, but less hierarchical style than men; and therefore, the style can generate better teamwork and collaboration within a group. Likewise, Litz and Folker (2002) and Fenwick and Neal (2002) point out that while "competition," "hierarchy," and "low emotionality" are suitable words for males, "cooperation" and "high emotionality" are more appropriate words to describe females. Also, such enhanced collaboration and team-based works are critical factors to generate innovation and creativity. Even if an organization is filled with diverse and different knowledge but such ideas are not freely and actively shared with group members, there will not be any innovative achievement. Dezső and Ross (2008) suggest that the management practice of encouraging participation and collaboration of female groups tend to increase the creative and innovative activities of the employees, while the dictatorial and controlling style of management of male groups may disturb such activities. These positive effects of gender diversity on the performance of firms are supported by some empirical works too. For

example, based on the top 1,500 U.S. firms from 1992 to 2006, Dezső and Ross (2008) demonstrate a significantly positive relationship between female participation below the CEO level and firm performance measured by the ratio of the company's market value to book value. The study of McMillan-Capehart (2003) shows a significant and positive effect of gender diversity on sample firms' profitability. Frink and others (2003) also present that the percentage of female employee is significantly and positively associated with profitability in 291 different organizations in the U.S.

On the other hand, a theory contrary to the positive effects of gender diversity exists. People usually feel more comfortable interacting with a similar group, and gender is a popular means to define similarity among people. Likewise, Messick and Mackie (1989) note that categorization based on visible differences—such as gender, race, or age—is especially common. If one gender group defines other gender group as "different," the smooth cooperation and communication between two gender groups may be difficult; and thus, conflicts within the organization may arise. Obviously, it will cause a strain on previously effective teamwork and slow down the performance. Similarly, Ali and others (2011) suggest that people tend to see one's own group as more superior, and Earley and Mosakowski (2000) and Cox and Blake (1991) note that teams containing heterogeneous factors tend to communicate less frequently and therefore experience more conflicts. Litz and Folker (2002) argue that since the management styles among males and females vary, such differences may lead to less speed in the decision-making process. Based on Spanish corporations listed on the local stock market, Gallego Á lvarez and others (2010) demonstrate that the proportion of female employees has a significant and negative effect on the companies' profitability for the period from 2004 to 2006. Using a

national sample of 177 banks, Richard and others (2003) show that gender diversity has no effect on the sample firms' performance. Studying 92 workgroups of moving firms in the U.S., Jehn and others (1999) present that the more gender diversity there is in a group, the more conflicts arise.

Likewise, it seems difficult to come up with a reconciled empirical result regarding the link between gender diversity and a firm's performance, although academics and practitioners agree with an economic necessity to combine both sexes into the worker. In fact, in reality, it seems like it is necessary to examine more than a simple linear relationship between the two variables. For example, although IBM is one of the best firms utilizing diversified workers including women and minority groups to outperform rival companies and to interact effectively within the diversified markets (e.g., the number of female executives worldwide has increased by 370% since 1995, and 52% of IBM's top 52 executives who determine corporate strategy are women), the positive effect of such diversity did not appear from the beginning. Instead, the initiative required a lot of work (Thomas, 2004). Therefore, considering what's beyond the simple independent positive and negative effects of gender diversity is essential.

The combination of existing theories may explain why the initiative processes of IBM remain struggling. When there is a very low level of gender diversity within an organization and thus quite a small number of female workers, obviously, the presence of a female group is not noticeable to the existing majority group—the males. However, as additional female employees are added within the group, the presence becomes more prominent, and the small group is now regarded as a minority group or as out-group members (Earley and Mosakowski, 2000). Brewer (1979) suggests that the categorizing

of people into out-group and in-group leads existing majority members to perceive minority members as less trustworthy, less honest, and less cooperative. Similarly, Loden and Rosener (1991) note that the out-group is typically regarded as deficient, causing increased stereotyping, polarization, and anxiety. In turn, minority group or out-group members will physically or mentally leave the organization since they will perceive themselves as the people who do not belong to the organization (Tsui et al., 1992). Likewise, once a female group begins to be perceived as the minority group, then inefficient teamwork, lack of cooperation, and conflicts will result. However, the downward trend will not necessarily last. If females are constantly being added to the organization, after a certain moderate level, the group will have enough numbers not to be perceived as a minority; and thus, the prejudice on female workers will decrease. Similarly, Alexander and others (1995) suggest that in-group and out-group identities can be reduced by evenly diffusing subgroup members over the categories of diversity. Because of the disappearance of prejudice and thus stereotyping and anxiety regarding female employees, the efficient collaboration and communication to utilize the diverse and different knowledge of female members are possible. Accordingly, all these will influence performance in a positive way. In short, the correlation between female workers and a firm's performance may demonstrate a U-shaped curve. The qualitative field test of Earley and Mosakowski (2000) may corroborate the process. The test shows that groups with a moderate level of racial diversity exhibit the maximum level of conflict and lack of communication when compared with groups with low and high levels of racial diversity.

On the other hand, such a positive relationship between female employees and the firm's performance after a certain threshold level does not last forever either. If the number of female members keeps increasing, the existing majority members—the males—will perceive them as a threat; and thus, economic competition will increase as well (Ali et al., 2011). As the two different gender groups regard each other as rivals, not partners, within the same organization, there can be a lack of effective sharing and cooperation; and therefore, conflict and poor team performance may rise again. In addition, Richard and others (2002) note that an almost equally balanced group means there is no dominant group who will control the organization efficiently, and such an inefficiency will cause the process not to run smoothly. In this sense, there may be some optimal level of the proportion of female employees. In fact, such an optimal level has been presented empirically in a few papers. For example, Ali and others (2011) demonstrate partial support for the inverted U-shaped curvilinear relationship between gender diversity and performance, using more than 200 Australian firms. Based on 291 different organizations, Frink and others (2003) show an inverted U-shaped relationship between the percentage of female employees and organization profitability.

Therefore, the above leads to the following hypothesis:

Hypothesis 1: The relationship between female ratio and firm profitability is the sigmoid curvilinear relationship, with the slope negative at low levels, positive at medium levels, and negative again at high levels of female ratio.

Likewise, this paper argues that the relationship between female employees and the firm's profitability is more than a simple linear relationship; and therefore, various circumstances should be considered to understand its dynamic correlation. In a similar manner, Ely (2004) suggests that organizational scholars investigating the link between racial diversity and performance within a workgroup have generally concluded that the effect is not direct. Therefore, besides considering the sigmoid curvilinear relationship to detect more complicated patterns of the relationship between female workers and profitability, another method is added in the analysis—that is, the inclusion of interaction terms in multiple regression equations because it may not be true that the effect of female employees on the firm's profitability is always consistent, no matter how the level of another independent variable changes. Likewise, Tosi and Slocum (1984) suggest that a firm's performance is generated by the fit between other various organizational processes, such as technology, structure, strategy, culture, etc. Richard and others (2006) note that considering the varying effects of organizational diversity along with different kinds or levels of organizational and contextual conditions is critical. In fact, Richard and his colleagues have examined such a contingency theory regarding the effect of racial diversity. For example, Richard and others (2006) show the significant moderating effects of an organization's structure on the correlation between both racial and gender diversity and performance based on the U.S. banking industry. Using a national sample of 177 banks, Richard and others (2003) also demonstrate that racial diversity's association with performance depends on the firm's level of innovation.

In this paper, the moderating effect of globalization on the correlation between female workers and a firm's profitability is examined. Specifically, export at the firm

level is considered as a different level of organizational and contextual condition because of the characteristic of the sample firms, the top innovative companies in South Korea. It is well known that export has been an exceptionally meaningful strategy for the growth of the country and its major corporations, according to the outward-oriented economic policy. An interesting point is that the firms in South Korea have always regarded active exporting as their destiny. Such an export-oriented strategy has been driven not by any other factor, but by the very small size of the given domestic market. The firms always insist that such a small local territory cannot satisfy their supply and therefore have looked to the international market. Similarly, Lu and Beamish (2001) and Grant and others (1988) note that the most obvious benefit from exporting is gaining larger volumes of sales and production in geographically extended markets and therefore achieve scale and scope of economies. In addition, the South Korean peninsula, surrounded by sea, makes the firms export and behave in an outward-oriented policy more easily. Therefore, to explain the performance of South Korean firms, their export should not be omitted.

On the other hand, by having more female employees and thus increasing the level of gender diversity within an organization (the mean of the ratio between the number of female employees and the total number of employees of the sample is 15.71%), the company can generate a more effective strategy to enter the overseas market because, as noted earlier, more diversified and different knowledge may increase the understanding of international markets. Similarly, Carter and others (2003) and Campbell and Mínguez Vera (2007) suggest that an increased number of female workers promotes a better intuitiveness of the marketplace and therefore an ability to penetrate markets. In addition, the inherent characteristic of women (e.g., being more detailed and more patient

with forthcoming outcomes) may be more suitable for exploring the market overseas. The successful entrance into a global market deals with a lot more different kinds of data and analyses than can be found in a domestic market. Utilizing and sorting such tremendous amount of information to come up with a very effective strategy may require the meticulous nature of women. Also, generating a reasonable amount of return in the international market is impossible in the beginning. Since it deals with different customers with diverse cultures, it requires serious investigation along with patience. Likewise, Brusch (2002) suggests that women prefer longevity, rather than fast company growth. Further, Cox (1994) notes that female groups bring insight and cultural sensitivity into an organization and that they are associated with reaching new and different markets.

In this sense, considering the varying effects of female employees and of different levels of export on profitability is essential, and the following can be hypothesized:

Hypothesis 2: The correlation between female workers and a firm's profitability will be more positive when the firm pursues active export.

Besides contributing two new hypotheses and their results—which have not been examined in existing literature, to the best of my knowledge—this paper has some other features as well. First, using longitudinal firm-level data (e.g., the net amount of realized export, sales, the number of female employees, etc.) can effectively control unobservable or immeasurable firm-specific factors. Particularly, because of data availability, it has been difficult for other papers to employ export data at the firm level in various kinds of

empirical analyses. Even the link between export at the firm level and a company's profitability has been investigated in a limited number of studies (Wagner, 2012; Grazzi, 2011; Liu and Buck, 2007). However, thanks to the general trait of financial statements issued by Korean firms, which discloses the realized value of many kinds of different variables (including export) annually, the rich information of continuity at the firm level could be used.

