INNOVATION IN KOREA

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ABSTRACT

This thesis seeks to understand the factors that influence the innovation performance of firms and regions in Korea and whether innovation activities and performance are evenly distributed across geographic regions.

Since the 1960s, the performance of the Korean economy has been shaped by economic development strategies based on interaction between public sector institutions and private sector firms that has contributed to the successful achievement of development goals. More recently, government strategy has focused on innovation and policy measures designed to support innovation activity.

The national systems of innovation approach and developments of it, such as regional systems of innovation, provide a comprehensive theoretical framework to analyse the internal and external factors that influence firms' innovation performance. Using the elements of innovation activity identified by the systems of innovation approach, hypotheses were developed and empirically tested using quantitative and qualitative techniques.

The quantitative analysis focuses on firm and regional influences on innovation using the Korea Innovation Surveys for 2008, 2010 and 2012. This is supplemented by qualitative analysis in the form of two industry/regional case studies, one on the high-technology games industry in Seoul and one on the more traditional footwear industry around Busan region.

The thesis finds evidence that 'systems' variables are positively associated with innovation. In particular, the empirical results suggest that cooperation provides a positive influence on product and process innovation in all survey years. Different public policy measures, including financial support for innovation, influence different types of innovation. The proportion of firms that were innovators increased from 2008 to 2010 followed by a decrease in 2012 and the regional variation of the innovation activities became narrower showing convergence from 2008 to 2010, before widening in 2012. The case study findings suggest cooperation plays a strong part in all aspects of innovation activities in both high-tech and traditional industries.

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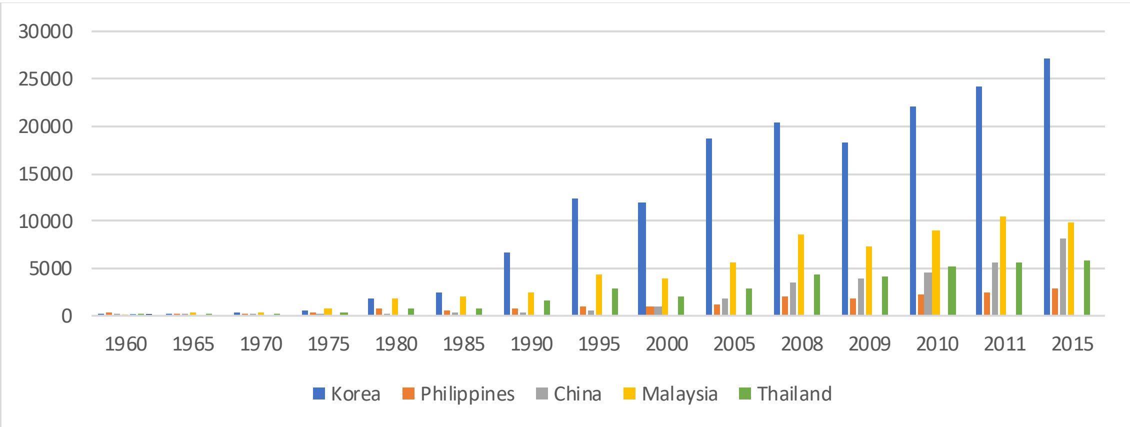
INTRODUCTION

In 1960 Korea was one of the poorest countries in the world, with GDP per capita of $158, lower than that of Malaysia ($235) and the Philippines ($254) but by 2015 Korea's GDP per capita stood at $27,105, several times that of its 1960s peers. Korea's rapid economic growth enabled it to become an OECD member in 1996, while by 2010 it had joined the OECD Development Assistance Committee, which includes 30 of the largest aid providers (OECD, 2018). Figure 1.1 shows Korea's economic development over the period 1960-2015 in comparison to other Asian economies and illustrates what Chang (2008) has termed the 'Korean economic miracle'.

Figure 1.1 Comparisons of GDP per Capita among Far Eastern Countries between 1960 - 2015 (current $)



(Source: Databank.Worldbank.org, 2017)

Korean economic performance between the 1960s and 2010 provides an outstanding example of economic 'catch-up' for low-income countries and there has been extensive debate on the variations in growth rates between countries and on the question of what causes these differences.