Also, this study concentrates on the most innovative companies in South Korea during the last decade. The economic and innovative performance of South Korean firms has received a great deal of attention because of its exceptional speed of growth. Although the nation's strong emphasis on the level of human capital, along with export-oriented strategy, has been regarded as an important ingredient for rapid growth (Page, 1994), to the best of my knowledge, there have hardly been case studies that have examined the effect of human capital, particularly of qualified female workers, in South Korea. The local population of highly educated people frequently serves as proxy of the level of human capital, and Barro and Lee's (2010) set of data is one of the most popular often used by many social scientists. According to the data, in terms of average years of tertiary schooling among the total female population over age 25 between 2000 and 2010 (for the sample period), South Korea was the 14th-highest country among 146 different countries.

Table 1- Average years of tertiary schooling among the total female population over age 25 between 2000 and 2010

Although South Korea has had qualified female workers and its major corporations have recently pursued gender diversity in their employees,[2] it still seems that many corporations in the country have been hesitant to utilize the assets more actively in comparison with other countries. In fact, the *Economist* (2011) points out that although South Korea has many highly educated women, most of them just stay at home because, as Choi and others (2001) note, there are several obstacles for them to exert their skills and efforts in a work environment, including discriminatory hiring policies and ineffective legislation on the rights of working women. Also, there has been an implicit socially built assumption that women have less leadership skills (e.g., the army has no high-ranking female general). The most recent report by OECD (2012) gives a clearer picture. In terms of female employment rate calculated by dividing the number of female employees aged 15 to 64 by the total female population of the same age, the percentage number has always been lower than the average number of OECD countries.

Figure 5- The female employment rate of South Korea vs. OECD countries

In this sense, this empirical analysis and its results may offer some implications to the major innovative companies in South Korea for understanding the true benefits of female workers for further growth, on one hand, and some limitations, on the other. In addition, according to Ali and others (2011) and Frink and others (2003), there has been sparse research regarding gender diversity and performance at the organization level; and thus, contradictory results have been presented. Therefore, based on the sigmoid (S)

[2] Refer to the news article titled "삼성-LG 혁신 화두는 다양성," published in *Dong-a Ilbo* by Jeon, S. (2010).

curve model, as well as on varying effects of female employees along with different levels of export on a firm's profitability, this paper may propose to help reconcile the disparities in the literature.

3. Empirical Analysis

3.1 Model and Data

The econometric analysis of the effect of gender diversity on a firm's profitability in South Korea starts from the following baseline model, where subscripts *i* and *t* denote firm and time period, respectively:

$$\mathbf{Y_{it}=\beta_0+\beta_1 Female_{it}+\beta_2 Export_{it}+\beta_3 Innovation_{it}+\beta_4 ln(Capital_{it})+\beta_5 ln(Labor_{it})+\varepsilon_{it}}$$

All the necessary data used in the analysis are retrieved from the Data Analysis, Retrieval and Transfer System (DART, http://englishdart.fss.or.kr/), operated by the Financial Supervisory Service (Korean version of the U.S. Securities and Exchange Commission). All publicly listed companies in South Korean stock markets are required to release major financial statements and other informative data regarding themselves quarterly and annually through the DART, and the information submitted is always made available to the public. The first year of available data is from 1999. In addition, for the analyses, all annual nominal values (e.g., R & D expenditure, revenue, the realized value of export, net equity value, etc.) are deflated using the GDP deflator from the database of World Development Indicators. All values are presented in 2005 constant currency.

To measure profitability (the dependent variable), the accounting-based measures return on sales (*ROS*) and return of assets (*ROA*), which are transformed into natural logarithm, are used. Those data are among the most popular proxies of firm performance, and thus, many scholars use them along with various independent effects on profitability at the firm level (e.g., Richard et al., 2006; Contractor et al., 2002; Lu and Beamish, 2001; Hitt et al., 1997; Tallman and Li, 1996).

On the other hand, *Female* is a key independent variable as a proxy of gender diversification within a firm in the analysis and is measured by the ratio of female workers and total number of employees (Frink et al., 2003). Since the sample firms' female employee ratio is quite low (as Table 2 shows, its mean is 15.71%), the greater the proportion of female workers means the more diversity in terms of gender.

Export is each firm's annual export intensity measured by the ratio of the net amount of realized export to total revenue in millions of South Korean currency. Such measure is by far the most popular variable in empirical international business research, and also, its objective measurement is another benefit (Pla-Barber and Alegre, 2007).

Innovation is a proxy of overall innovative performance within a firm and thus a critical variable to be controlled in this analysis because of its potential positive effect on a firm's profitability. A company's innovative activities can influence its production process and result in efficient manufacturing. Accordingly, it can present price-competitive products in markets. Also, through an active pursuing of technological change, a firm can create more valuable and attractive goods and supersede its rival companies (Sher and Yang, 2005; Zhao and Li, 1997). *Innovation* is a created variable

through factor analysis of each firm's annual research and development (R & D) expenditure in millions of South Korean currency and the number of patent data of each firm retrieved from the most recent publication by the KIPO. Through the method of combining the two different data, it may be expected to capture the overall innovative performance within a firm. A sole variable of R & D expenditure will likely cover the *input* of innovative activities only. However, adding the patent data, which captures the *output* of a firm's such activities, allows measuring the broader meaning of technological change within the company. Similarly, Hagedoorn and Cloodt (2003) note that such a composite measurement can capture the more complex and informative innovative performance of a firm.

ln*(Capital)*, measured by the natural log transformed of net equity value, is served as a proxy of each firm's capital stock, while ln*(Labor)*, measured by the natural log transformed of the number of total employees, is served as a proxy of the size of a firm. Other than the major explanatory variables, these are controlled as firm-specific factors influencing the financial performance of the sample companies.

More explanatory variables are added to the baseline model to increase the reliability of the regression results and test the hypotheses, and thus, it extends to the following, where *ExpXFemale* is the interaction term between the *Female* and *Export* variables. *FemaleSQ* and *FemaleCube* are the squared and cubed term of *Female* variable, respectively:

$$\mathbf{Y_{it}=\beta_0+\beta_1 Female_{it}+\beta_2 Export_{it}+\beta_3 ExpXFemale_{it}+\beta_4 FemaleSQ_{it}+\beta_5 FemaleCube_{it}}$$
$$\mathbf{+\beta_6 Innovation_{it}+\beta_7 ln(Capital_{it})+\beta_8 ln(Labor_{it})+\beta D+\varepsilon_{it}}$$

Lastly, *D* is a vector of dummies of the sectors included in each model. Following Ali and others (2011) and Frink and others (2003), there may be differences in terms of the effect of the proportion of female workers in service sectors versus nonservice sectors because service industries typically have higher female representation. Therefore, two vectors of sector dummies—service and nonservice industry—are added. In the sample, service industry includes information technology (IT) service or the consulting industry. In addition, the cosmetic industry is also added because the industry traditionally has had higher female representation[3].

It should be noted that in the sample, the data are not continuous for all firms. Because of the restructuring of ownership or a merger and acquisition (M & A), the entry and exit of firms happen in the middle of the sample period. In addition, only the firms which are publicly listed in stock markets are required to offer their major financial data (e.g., revenue, R & D expenditure, net equity, etc.) to the DART. Among 100 firms listed by the KIPO, 29 are not publicly listed companies. In this sense, the specific number of firms used in this analysis is 71, and some of the firms in the data set cannot be tracked over the full 10-year period.

Table 2- The list of variables

[3] On the other hand, year dummies are not included, because I expect that the sample firms are unlikely to be exposed to common time-specific factors in terms of hiring female workers in South Korea.

3.2 Results

Table 3 shows the results of major regression analyses. Each column in the table reflects the result of a different model. The left four columns (Models 1 through 4) employ natural logarithm transformed *ROS* as a dependent variable, and the right four columns (Models 5 through 8) use natural logarithm transformed *ROA* as an alternative dependent variable. Model 1 and Model 5 in Table 3 report the baseline model analyzing the effect of female workers on a firm's profitability. Models 2 and 3 as well as Models 6 and 7 show the baseline model extended by additional explanatory variables to test hypotheses. For example, in Model 2 and Model 6, the interaction term between *Female* and *Export* is added to test hypothesis 2. Similarly, Models 3 and 7, the full models, include the squared and cubed term of *Female* (i.e., *FemaleSQ* and *FemaleCube*) to test hypothesis 1. To reduce concerns of reverse causality and to avoid simultaneity between explanatory variables and the dependent variables, the full models (Models 3 and 7) are tested with all independent variables lagged for one period, and the results are quite similar. The results are shown in Models 4 and 8.

Table 3- Linear regression of return on revenue and assets from major innovative companies in South Korea (2000–2009)

Looking at the baseline models (Models 1 and 5) first, the effect of *Female* is highly significant and positive on a firm's profitability. In this sense, female workers may offer different and diverse ideas to enhance the innovative activities in various divisions (e.g., marketing, strategy, product planning, R & D, etc.), increase the understanding of marketplaces so that firms can react to them and customers effectively, and solve internal

problems more efficiently and smoothly because of the natural-born attitude of being good listeners and consensus builders.

Moving to the next models (Models 2 and 6), the effect of *Female* becomes insignificant, however. Instead, the effect of the interaction variable between *Female* and *Export*, *ExpXFemale*, is statistically significant and positively associated with a firm's profitability. Thus, the results support hypothesis 2. Friedrich (1982) notes that in models with multiplicative terms, the coefficients of component variables (e.g., *Female* and *Export*) describe the particular trend of effects on the dependent variable. That is, each component variable's coefficient value and its statistical significance when its interacting variable is equal to zero. For example, in this model, the coefficient value of *Female* describes its effect on profitability when *Export* is zero. Likewise, the coefficient value of *Export* describes its effect on the dependent variable when there is no female employee. Therefore, the results suggest that the women in a company may not contribute much in terms of profitability if the firm does not export. Conversely, the contribution of female workers to a firm's profitability is positive and statistically significant if the firm pursues active exporting. Similarly, the effect of export on a firm's profitability can become significantly positive when the firm has female workers. In this sense, it can be assumed that the area at which female workers exert their beneficial influences the most is in increasing market understanding (e.g., promoting a better intuitiveness of the marketplace and thus an ability to penetrate overseas markets and bringing insight and cultural sensitivity into the organization and therefore reaching new and different markets more effectively).