According to Chang (2008, p. 15), the Korean economic miracle, was "the result of a clever and pragmatic mixture of market incentives and state direction". Like the US and the UK, Korea is no exception in having policy recipes (Chang, 2008, p. 15) for economic growth and it was the combination of the various industrial policies, government leadership and the renowned New Village Movement[1] (Sonn and Gimm, 2013; Andronova, 2014).

In his seminal 1956 paper Solow modeled the relationship between economic growth and exogenous technological change. Subsequent research has sought to explain the sources of technological change, focusing on the role of innovation (Rosenberg, 2004). Innovation activity in Korean economy, however, relied on what is termed as reverse engineering (Kim, 1999, p. 189). This was an important part of industrial development, learning through a detailed examination of how a product from technologically advanced countries is built, and reproducing the same product.

This model, accompanied by low labour costs, allowed Korea to be competitive in the world market until labour costs began to rise. Korea, at this stage, could not solely depend on low technology, labour-intensive manufacturing industries and needed to move towards investment in technology intensive industries to increase productivity and reduce unit labour costs.

It is argued that the focus for advanced economies, should be the promotion of learning and innovation capabilities. Innovation, from a Schumpeterian perspective, is of the utmost importance, in order to recombine knowledge and resources in a way that can produce higher value (Foster, 2010; Asheim *et al.*, 2015).

Innovation, therefore, is a much-discussed issue (Lundvall *et al.*, 2002; Landry *et al.*, 2002; Marinova and Phillimore, 2003; Edquist, 2005; Rodrigueze and Crescenzi, 2008; Festre *et al.*, 2017) seen as a crucial aspect of economic development policy and led to Korea becoming the first ranked country (overtaking Japan) among the world's 50 most innovative countries in 2015 (Bloomberg, 2015).[2]

The level of economic growth and the transformation of the country into a hotbed of innovation in such a short period of time has been remarkable. However, Korea stands out as an anomaly in contrast to many low-income countries who have struggled to

[1] This so called 'Saemaul' movement which is a rural development initiative launched in April 1970 in Korea. The leaders that were half civilian and half bureaucratic agents were heavily involved in diffusing hegemonic discourse during the industrialisation that brought about rapid structural transformation (Sonn and Gimm, 2013). This movement is considered as one of official development assistance programmes of Korea through which growth of the agricultural productivity and reduction in the income gap between urban and rural areas were intended (Andronova, 2014).

[2] Categories included in the index were Research and Development, Manufacturing (since it takes a high level of know-how to be at the leading edge of producing things), High-Tech firms, Post-secondary education, Research Personnel, and Patents.

improve their economies without the same success Korea had. This research examines the factors shaping Korea's performance in innovation as well as how innovation performance and activities are evenly distributed geographically within Korea.

The start of the 1980s saw the commencement of an OECD project on 'Science, Technology and Competitiveness'. This project gave birth to the systems of innovation approach (Freeman, 1982; Asheim *et al.*, 2015) which is "the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies" (Freeman, 1987, p. 1). Asheim *et al.* (2015, p. 2) argued that unlike innovation in a linear model, where input to R&D results in inventions, which then lead to commercialisation, the systems of innovation approach emphasises that innovation results from complex, interactive and cumulative knowledge and learning processes that involve many different actors. Innovation is related to the competitiveness of firms and as a result the growth of firms, and the systems of innovation approach acknowledges that innovation appears in various forms and is produced through interdependencies among many different actors.

The aim of this thesis, therefore, is to identify and analyse the drivers of innovation and of innovation activity at the firm and regional levels. The mix of public and private sector institutions (Chang, 2008) involved in Korea suggests that the systems of innovation approach provides a suitable framework for analysing innovation in Korea.

Based on theories of innovation, elements of innovation activity will be identified and hypotheses developed and empirically tested. The innovation systems approach led to the development of the OSLO manual and the Community Innovation Surveys, later diffused to the Korea Innovation Survey. Firms in the manufacturing sector which participated in the Korea Innovation Surveys of 2008, 2010 and 2012 will be used in the empirical sections. These three datasets have been chosen because these dates cover the periods before and after the financial crisis of 2008, which makes comparison from before and after the crisis possible.

Analysis will be carried out at the firm as well as the regional level for each survey year. This will be supplemented by detailed case studies of two specific industries; the games industry as an example of a high-tech industry and the footwear industry as an example of a low-tech one. Examination into the two industries lead a deeper understanding of the process of innovation and identification of the factors that shape innovation.