It is quite unexpected that the effect of *Export* is strongly negative, and such an effect is consistent in all models because the analysis is based on the sample firms in South Korea, which have pursued exporting as a key strategy for growth. However, before concluding the negative effect of export on profitability, several factors should be noted. First, during the sample period, Korean local currency has been consistently appreciated until the subprime mortgage crisis began. For example, according to Figure 2, the ratio of Korean local currency to the U.S. dollar has continuously gone down, which means the appreciation of Korean local currency[4]. Second, the manufacturing facilities for goods of the sample firms are mostly located in South Korea. Third, on average, the ratio between revenues generated by export and total sales for the sample firms during the period 2000–2009 is more than 50%. In other words, the firms' revenue highly depends on the overseas market rather than the domestic one. Therefore, as the local currency is appreciated, the value of sales from the overseas market decreases. However, since the goods are still manufactured in the local territory and the cost is still same, the net income will decrease. If a firm wants to keep the profit margin as before, they should increase the sales price, and it will make their goods less competitive in international markets. For example, many Korean firms in the automotive, chemical, and material industries are suffering from another period of local Korean currency appreciation. Looking at the case of Kia Motors, they anticipated that the first-quarter earnings of 2013 would be decreased by 12.7% in comparison with the same quarter of the previous year.[5] Such a strong

[4] For more data, refer to the central bank's Economic Statistics System (ECOS) of South Korea (http://ecos.bok.or.kr/).

[5] For the detailed information, see the news article titled "원화 강세 · 엔화 약세...車 · 철강 · 석유화학 설상가상," published in *Herald Economics* by Lee, T. (2013).

negative effect of export on profitability is also demonstrated in the empirical analysis by Lu and Beamish (2006) based on 164 Japanese firms during the period from 1986 to 1997 with similar reasons.

Figure 6- The exchange rate between the Korean won and the U.S. dollar (2000–2009)

On the other hand, although the Korean local currency was steeply depreciated as soon as the subprime mortgage crisis began in mid-2008, as Figure 2 shows, the global financial crisis made the consumer demand worldwide anemic, and the small South Korean domestic market could not make up for the decreased demands overseas. In fact, in South Korea, export accounts for more than one-third of the GDP; and because of the global financial crisis, it dropped by 34% in 2009 from the previous year[6]. In this sense, the firms in South Korea, particularly those pursuing an export-oriented strategy and generating much of sales through export, need to understand that the effect of export on profitability may even be reversed during such a currency fluctuation or a globally depressed economic period in the short to mid run. Therefore, foreign exchange hedge and diversification of the global target market or manufacturing facilities may be necessary strategies they can consider. However, it should be noted that poor performance due to exporting in the short run cannot be the reason for less emphasis on export because export has been a critical factor resulting in the dramatic growth of South Korea. By accepting more rigorous clients and competitors in global markets, the country

[6] Refer to the news article titled "Asia's export-reliant economies feel pain of slowdown," published in Agence France-Presse in 2009.

has demanded to learn advanced technological knowledge and improve further. Similarly, Bruton (1998) emphasizes such learning activities and thus knowledge acquisition as the most important and primary sources for development.

The results of Models 3 and 7 well support hypothesis 1. The regression function shows a negative linear term, a positive squared term, and a negative cubed term again. The coefficient of each variable is highly significant. Therefore, the result suggests that beginning at the origin, the effect of female workers on a firm's profitability is negative until a certain moderate level. However, after the threshold level, as additional female workers are added within an organization, its effect turns positive. Unfortunately, such an upward trend does not last forever. Once it reaches a certain optimal level, the effect of female workers becomes negative again. Therefore, the firms in South Korea need to always remember the word "too." Both too small a number of female workers and too many of them may have a negative influence on the firms' performance because of the lack of efficient teamwork.

Additional interesting results are found through other explanatory variables. A firm's innovative activities (*Innovation*) is strongly and positively associated with returns on assets and sales. In this sense, innovation not only creates valuable products and strategies for various divisions, thus boosting performance in the markets, but also enhances the quality of the productive process and improves profitability. On the other hand, the size of companies, *Labor*, has consistent negative effects on returns on sales and assets, and the effect is statistically significant. It indicates that a 1% increase in *Labor* is associated with about a 0.3%–0.4% decrease in the return on sales and assets. Therefore, the negative effect of a firm's size (e.g., increasing organizational costs)

supersedes its positive effect (e.g., increasing economies scale)[7]. Particularly, during the sample period, the net income of the top innovative companies in South Korea has suffered because of the appreciated local currency along with the constant manufacturing costs and the decreased sales from the overseas market resulting from the global financial crisis. Due to the circumstances, additional employees and thus increased organizational costs may have exacerbated their profitability.

3.3 Prediction of Threshold and Optimal Level

As the empirical results demonstrate, there exists a threshold and optimal level of the ratio of female employees. As the last part of this section, I try to figure out the specific percentage of female workers in those two points. One way to do this is through the use of calculus. The two turning points are where the differentiated cubic equation is equal to zero. Therefore, if, for example, the correlation between *y* and *x* is estimated with the following cubic equation:

$$Y_i=a+ b_1x_i+ b_2x_i^2+ b_3x_i^3+ e_i,$$

then estimators of the threshold and optimal level are

$$\{-\beta_2- \sqrt{} (\beta_2^2- 3\beta_1 \beta_3)\}/3 \beta_3 \text{ and } \{-\beta_2+ \sqrt{} (\beta_2^2- 3\beta_1 \beta_3)\}/3 \beta_3,$$

respectively, where β is the estimator of *b*.

The calculation generates that the threshold and optimal level of this analysis are 16.67% and 46.88%, respectively, when the dependent variable is ln(*ROS*). On the other

[7] Similarly, the study of Kaen and Baumann (2003), based on 64 U.S. manufacturing industries between 1990 and 2001, shows the significant and negative effects of the number of employees on profitability.

hand, the two turning points are 13.78% and 44.70%, respectively, in the case of ln(*ROA*) as the dependent variable.

However, it should be noted that the threshold and optimal level generated through the above are numbers with uncertainties. The Markov Chain Monte Carlo (MCMC) method is an effective way to control such uncertainties for linear regression prediction. Moreover, according to Plassmann and Khanna (2007), the MCMC method is very suitable for the assessment of the precision of turning points of a polynomial equation including high order (e.g., *FemaleCube*). Applying the MCMC method into the full model (Model 3) suggests that the median threshold level is 16.13%, with 95% credible interval between 12.09% and 24.62%. On the other hand, the median optimal level is 46.76%, with 95% credible interval between 39.42% and 82.33%. In case of another full model (Model 7) employing ln(*ROA*) as a dependent variable, the numbers are 13.75%, with 95% credible interval between 8.17% and 19.51%, and 44.66%, with 95% credible interval between 39.10% and 62.03%, respectively.

In this sense, an organization needs to have at least about 15% of female workers to benefit from their positive influences and thus increase profitability. On the other hand, an organization with more than half of female workers may experience the negative effect of gender diversity on its team performance and thus profitability. The number corroborates with some notes by other scholars. For example, Richard and others (2002) suggest that an almost equally balanced group means there is no dominant group who will control the organization efficiently, and such an inefficiency will cause trouble in the process. Blalock (1967, p. 148) argues that “one would expect the greatest perceived competition among near equals.”

Table 4 -The predicted value of threshold and optimal points from linear regression and MCMC

4. Conclusion

Focusing on a certain aspect of worker diversity—gender diversity—both researchers and practitioners around the world emphasize the positive effect of diversity on a firm's performance largely because of three possible positive influences. One of them is enhanced creativity and innovation upon more diversified and different knowledge and ideas added within an organization. There is absolutely something that each gender knows more about and understands better, and such unique ideas can dilate the scope of thinking and result in a quite innovative product, strategy, planning, etc. A firm can also enhance the understanding of the marketplace by increasing gender diversity. As time passes, the line between major and minor customer groups that depend on gender becomes thinner and thinner. In this sense, if a company does not have a sufficient level of gender diversity, the firm cannot come up with an effective plan and thus product to satisfy its customer groups. In addition, an organization with gender diversity, thus including more female workers, can solve internal problems more efficiently and smoothly than an organization without such diversity because women are inherently good listeners with patience and are thus consensus builders.

However, it seems difficult to come up with a reconciled empirical result regarding the link between gender diversity and a firm's performance. This paper argues that the relationship between female employees and the firm's profitability is more than a simple linear relationship; and therefore, various circumstances should be considered to

understand its dynamic correlation. Accordingly, based on the sigmoid (S) curve model, as well as on varying effects of female employees along with different levels of export on a firm's profitability, this paper may propose to help reconcile the disparities in the literature.

By using a panel of firm-level data from the top 100 most innovative South Korean firms, based on the most recently published ranking by the Korean Intellectual Property Office (KIPO) and according to the accumulated number of patent applications for the period 2000–2009, the results demonstrate that female workers within an organization strongly influence the firm's profitability in a positive way. Particularly, they increase market understanding and thus the firm's ability to penetrate the overseas market; and their insight and cultural sensitivity help the organization to reach new and different markets more effectively. Also, a firm's innovative activities not only create valuable products and strategies to boost performance in the markets but also enhance the quality of the productive process and thus improve profitability. However, it should be noted that the effect of female workers on profitability is not a simple linear relationship. That is, there is S-curve relationship between the effect of female workers and a firm's profitability.

On the other hand, during the sample period, the effect of exporting on profitability has been significantly negative because appreciated local currency decreased the value of sales overseas, while the manufacturing costs remained unchanged. In addition, as a firm grows in terms of the number of its employees, the organizational costs grow as well, and therefore, it worsens the firm's profitability.

Lastly, I try to figure out the specific percentage of female workers in those two points through the use of calculus and MCMC method. The results suggest that an organization needs to have at least about 15% of female workers to benefit from their positive influences and thus increase profitability. On the other hand, an organization with a little less than half of female workers may maximize its team performance in terms of profitability.

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Tables and Figures for Essay 1

Table 1- Countries with less than total 30 patents granted from the USPTO between 1977 and 2010

Country	Total number of patents	Country	Total number of patents
LATVIA	29	MADAGASCAR	4
JORDAN	25	NICARAGUA	4
ANDORRA	25	ANGUILLA	3
KAZAKHSTAN	25	BRUNEI DARUSSALAM	3
HONDURAS	22	SEYCHELLES	3
EL SALVADOR	22	DOMINICA	3
CHINA, MACAU S.A.R.	21	GUYANA	3
TUNISIA	20	MYANMAR	3
SYRIA	18	PAPUA NEW GUINEA	3
TURKS AND CAICOS ISLANDS	18	SURINAME	3
SERBIA	17	YEMEN	3
BOLIVIA	17	MACEDONIA	2
NETHERLANDS ANTILLES	17	BANGLADESH	2
VIET NAM	16	CHAD	2
ARMENIA	15	CONGO, DEM. REPUBLIC OF THE	2
HAITI	12	GUADELOUPE	2
UZBEKISTAN	12	KOREA, NORTH	2
AZERBAIJAN	11	LIBERIA	2
ANTIGUA AND BARBUDA	11	MARSHALL ISLANDS	2
OMAN	10	NAMIBIA	2
IRAQ	10	NEW CALEDONIA	2
MOLDOVA	10	PALAU	2
SAINT KITTS AND NEVIS	9	SAN MARINO	2
QATAR	8	VANUATU	2
PARAGUAY	8	ALBANIA	1
FRENCH POLYNESIA	7	ANGOLA	1
MAURITIUS	7	BELIZE	1
NORFOLK ISLAND	7	BENIN	1
GIBRALTAR	6	BURKINA FASO	1
ALGERIA	6	COCOS ISLANDS	1
ARUBA	6	COOK ISLANDS	1
BAHRAIN	6	ETHIOPIA	1
CAMEROON	6	FAROE ISLANDS	1
FIJI	6	FRENCH GUIANA	1
SAMOA	6	GABON	1
GHANA	5	GUINEA	1
GREENLAND	5	MALAWI	1
SENEGAL	5	MARTINIQUE	1
TANZANIA	5	MAURITANIA	1
UGANDA	5	SAINT VINCENT AND THE GRENADINES	1
BOSNIA AND HERZEGOVINA	4	SOLOMON ISLANDS	1
COTE D'IVOIRE	4	SWAZILAND	1
KYRGYZSTAN	4		

source: the U.S. Patent and Trademark Office (USPTO),
http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_allh.htm

Table 2- Description and source of variables

Variable Name	Description	# of Countries	Years Covered	Source
PATENTS	The number of all types of patents granted by country and year	178	1977-2010	U.S. PATENT AND TRADEMARK OFFICE
EXPORT	The constant value of total merchandise flows of exports for each country in millions of US dollars	233	1948-2010	United Nations Conference on Trade and Development
IMPORT	The constant value of total merchandise flows of imports for each country in millions of US dollars	233	1948-2010	United Nations Conference on Trade and Development
TRADE	The sum of EXPORT and IMPORT	233	1948-2010	
FDI	The constant value of total merchandise inflows of FDI for each country in millions of US dollars	233	1970-2010	United Nations Conference on Trade and Development
OPENNESS	An index called Freedom to Trade Internationally to capture overall effects of exposure to global markets	141	1970-2009	Fraser Institute
International Linkages	A created variable based on EXPORT, IMPORT, FDI and OPENNESS through factor analysis			
HK_TER	Average years of tertiary schooling among the total population over age 25 in each country	146	1950-2010	Barro-Lee Educational Attainment Dataset
CL_RES	The level of restriction on civil liberties	197	1972-2010	Freedom House
PROP	An index called Legal Structure and Security of Property Rights to measure the level of property rights in each country	141	1970-2009	Fraser Institute
FRACTION	The degree of ethnic fractionalization	215	one year for each country	Alesina, Alberto, Arnaud Devleeschauwer, William Easterly, Sergio Kurlat, and Romain Wacziarg. 2003. "Fractionalization". Journal of Economic Growth 8 (June): 155-194.
URBANIZATION	The percentage of population residing in urban areas	224	1950-2010	United Nations, Department of Economic and Social Affairs, Population Division
NATURAL	The sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents out of GDP	216	1970-2010	The World Bank Data
KGDPC and KGDP	The constant value of GDP per capita and GDP (PPP adjusted) in thousand I$	189	1950-2009	Penn World Table Version 7.0

Table 3- Zero inflated negative binomial regression of number of patents in 178 countries, 1977-2010

	Dependent variable lead by 1 year				*Dependent variable lead by 2 year*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXPORT	**0.0000161*** **				**0.0000163*** **			
	(10.79)				(10.43)			
IMPORT	**-0.00000859*** **				**-0.00000846*** **			
	(-5.37)				(-5.09)			
FDI	**-0.0000104*** **	**-0.0000192*** **			**-0.0000120*** **	**-0.0000203*** **		
	(-4.38)	(-9.61)			(-5.07)	(-10.05)		
TRADE		**0.00000427*** **				**0.00000437*** **		
		(14.52)				(14.30)		
OPENNESS			**0.303*** **				**0.315*** **	
			(9.28)				(9.73)	
International Linkages				**0.682*** **				**0.684*** **
				(8.84)				(8.60)
HK_TER	**0.921*** **	**1.082*** **	**0.976*** **	**1.038*** **	**0.936*** **	**1.087*** **	**1.000*** **	**1.047*** **
	(7.63)	(8.97)	(7.54)	(8.27)	(7.49)	(8.72)	(7.47)	(8.06)
CL_RES	**-0.183*** **	**-0.140*** **	**-0.0659***	**-0.108*** **	**-0.163*** **	**-0.125*** **	-0.0517	**-0.0936*** **
	(-6.87)	(-5.30)	(-2.44)	(-3.95)	(-6.09)	(-4.70)	(-1.90)	(-3.39)
PROP	**0.321*** **	**0.336*** **	**0.226*** **	**0.282*** **	**0.328*** **	**0.341*** **	**0.228*** **	**0.286*** **
	(10.91)	(11.34)	(7.39)	(9.33)	(11.13)	(11.48)	(7.46)	(9.43)
FRACTION	**0.560*** **	**0.651*** **	**0.296***	**0.446****	**0.457*** **	**0.553*** **	0.193	**0.340***
	(4.08)	(4.71)	(2.15)	(3.14)	(3.33)	(4.00)	(1.41)	(2.39)
URBAN	**0.0272*** **	**0.0278*** **	**0.0289*** **	**0.0278*** **	**0.0266*** **	**0.0273*** **	**0.0277*** **	**0.0269*** **
	(12.88)	(13.35)	(13.79)	(12.71)	(12.42)	(12.89)	(13.09)	(12.09)
NATURAL	**-0.0491*** **	**-0.0408*** **	**-0.0414*** **	**-0.0406*** **	**-0.0498*** **	**-0.0417*** **	**-0.0423*** **	**-0.0415*** **
	(-12.94)	(-11.07)	(-10.62)	(-10.51)	(-13.14)	(-11.38)	(-10.94)	(-10.81)
KGDPC	**0.0000268*** **	**0.0000300*** **	**0.0000531*** **	**0.0000426*** **	**0.0000269*** **	**0.0000299*** **	**0.0000522*** **	**0.0000428*** **
	(4.59)	(5.07)	(9.15)	(6.92)	(4.49)	(4.93)	(8.83)	(6.79)
KGDP	**9.44e-10*** **	**8.56e-10*** **	**1.60e-09*** **	**1.10e-09*** **	**9.61e-10*** **	**8.87e-10*** **	**1.64e-09*** **	**1.14e-09*** **
	(14.27)	(13.16)	(31.99)	(16.40)	(14.00)	(13.16)	(31.62)	(16.59)
Constant	-1.100***	-1.597***	-3.066***	-1.159***	-1.052***	-1.622***	-3.042***	-1.191***
	(-3.95)	(-5.77)	(-9.87)	(-4.00)	(-3.72)	(-5.86)	(-9.67)	(-4.14)
Inflate								
EXPORT	-0.000287				-0.000210			
	(-1.93)				(-1.47)			
IMPORT	0.0000129				-0.0000757			
	(0.12)				(-0.69)			
FDI	-0.000317	-0.000157			0.0000585	0.000153		
	(-0.98)	(-0.43)			(0.15)	(0.45)		
TRADE		**-0.000117***				**-0.000135***		
		(-2.26)				(-2.54)		
OPENNESS			0.136				0.0918	
			(1.38)				(0.94)	
International Linkages				0.0929				-0.274
				(0.12)				(-0.35)
HK_TER	**-1.592****	**-1.347***	**-1.552***	**-1.551***	**-1.725****	**-1.569***	**-1.495***	**-1.527***
	(-2.63)	(-2.20)	(-2.41)	(-2.47)	(-2.73)	(-2.48)	(-2.24)	(-2.34)
PROP	0.135	0.140	-0.00541	0.0269	0.160	0.171	0.0406	0.0755
	(1.47)	(1.52)	(-0.06)	(0.29)	(1.73)	(1.83)	(0.42)	(0.80)
CL_RES	0.127	**0.175***	**0.174***	**0.176***	**0.172***	**0.206****	**0.192***	**0.192***
	(1.63)	(2.31)	(2.28)	(2.35)	(2.16)	(2.66)	(2.47)	(2.52)
NATURAL	**0.0571*** **	**0.0487*** **	**0.0444*** **	**0.0407*** **	**0.0519*** **	**0.0505*** **	**0.0457*** **	**0.0421*** **
	(3.70)	(4.30)	(4.25)	(3.94)	(3.41)	(4.35)	(4.23)	(3.96)
KGDPC	**-0.0000843*** **	**-0.0000816*** **	**-0.0000870*** **	**-0.0000812*** **	**-0.0000822*** **	**-0.0000805*** **	**-0.0000919*** **	**-0.0000850*** **
	(-4.10)	(-4.02)	(-4.35)	(-4.06)	(-3.97)	(-3.90)	(-4.42)	(-4.12)
KGDP	**-5.40e-08*** **	**-5.76e-08*** **	**-9.11e-08*** **	**-8.70e-08*** **	**-5.63e-08*** **	**-5.90e-08*** **	**-9.28e-08*** **	**-8.78e-08*** **
	(-4.14)	(-4.52)	(-8.65)	(-8.38)	(-4.24)	(-4.61)	(-8.51)	(-8.24)
Constant	0.901	0.714	0.529	1.210	0.674	0.482	0.483	0.749
	(1.53)	(1.20)	(0.71)	(1.62)	(1.14)	(0.81)	(0.64)	(1.00)
lnalpha								
_cons	0.487***	0.519***	0.586***	0.573***	0.489***	0.519***	0.582***	0.575***
	(16.15)	(17.31)	(20.28)	(19.37)	(16.08)	(17.20)	(20.02)	(19.27)
N	2949	2949	2959	2877	2884	2884	2897	2811

z statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Table 4- Negative binomial regression of number of patents in 178 countries, 1977-2010