Beginning at the firm level, this thesis will examine the elements involved in the process of innovation and will test if they are significant in producing innovative success. The flow of governmental policies implemented to increase economic development and the importance and roles of organisations involved in the innovation process will be examined. By repeating the examination for each of the three surveys, a pattern of significant elements for the production of innovation will be identified.

Regional innovation analysis will make a prominent contribution when geographically uneven innovation (Morgan, 1997; Asheim *et al*., 2015) and elements influencing the generation of knowledge (Cardinal and Hatfield, 2000; Antonelli and Colombelli, 2015; Cristiano, 2015; Grigoriou *et al*., 2017) and a region's innovation capacity (Cooke *et al*., 1997; Lawson and Lorenz, 1999; Patrucco, 2005; Li, 2009) are explored. For regional analysis, therefore, the regional variation in innovation performance across sixteen regions - highlighting the innovation activities that influence the production of innovation - will be examined.

Earlier studies on systems of innovation in Korea include; a study by Suh (2000) who evaluated the systems of innovation in Korea as a late-comer, focusing on government policy in knowledge diffusion, research led by Yim (2006) which looked into Korean systems of innovation and focusing on government policies; Lee and Park (2006) who explored R&D contributions to innovation using electronic parts and mechanical industries in Korea; Lee (2010) who evaluated the technological development of industries within Korea's systems of innovation; Chung (2011) who studied national systems of innovation focusing on the automobile industry in Korea; and Lee (2014), who carried out studies on how triple helix actors perform R&D collaboration in systems of innovation in Korea.

Furthermore, while Yoon (2015) evaluates systems of innovation in Korea - looking into collaboration patterns and cooperation using triple helix models based on co-patent data - a study by Stek and van Geenhuizen (2015) looks into the collaboration between universities and industries for innovation using patent data. In addition, the study by Sonn and Kang (2016) analyses the way the regional innovation concept is used in regional policies between 2003 and 2008.

These earlier studies in Korea, using a systems of innovation perspective, do not employ quantitative, empirical examination on innovation performance and individual innovation activities at the firm and regional level. Interdependencies among actors in innovation are important and public policies need to be designed to spread knowledge among the actors including firms, universities and public support providers to enhance the innovation capacity. In this thesis, therefore, empirical analysis will be carried out in an effort to answer the following overarching questions:

Research question 1

What factors influence the innovation performance of firms in Korea?

Research question 2

Are innovation activities and performance evenly distributed across geographic regions?

This thesis is organized in nine chapters including the introduction and the conclusion. Chapter two is an overview of Korean economic development, in particular the role of government policy in achieving unprecedented economic growth. Regional economic performance has been reviewed using GRDP per capita in Korea.

Chapter three reviews the literature on systems of innovation, focusing on the appearance and importance of systems approach of innovation followed by a review of the literature on the introduction of the main systems of innovation, as well as the National, Regional, and Sectoral systems of innovation together with the recent analytical framework for innovation, Triple Helix Model. Particular attention will be paid to the historical development and complementarities of these concepts.

Research methodology will be discussed in chapter four where a combination of qualitative and quantitative methods will be employed. While the qualitative method uses industry case studies, the quantitative method employs logistic regression analysis for cross sectioning. The chapter discusses these analysis methods and the datasets that will be used in the analysis.

Expanding beyond the literature review on the systems of innovation in chapter three, in chapter five the conceptual framework will be developed. Innovation activities will be identified through the literature on innovation and hypotheses will be developed based on these identified innovation activities; they will include research and development, human capital, public support, cooperation, and access to innovation funds.

Regional analysis will be carried out in chapter six. Through the analysis, the measurements of innovation and aspects of innovation activities across regions will be compared. The focus of the analysis will then be narrowed down to the firms across regions and the regional variations in innovation performance and innovation activities will be observed.

Chapter seven includes the demographics of firms through descriptive data analysis, followed by the introduction of dependent and independent variables together with control variables and their measurements. Following a general oversight of the behaviour of firms in Korea, statistical analysis is carried out for hypothesis testing. The results are presented for 2008, 2010 and 2012 in the Korea Innovation Survey.

For an in-depth understanding of the systems of innovation in Korea[3], industry studies are carried out in chapter eight. The chapter discusses the systems of innovation being applied in two industries, one of a low-tech nature and the other high-tech. Utilising the triple helix analytical framework, the actual workings of government, university and industry in production of innovation is discussed, based on the fieldwork outcome.

This thesis concludes in chapter nine with the main findings of the analysis. It includes policy implication, the limitations discovered whilst carrying out the research, together with areas for further research.

[3] 'Korea' throughout this thesis means 'South Korea'

Chapter 2
KOREAN ECONOMY

In this chapter, the background and the process of economic development in Korea will be observed in detail focusing on the systems perspective of nation and the regions.

Between 1964 and 2014 Korea achieved a rate of economic growth that was remarkable by international standards. This is despite the argument by Krugman (1994) who emphasised that economic growth in the so-called East Asian Tiger economies was possible due to the usage of cheap labour and therefore this source of growth would diminish as wages rise.

Geographically Korea is a small country, similar in size to New Jersey or Hungary, but heavily populated like Bangladesh. The Korean government made vigorous efforts to build a leading systems of innovation including effective changes in science and technology policies and institutional reformation in accordance with the progress of economic development and that led to the transformation of Korea from imitator to innovator (Kim and Nelson, 2000, p. 9).

Korea grew faster than the fastest growing country in the world, Taiwan, in the 1970s and 1980s and Chang (1994, p. 97) suggests that this successful story of Korea's transformation has to be explained by more than the market led demands. According to Chang (1994, p. 97) there was a powerful 'push' factor generated from the strong industrial policy behind the achievement in Korea.

In their research, Lee and Mathews (2012, p. 223) also studied the process that resulted in the sustained catch up of firms in Taiwan and Korea, two countries that successfully made the transition from imitator to innovator. For a successful sustained catch up, firms need to design capabilities to produce product innovation and product differentiation. By arguing these require a high degree of subsidisation of R&D and the promotion of R&D consortia that are supported by public research institutions, Lee and Mathews (2012, p. 233) emphasise the importance of public policy in making the catch-up process sustainable.

The Korean government was first established in 1948 following the liberalisation from Japanese colonial rule from 1910 until 1945 when modernisation and exploitation took place simultaneously. During the Korean War that lasted from 1950 till 1953 the infrastructural foundations that were laid during Japanese colonisation were mostly destroyed.

Ironically, the Korean War provided a positive influence on the subsequent economic development of the country since the traditional rigid Korean society had been transformed to a highly mobile one by forcing geographical mobility and also influencing the rapid formation of basic skills among the male labour force (Kim, 1993, p. 358).

The Korean government launched its industrialisation programme in the early 1960s. Until the 1960s Korea was amongst the poorest countries in the world and was highly populated with a population growth rate of nearly 3% a year and with more than 40% of the population suffering from extreme poverty. Since the 1960s Korea experienced swift economic development associated with a shift in labour from rural agricultural areas to urban industrial areas. Korean society was agrarian, traditional and isolated from the West. This made the country reliant on foreign aid, largely from America (Giroud *et al.*, 2012, p. 4).

A well combined market economic system and national planning system enabled Korea's economic growth (Jang, 2011, p. 576). The modernisation first started by focusing on mobilising resources efficiently through a planning system in the early 1960s. Private sector entrepreneurship was linked with political leadership in the public sector aiming towards the national goal of economic development (Jang, 2011, p. 577).

On the other hand, there were problems related to Korea's development such as high levels of debt, weak economic structure, low levels of production, low levels in the educational system, poor recognition of the private sector and SMEs' contribution to innovation and lack of motivation, commitment and trust (OECD, 2009; Marcus, 2012; Clark, 2015).

2.1 KOREAN ECONOMIC DEVELOPMENT

Korea experienced rapid real GDP growth of 7 to 9% with an inflation rate of around 5% annually from 1962 until the country suffered from the East Asian economic crisis in 1997 when GDP growth rate fell to minus 7 percent between 1996 and 1997 (Data.worldbank.org$_a$). In December 1997, the Korean government had to seek financial assistance from the IMF and also had to carry out drastic institutional and policy reforms in order to rectify the country's problematic economic structure. With the legal systems and practices that had to be adjusted according to the conditions that the IMF imposed, the unreserved collective effort made by the government, the people and firms to recover from the financial shock, Korea paid off the debt to the IMF within a remarkable four years in 2001.