	(1)	(2)	(3)	(4)
EXPORT	**0.0000201*** **			
	(4.50)			
IMPORT	**-0.0000113***			
	(-2.45)			
FDI	**-0.0000143****	**-0.0000221*** **		
	(-2.92)	(-5.25)		
TRADE		**0.00000475*** **		
		(6.19)		
OPENNESS			**0.325*** **	
			(4.98)	
International Linkages				**0.771*** **
				(3.64)
HK_TER	**1.059*** **	**1.238*** **	**1.208*** **	**1.257*** **
	(3.66)	(4.32)	(3.94)	(4.22)
CL_RES	**-0.121***	-0.0961	-0.0580	-0.0838
	(-2.16)	(-1.71)	(-1.01)	(-1.45)
PROP	**0.346*** **	**0.360*** **	**0.254*** **	**0.303*** **
	(5.74)	(5.94)	(4.14)	(4.92)
FRACTION	0.437	**0.601***	0.270	0.440
	(1.46)	(2.02)	(0.90)	(1.43)
URBANIZATION	**0.0327*** **	**0.0336*** **	**0.0321*** **	**0.0325*** **
	(7.23)	(7.56)	(7.06)	(6.92)
NATURAL	**-0.0497*** **	**-0.0405*** **	**-0.0413*** **	**-0.0413*** **
	(-6.65)	(-5.80)	(-5.72)	(-5.75)
KGDPC	**0.0000351****	**0.0000358****	**0.0000511*** **	**0.0000467*** **
	(2.66)	(2.68)	(3.99)	(3.42)
KGDP	**1.23e-09*** **	**1.14e-09*** **	**1.89e-09*** **	**1.44e-09*** **
	(7.41)	(7.05)	(14.73)	(9.10)
Constant	-2.346***	-2.803***	-4.127***	-2.117***
	(-4.56)	(-5.57)	(-6.96)	(-3.87)
lnalpha				
_cons	0.580***	0.607***	0.655***	0.664***
	(9.28)	(9.77)	(10.88)	(10.82)
N	551	551	557	543
pseudo R-sq	0.188	0.186	0.178	0.179

z statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Table 5- Additional variables for democracy

Variable Name	Description	# of Countries	Years Covered	Source
CL_RES	The level of restriction on civil liberties	197	1972-2010	Freedom House
PR_RES	The level of restriction on political rights	197	1972-2010	Freedom House
CL_RES_CAT	Category values of CL_RES: Free, Partly Free, Not Free	197	1972-2010	Freedom House
PR_RES_CAT	Category values of PR_RES: Free, Partly Free, Not Free	197	1972-2010	Freedom House
DEM_POL2	The degree of democracy according to participation and competition in elections and checks on the executive	165	1800-2010	Polity IV Project
REG	Regime type: 1 for dictatorship and 0 for democracy	135 (+)	1946-2002	ACLP Political and Economic Database

Table 6- Zero inflated negative binomial regression of number of patents in 178 countries, 1977-2010

	(1)	(2)	(3)	(4)	(5)	(6)
TRADE	**0.00000427*** **	**0.00000420*** **	**0.00000433*** **	**0.00000447*** **	**0.00000361*** **	**0.00000604*** **
	(14.52)	(14.12)	(14.74)	(14.26)	(12.63)	(13.87)
FDI	**-0.0000192*** **	**-0.0000188*** **	**-0.0000190*** **	**-0.0000193*** **	**-0.0000170*** **	**-0.0000245*** **
	(-9.61)	(-9.31)	(-9.50)	(-9.33)	(-8.81)	(-8.82)
HK_TER	**1.082*** **	**1.114*** **	**1.039*** **	**1.030*** **	**0.721*** **	**0.939*** **
	(8.97)	(9.23)	(8.66)	(8.53)	(6.26)	(5.98)
CL_RES	**-0.140*** **					
	(-5.30)					
CL_RES_CAT		**-0.344*** **				
		(-6.27)				
PR_RES			**-0.151*** **			
			(-6.82)			
PR_RES_CAT				**-0.243*** **		
				(-4.88)		
DEM_POL2					**0.0875*** **	
					(14.80)	
REG						**-0.449*** **
						(-4.85)
PROP	**0.336*** **	**0.338*** **	**0.334*** **	**0.344*** **	**0.292*** **	**0.336*** **
	(11.34)	(11.29)	(11.39)	(11.43)	(10.49)	(9.71)
FRACTION	**0.651*** **	**0.669*** **	**0.590*** **	**0.653*** **	0.111	**0.726*** **
	(4.71)	(4.83)	(4.36)	(4.68)	(0.85)	(4.62)
URBAN	**0.0278*** **	**0.0268*** **	**0.0270*** **	**0.0280*** **	**0.0272*** **	**0.0292*** **
	(13.35)	(12.74)	(12.91)	(13.25)	(13.36)	(11.62)
NATURAL	**-0.0408*** **	**-0.0384*** **	**-0.0400*** **	**-0.0401*** **	**-0.0367*** **	**-0.0476*** **
	(-11.07)	(-10.20)	(-10.83)	(-10.67)	(-10.30)	(-10.50)
KGDPC	**0.0000300*** **	**0.0000301*** **	**0.0000299*** **	**0.0000324*** **	**0.0000389*** **	**0.0000357*** **
	(5.07)	(5.09)	(5.17)	(5.51)	(7.10)	(4.61)
KGDP	**8.56e-10*** **	**8.37e-10*** **	**8.15e-10*** **	**8.12e-10*** **	**8.36e-10*** **	**6.76e-10*** **
	(13.16)	(12.66)	(12.57)	(11.13)	(13.90)	(7.93)
Constant	-1.597***	-1.735***	-1.464***	-1.880***	-1.852***	-1.724***
	(-5.77)	(-6.66)	(-5.37)	(-7.24)	(-7.87)	(-6.22)
Inflate						
TRADE	**-0.000117***	**-0.000122***	**-0.000121***	**-0.000103***	**-0.000149** **	**-0.000140***
	(-2.26)	(-2.31)	(-2.32)	(-1.99)	(-2.69)	(-2.31)
FDI	-0.000157	-0.000155	-0.000172	-0.000235	-0.0000542	-0.000682
	(-0.43)	(-0.42)	(-0.45)	(-0.62)	(-0.16)	(-1.27)
HK_TER	**-1.347***	**-1.331***	**-1.440***	**-1.522***	**-1.684** **	-1.056
	(-2.20)	(-2.17)	(-2.37)	(-2.48)	(-2.58)	(-1.36)
CL_RES	**0.175***					
	(2.31)					
CL_RES_CAT		0.259				
		(1.65)				
PR_RES			0.0799			
			(1.35)			
PR_RES_CAT				0.145		
				(1.09)		
DEM_POL2					-0.00971	
					(-0.57)	
REG						**0.509***
						(2.05)
PROP	0.140	0.149	0.109	0.0989	0.0916	0.0828
	(1.52)	(1.56)	(1.20)	(1.08)	(0.99)	(0.84)
NATURAL	**0.0487*** **	**0.0515*** **	**0.0491*** **	**0.0480*** **	**0.0396** **	**0.0560*** **
	(4.30)	(4.56)	(4.29)	(4.25)	(3.21)	(3.75)
KGDPC	**-0.0000816*** **	**-0.0000887*** **	**-0.0000882*** **	**-0.0000937*** **	-0.0000385	**-0.0000730** **
	(-4.02)	(-4.39)	(-4.35)	(-4.53)	(-1.16)	(-3.28)
KGDP	**-5.76e-08*** **	**-5.64e-08*** **	**-5.45e-08*** **	**-5.48e-08*** **	**-5.00e-08*** **	**-5.28e-08*** **
	(-4.52)	(-4.20)	(-4.23)	(-3.91)	(-3.76)	(-3.59)
Constant	0.714	1.032	1.220*	1.414**	1.528***	1.205*
	(1.20)	(1.89)	(2.28)	(2.82)	(3.37)	(2.32)
lnalpha _cons	0.519***	0.519***	0.511***	0.506***	0.400***	0.480***
	(17.31)	(17.23)	(17.01)	(16.58)	(12.90)	(13.41)
N	2949	2873	2948	2813	2827	2182

z statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Table 7- The mean/median level of variables

Variable	No. Obs.	Mean/Median	Std. Dev.	Min	Max
EXPORT	618	3168.451	6399.543	46.93761	73018.05
IMPORT	618	3507.862	4438.408	265.4753	36348.73
FDI	618	232.3683	438.9481	-587.783	3432.783
HK_TER	618	0.1712268	0.1428516	0.005	0.65742
CL_RES	618	4	1.407631	1	7
PROP	618	4.491748	1.300696	1.6	8.15
FRACTION	618	0.5130896	0.2610429	0.0394	0.9302
NATURAL	618	8.53418	11.47251	0.005361	57.73613
URBAN	618	47.17171	18.19356	7.53	88.572
KGDPC	618	4175.249	4251.422	510.94	24976.35
KGDP	618	2.12E+07	3.00E+07	1081106	2.08E+08

Table 8- The list of significant variables to be predicted

Variable	Range to be predicted	Interval	Unit
EXPORT	40-80,000	1600	mil. $US
HK_TER	0-1	0.01	year
NATURAL	0-60	1	%
KGDPC	500-25,000	500	thous. $US
KGDP	1,000,000-300,000,000	6,000,000	thous. $US

Figure 1- Components of baseline model

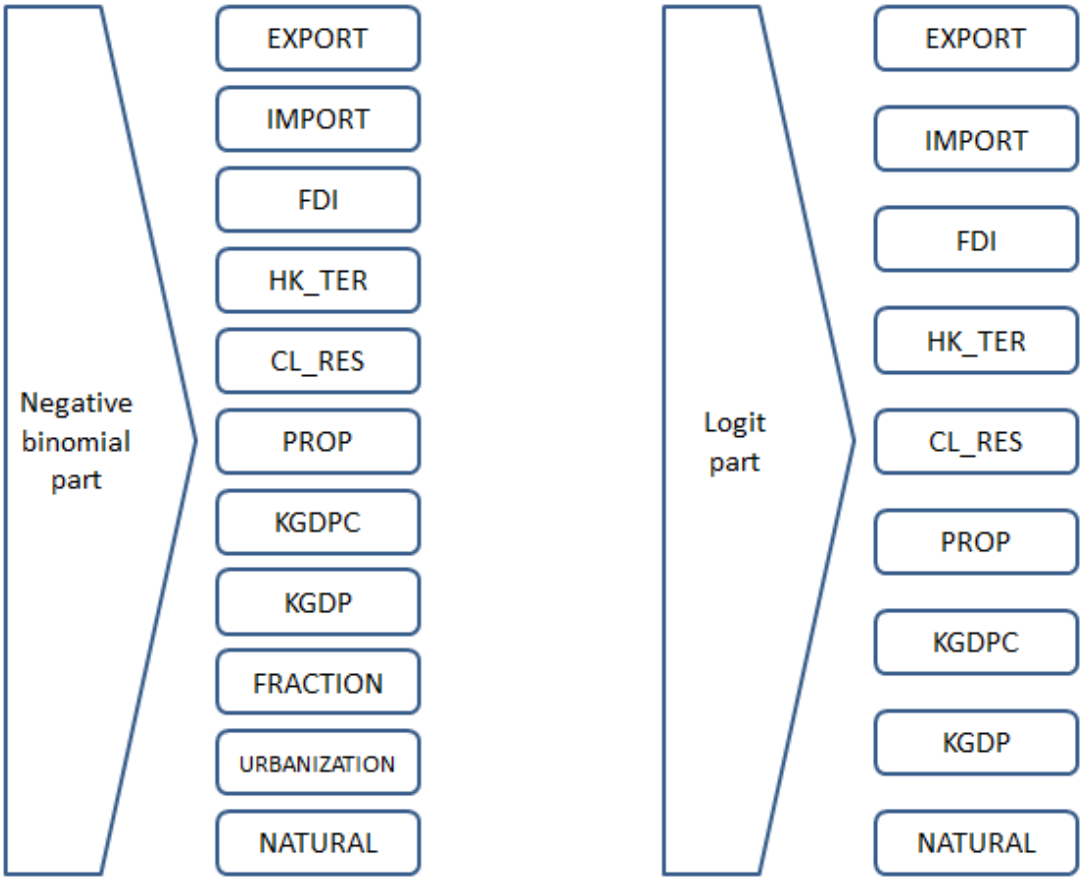
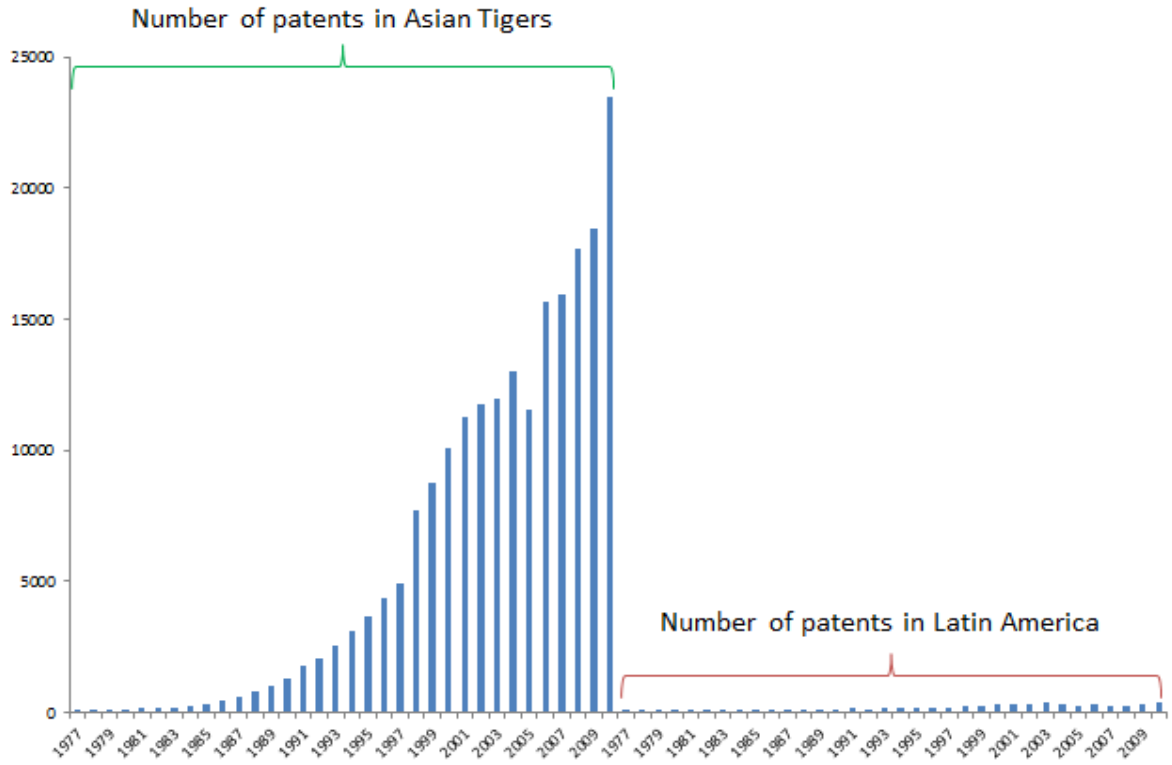
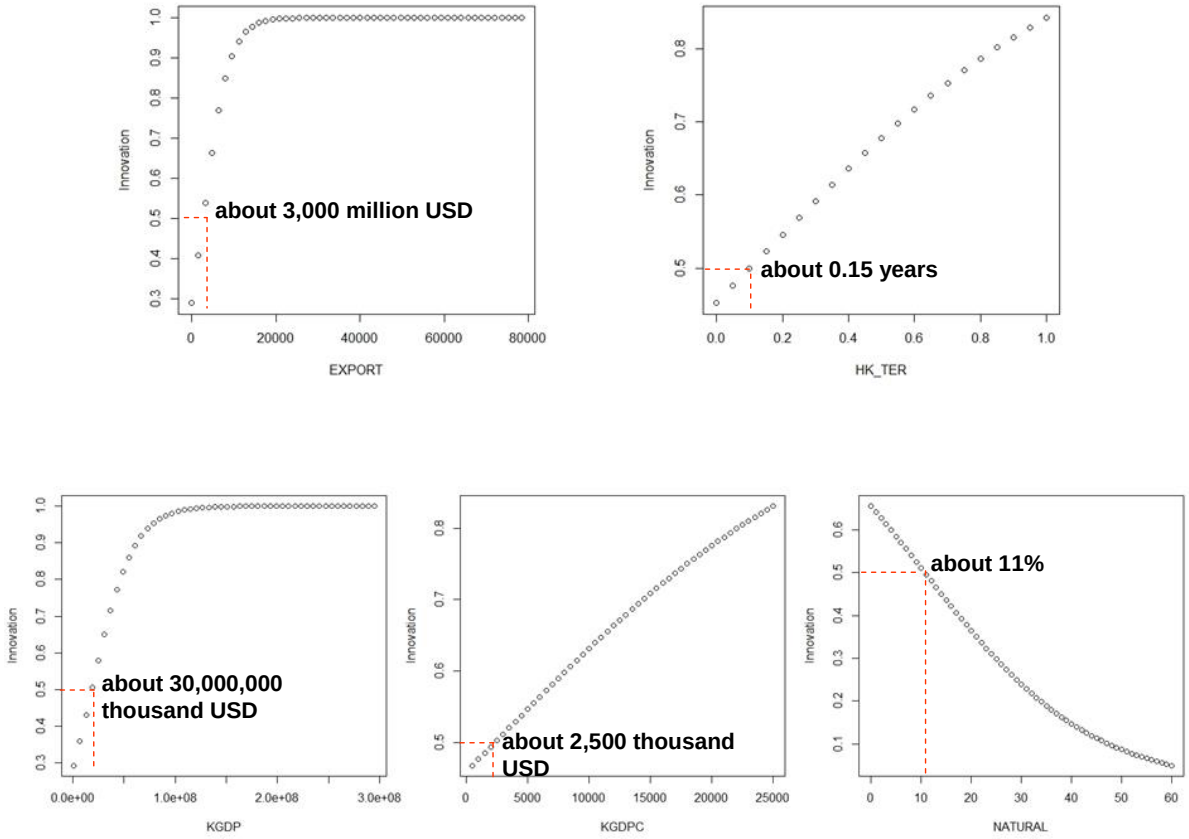


Figure 2- Annual total number of patents of Asian Tiger countries and Latin America's 4 largest GDP countries between 1977 and 2010



source: the U.S. Patent and Trademark Office (USPTO), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_allh.htm

Figure 3- The graphs of predictions



Tables and Figures for Essay 2

Table 1- The list of variables

Variable Name	Description	Source
Patent	the measure of innovation (the dependent variable)	the KIPO
Export	each firm's annual export intensity measured by the ratio of net amount of realized export to total revenue in millions of South Korean currency	the DART
FDI	the realized value of FDI in millions of U.S. dollars at 13 different sectors	the MKE
Creative	measured by each firm's annual R & D expenditure in millions of South Korean currency, and captures the creative effect of R & D	the DART
Learning	the interaction term between Creative and Export variables capturing the learning effect	
Learning2	the interaction term between Creative and FDI variables capturing another learning effect	
University	the annual number of patent data by all local universities in South Korea and classified into five different types of technology (i.e., chemicals, electronics, energy, machinery, and other technologies).	the KIPO
Diverse	a diversification level of product lines and measured by 1-∑Sp2, where Sp is the proportion of annual sales of the pth product in each firm	the DART
Capital	served as a proxy of each firm's capital stock, and measured by net equity value	the DART
Labor	served as a proxy of each firm's labor input and size of the firm, and measured by the number of total employees	the DART

*All variables are transformed into a logarithm to reduce the skew of the data, except *Export* and *Diverse*.

Table 2- Linear regression of number of patents from major innovative companies in South Korea, 2000-2009

Log(Patents)	(1)	(2)	(3)	(4)	(5)
Export	**0.628****	-0.937	-1.102	-0.914	-1.083
	(3.25)	(-0.88)	(-1.04)	(-0.93)	(-1.12)
Creative(=R&D)	**0.616*****	**0.531*****	**0.524*****	**0.578*****	**0.571*****
	(9.13)	(7.22)	(7.26)	(8.08)	(8.16)
Learning(=R&D*Export)		0.156	0.170	0.126	0.140
		(1.56)	(1.71)	(1.35)	(1.52)
University			**0.661***		**0.670***
			(2.21)		(2.26)
Diverse				**-1.233*****	**-1.230*****
				(-5.83)	(-5.84)
Capital	-0.0240	-0.0263	-0.00388	-0.0598	-0.0362
	(-0.27)	(-0.30)	(-0.04)	(-0.71)	(-0.44)
Labor	**0.299****	**0.277****	**0.242****	**0.352*****	**0.315*****
	(3.13)	(2.90)	(2.64)	(3.72)	(3.50)
Constant	-4.428***	-3.390***	-6.897***	-2.953**	-6.508***
	(-8.07)	(-3.47)	(-3.85)	(-3.29)	(-3.75)
N	516	516	516	515	515
adj. R-sq	0.711	0.712	0.716	0.733	0.737
F	95.14	100.8	90.65	101.3	93.57

Robust t statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Table 3- Accumulated number of patents granted by the USPTO for the period from 2000 to 2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Sum
USA	97,011	98,654	97,124	98,590	94,128	82,586	102,267	93,690	92,001	95,038	951,089
JAPAN	32,922	34,890	36,339	37,248	37,032	31,834	39,411	35,941	36,679	38,066	360,362
GERMANY	10,824	11,894	11,957	12,140	11,367	9,575	10,889	10,012	10,085	10,352	109,095
TAIWAN	5,806	6,545	6,730	6,676	7,207	5,993	7,920	7,491	7,779	7,781	69,928
KOREA, SOUTH	3,472	3,763	4,009	4,132	4,671	4,591	6,509	7,264	8,730	9,566	56,707
UNITED KINGDOM	4,085	4,351	4,190	4,028	3,895	3,553	4,323	4,029	3,834	4,009	40,297
CANADA	3,925	4,063	3,857	3,894	3,781	3,177	4,094	3,970	4,125	4,393	39,279
FRANCE	4,173	4,456	4,421	4,126	3,686	3,106	3,856	3,720	3,813	3,805	39,162
ITALY	1,967	1,978	1,962	2,022	1,946	1,591	1,899	1,836	1,916	1,837	18,954
NETHERLANDS	1,410	1,494	1,681	1,570	1,537	1,200	1,647	1,596	1,725	1,558	15,418
SWEDEN	1,738	1,933	1,824	1,629	1,388	1,189	1,360	1,278	1,260	1,231	14,830
SWITZERLAND	1,458	1,557	1,532	1,433	1,405	1,106	1,388	1,280	1,403	1,454	14,016
AUSTRALIA	860	1,032	992	1,049	1,093	1,032	1,538	1,545	1,613	1,550	12,304
ISRAEL	836	1,031	1,108	1,260	1,092	976	1,325	1,219	1,312	1,525	11,684
FINLAND	649	769	856	944	954	751	1,005	943	908	997	8,776

source: the U.S. Patent and Trademark Office (USPTO), http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_allh.htm

Table 4- Average years of tertiary schooling among the total population over age 25 in OECD countries from 2000 to 2010

Country	Average years	Country	Average years
USA	1.682	Chile	0.671
New Zealand	1.358	Germany	0.661
Israel	1.269	Switzerland	0.620
Canada	1.258	United Kingdom	0.602
Japan	1.076	Denmark	0.587
Australia	1.026	France	0.583
Republic of Korea	0.962	Luxembourg	0.549
Ireland	0.928	Mexico	0.536
Estonia	0.917	Slovenia	0.495
Belgium	0.898	Hungary	0.495
Sweden	0.838	Austria	0.465
Norway	0.813	Poland	0.430
Greece	0.804	Slovakia	0.371
Netherlands	0.802	Czech Republic	0.341
Spain	0.740	Italy	0.327
Iceland	0.739	Turkey	0.299
Finland	0.709	Portugal	0.294

source: Barro, R. & Lee, J. (2010). A New Data Set of Educational Attainment in the World, 1950-2010. *NBER Working Paper No. 15902*.

Table 5- Linear regression of number of patents by major innovative companies, 2000-2009, with FDI variable

Log(Patents)	(1)	(2)	(3)	(4)	(5)
Export	**0.628****	-1.191	-1.429	-1.186	-1.429
	(3.24)	(-1.05)	(-1.27)	(-1.14)	(-1.39)
FDI	0.0203	0.276	0.334	0.315	0.374
	(0.45)	(1.13)	(1.40)	(1.37)	(1.66)
Creative(=R&D)	**0.616*****	**0.822****	**0.886****	**0.894*****	**0.959*****
	(9.12)	(2.99)	(3.26)	(3.50)	(3.80)
Learning(=R&D*Export)		0.182	0.203	0.152	0.174
		(1.70)	(1.91)	(1.54)	(1.79)
Learning2(=R&D*FDI)		-0.0231	-0.0288	-0.0250	-0.0308
		(-1.08)	(-1.38)	(-1.27)	(-1.60)
University			**0.694***		**0.701***
			(2.32)		(2.38)
Diverse				**-1.246*****	**-1.243*****
				(-5.94)	(-5.95)
Capital	-0.0248	-0.0320	-0.00950	-0.0668	-0.0431
	(-0.28)	(-0.36)	(-0.11)	(-0.79)	(-0.52)
Labor	**0.299****	**0.283****	**0.247****	**0.360*****	**0.322*****
	(3.14)	(2.95)	(2.69)	(3.80)	(3.57)
Constant	-4.697***	-6.861*	-11.26**	-6.919*	-11.38***
	(-6.02)	(-2.22)	(-3.20)	(-2.36)	(-3.39)
N	516	516	516	515	515
adj. R-sq	0.711	0.712	0.716	0.733	0.737
F	90.33	90.93	82.78	89.93	84.93

Robust t statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Table 6- Linear regression of number of patents by major innovative companies, 2000-2009, with FDI variable, Dependent variable lead by 1 year

Log (Patents)	(1)	(2)	(3)	(4)	(5)
Export	**0.715*** **	-1.167	-1.323	-1.184	-1.329
	(3.40)	(-0.99)	(-1.12)	(-1.11)	(-1.25)
FDI	0.0545	0.320	0.378	0.339	0.392
	(1.13)	(1.36)	(1.61)	(1.52)	(1.77)
Creative(=R&D)	**0.554*** **	**0.770** **	**0.835** **	**0.822** **	**0.882*** **
	(7.70)	(2.83)	(3.08)	(3.26)	(3.51)
Learning(=R&D*Export)		0.189	0.203	0.162	0.175
		(1.64)	(1.75)	(1.55)	(1.68)
Learning2(=R&D*FDI)		-0.0241	-0.0295	-0.0248	-0.0299
		(-1.15)	(-1.42)	(-1.28)	(-1.55)
University			0.514		0.477
			(1.64)		(1.52)
Diverse				**-1.185*** **	**-1.175*** **
				(-5.09)	(-5.02)
Capital	-0.0164	-0.0250	-0.00412	-0.0742	-0.0544
	(-0.16)	(-0.23)	(-0.04)	(-0.74)	(-0.56)
Labor	**0.314** **	**0.298** **	**0.266** *	**0.392*** **	**0.362*** **
	(2.90)	(2.78)	(2.58)	(3.75)	(3.62)
Constant	-4.620***	-6.867*	-10.36**	-6.594*	-9.838**
	(-5.41)	(-2.23)	(-2.85)	(-2.28)	(-2.86)
N	457	457	457	457	457
adj. R-sq	0.688	0.689	0.691	0.708	0.710
F	81.68	76.83	64.67	81.51	70.22

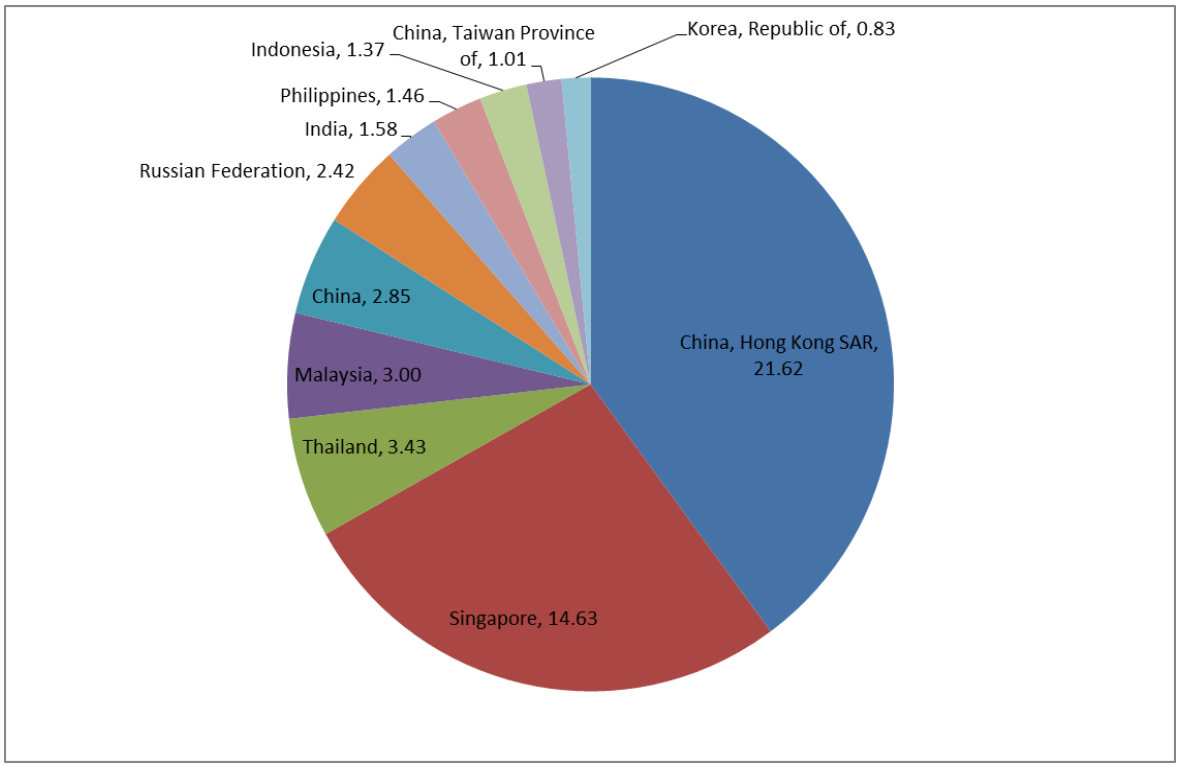
Robust t statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Table 7- Negative binomial regression of number of patents by major innovative companies, 2000-2009, dividing the sample into two different groups, top 50 and below 50

	Top 50 patenting firms	***Top 50 R&D/Sales firms***	***Below 50 patenting firms***	***Below 50 R&D/Sales firms***
Patents	(1)	(2)	(3)	(4)
Export	-0.0273	0.121	**0.611***	-1.114
	(-0.15)	(0.72)	(2.55)	(-1.07)
FDI	0.0325	-0.0383	-0.0130	**0.177*****
	(0.81)	(-0.81)	(-0.26)	(3.45)
Creative(=R&D)	**0.523*****	**0.249***	**0.232****	**0.801*****
	(4.93)	(2.11)	(2.87)	(5.77)
University	**0.638***	0.591	0.660	0.526
	(2.27)	(1.91)	(1.60)	(1.09)
Diverse	**-1.100*****	**-1.570*****	-0.282	**-1.055*****
	(-5.08)	(-6.30)	(-0.67)	(-3.34)
Capital	0.184	0.0760	**-0.214***	0.0334
	(1.95)	(0.77)	(-2.30)	(0.35)
Labor	0.0801	**0.623*****	0.269	0.131
	(0.64)	(4.93)	(1.89)	(0.61)
Constant	-6.782***	-5.634**	-1.566	-8.451**
	(-3.96)	(-3.01)	(-0.63)	(-2.86)
lnalpha				
Constant	-0.579***	-0.491***	-1.104***	-0.911***
	(-6.04)	(-5.69)	(-7.78)	(-8.53)
N	375	361	140	154
pseudo R-sq	0.113	0.124	0.035	0.123

Robust z statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001

Figure 1- Average of FDI per GDP from 2000 to 2009 in major emerging countries in Asia



source: United Nations Conference on Trade and Development (UNCTADstat)

Tables and Figures for Essay 3

Table 1- Average years of tertiary schooling among the total female population over age 25 between 2000 and 2010

Country	Average years
USA	1.67
Russian Federation	1.51
New Zealand	1.32
Ukraine	1.32
Israel	1.31
Australia	1.27
Canada	1.27
Estonia	1.02
Philippines	1.00
Ireland	0.96
Japan	0.96
Sweden	0.92
Belgium	0.88
Republic of Korea	**0.83**

source: R. Barro and J. Lee (2010). "A New Data Set of Educational Attainment in the World, 1950–2010." *NBER Working Paper No. 15902*.

Table 2- The list of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ROS	618	-0.0206461	0.7740913	-17.9563	0.4774811
ROA	622	0.0350125	0.1382866	-1.487894	0.3905077
Female	547	0.1570613	0.1473553	0.007895	0.6179686
Export/Sales	546	0.5193774	0.3086292	0.0001933	1.576934
Innovation	598	-7.52E-10	1	-2.545698	3.092283
ExpXFemale	491	0.0819776	0.1178119	0.0000267	0.5334651
Female Squared	547	0.0463422	0.0768851	0.0000623	0.3818851
Female Cubed	547	0.0181892	0.0389876	4.92E-07	0.235993
Capital	626	2709566	6080687	-1099733	6.16E+07
Labor	584	7104.721	12325.93	74	85813

Table 3- Linear regression of return on revenue and assets from major innovative companies in South Korea (2000–2009)

	Dependent Variable: ln(ROS)				***Dependent Variable: ln(ROA)***			
		Hypothesis 2	Hypothesis 1	Lagged		Hypothesis 2	Hypothesis 1	Lagged
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	**1.574*** **	0.253	**-9.354*** **	**-8.379** **	**1.771*** **	0.795	**-8.805*** **	**-7.292** **
	(4.61)	(0.57)	(-2.91)	(-2.38)	(4.95)	(1.59)	(-2.64)	(-2.00)
ExpXFemale		**2.565*** **	**2.700*** **	**2.613*** **		**1.894** **	**1.889***	**1.820***
		(2.98)	(3.12)	(2.85)		(2.00)	(1.96)	(1.78)
FemaleSQ			**38.04*** **	**32.65** **			**41.80*** **	**33.25** **
			(2.79)	(2.17)			(2.96)	(2.12)
FemaleCube			**-39.91** **	**-33.61***			**-47.65*** **	**-36.96** **
			(-2.57)	(-1.93)			(-2.94)	(-2.02)
Export	**-0.532*** **	**-1.000*** **	**-0.960*** **	**-1.078*** **	**-0.682*** **	**-1.028*** **	**-0.958*** **	**-1.100*** **
	(-2.70)	(-3.36)	(-3.19)	(-3.37)	(-3.25)	(-3.24)	(-3.01)	(-3.30)
Innovation	**0.345*** **	**0.335*** **	**0.372*** **	**0.374*** **	**0.453*** **	**0.445*** **	**0.473*** **	**0.452*** **
	(4.25)	(4.16)	(4.55)	(4.14)	(5.45)	(5.37)	(5.56)	(4.77)
Capital	**0.341*** **	**0.338*** **	**0.345*** **	**0.280*** **	**0.128***	**0.126***	**0.136** **	0.0741
	(4.68)	(4.68)	(4.86)	(3.84)	(1.82)	(1.79)	(1.97)	(0.99)
Labor	**-0.469*** **	**-0.464*** **	**-0.524*** **	**-0.437*** **	**-0.300*** **	**-0.297*** **	**-0.356*** **	**-0.261*** **
	(-5.69)	(-5.61)	(-6.21)	(-4.99)	(-3.47)	(-3.40)	(-4.04)	(-2.76)
Constant	-3.876***	-3.558***	-2.548***	-2.384***	-2.204***	-1.969***	-1.017	-1.006
	(-5.24)	(-4.82)	(-3.11)	(-2.71)	(-3.05)	(-2.71)	(-1.24)	(-1.12)
N	404	404	404	370	404	404	404	370
R-sq	0.174	0.186	0.209	0.182	0.161	0.167	0.185	0.164
adj. R-sq	0.161	0.172	0.191	0.162	0.148	0.152	0.167	0.143
F	20.51	18.25	15.96	12.16	17.95	15.29	12.88	9.859

Robust t statistics in parentheses
*p<0.05 **p<0.01 ***p<0.001
Female is the ratio of female employment.
ExpXFemale is the interaction term between Export and Female.
FemaleSQ is the squared term of Female.
FemaleCube is the cube term of Female.
Export is an export intensity measured by each firm's annual export divided by annual sales.
Innovation is the factor analysis of patents data and R & D expenditure.
Capital and Size are the log transformed amount of net equity in millions of South Korean currency and number of total employees, respectively.

Table 4- The predicted value of threshold and optimal points

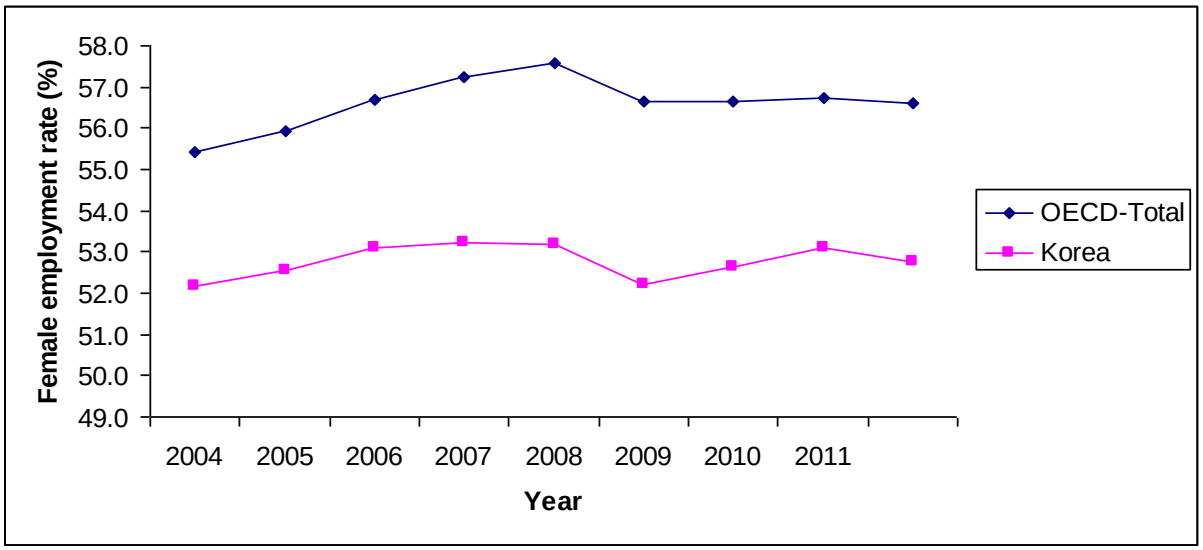
Dependent Variable = ln (ROS)

Method	*Threshold level*	*95% Credible Interval*	*Optimal level*	*95% Credible Interval*
Calculus	16.67%	.	46.88%	.
MCMC	16.13%	12.09% and 24.62%	46.76%	39.42% and 82.33%

Dependent Variable = ln (ROA)

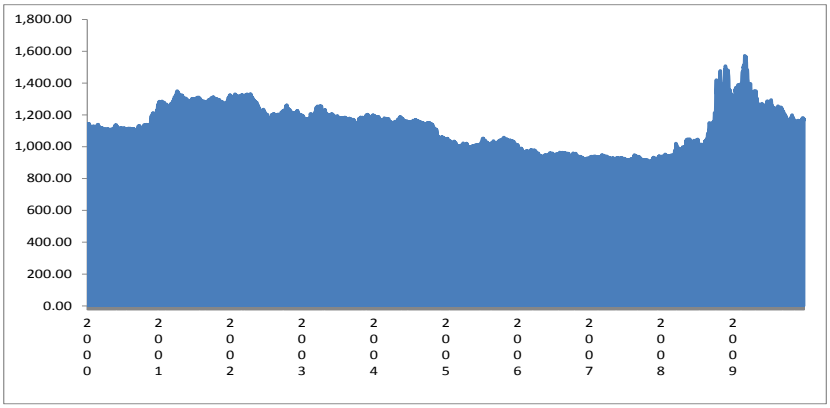
Method	*Threshold level*	*95% Credible Interval*	*Optimal level*	*95% Credible Interval*
Calculus	13.78%	.	44.70%	.
MCMC	13.75%	8.17% and 19.51%	44.66%	39.10% and 62.03%

Figure 1- The female employment rate of South Korea vs. OECD countries



source: OECD (2012), "Employment Rate of Women," *Employment and Labour Markets: Key Tables from OECD, No. 5*. doi: 10.1787/emp-fe-table-2012-1-en

Figure 2- The exchange rate between Korean Won and US dollar from 2000 to 2009



Y axis: Korean Won/US$
X axis: Year
source: the central bank's Economic Statistic System (ECOS) of South Korea (http://ecos.bok.or.kr/)

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Education

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Global Brand Analyst, Global OST (Operation and Strategy Team)

Lime Media Technologies Co., Ltd., Seoul, Korea, Jan. 2004 – Nov. 2005
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Conferences

Choo, Daewoong. & Xiang, Jun. "Why do Some Countries Hardly Innovate?" Evidence from Zero Inflated Negative Binomial" The Midwest Political Science Association (MPSA) 71st Annual Conference (Chicago, IL, April 2013)

Choo, Daewoong. "Two Different Effects of R&D on Innovation in South Korea: Evidence from The Firm Level Data" STGlobal Consortium 13th Annual Conference on Science & Technology in Society (Washington, DC, April 2013)