What lies behind Korea's fast economic growth has drawn much interest. Probably the most important factor behind this is the determination of Korean people to eliminate poverty (Kim, 1991, p. 54). Korean people work hard for long hours and this is one of the factors that contributed to rapid economic growth (Kim, 1991, p. 44).

Table 2.1 shows that Korean people worked for 2,864 hours a year in 1980 compared to an average 1,912 hours in OECD countries in the same year. Although this has been reduced to 2,113 hours while OECD countries worked 1,766 hours on average in 2015, Korean people work many more hours than other OECD countries. Furthermore, as we can also see from Table 2.2 listing productivity per hour, Korea has increased productivity per hour dramatically compared to other OECD countries.

Further reasons for the hard work include the memory that the older generation has about Japanese colonisation, the Korean War and the will not to put the country in the same situation again (Porter, 1990; Kim, 1999).

Table 2.1 Average Worked Hours Annually among OECD Countries

	1980	1990	2000	2010	2015
France	1,823	1,665	1,535	1,494	1,482
Germany	..	..	1,452	1,390	1,371
Japan	2,121	2,031	1,821	1,733	1,719
Korea	2,864	2,677	2,512	2,187	2,113
UK	1,767	1,765	1,700	1,650	1,674
US	1,813	1,831	1,836	1,778	1,790
OECD	1,912	1,883	1,840	1,772	1,766

(source: Stats.OECD.org)

Table 2.2 GDP per Hour Worked, Total, 2010=100, 1980 – 2015

	1980	1990	2000	2010	2015
France	57.4	76.8	91.5	100	104.1
Germany	57.3	72.2	89.9	100	104.7
Japan	47.4	71.1	89.1	100	104.8
Korea	17.1	35.7	63.7	100	110.0
UK	54.8	68.1	87.2	100	101.4
US	58.3	68	81.3	100	101.6
OECD	..	..	86.7	100	104.2

(source: Data.OECD.org$_a$, 2016)

Although the concept is rather ambiguous and cannot be easily utilised in policy making, National Systems of Innovation is important in the development of a country's economy.

Since the 1960s the NSI in Korea has been shaped by overall economic development strategies and this has been quite effective in achieving development goals quickly (Suh, 2000, p. 31). The radical improvement in the performance of the Korean economy can be found from the policy reforms that were introduced around 1965 (Chang, 1994, p. 98). As Chang (1994, p. 98) identified, the main policies included the implementation of realistic exchange rates that increased the profitability of exporting activities, trade liberalisation that made the economy more efficient by imposing on the producers competitive pressures, and increased interest rates so that the people were encouraged to save more. In order to make it more productive this spare capital was invested in economic activities.

Thus, innovation policy in Korea has been developed in line with the country's industrial policy. As Chang argues (1994, p. 101), rapid industrialisation in Korea was accompanied by strong state intervention and therefore it is essential to understand the industrial policy of Korea in order to comprehend the country's innovation policy (Park, 2001, p. 32).

Chunghee Park gained political power and decided to utilise five-year plans to increase the wealth of the nation and strengthen political stability. In 1970, President Park introduced the government led 'New Village' movement to modernise rural areas. The Five Year Economic Development Plan and New Village Movement went together in developing the country and these are considered to be sustained by people's hard work and motivation to have better lives in conjunction with the government's determined driving force (Kim, 1988; Suh, 2000; Hong, 2008). The basic purpose of government intervention was to make, *Jarip Gyongje*, an independent economy (Chang, 1994, p. 109).

The government-led Five Year Economic Development Plan in Korea was implemented from 1962 until 1996 when it was completed over seven different phases. Since the first phase was launched, the government took the lead in promoting sectoral and spatial industrial policies. Table 2.3 displays the focus industry during each phase:

Table 2.3 The Five Year Economic Development Plan in Korea

THE ECONOMIC DEVELOPMENT PLANS OF SOUTH KOREA		
Plan	Years	Emphasis
First	1962-1966	Electrical Power, Fertilizer Production, Petroleum Refining, Cement, Synthetic Fibers
Second	1967-1971	Steel, Machines, Chemicals and Modernization of Industry
Third	1972-1976	Iron & Steel, Transport Equipment, Machines, Ships, Petrochemicals, Electronics
Fourth	1977-1981	Iron & Steel, Machines, Ships, Petrochemicals, Electronics, Nonferrous Metals
Fifth	1982-1986	Precision Machinery, Electronics and Higher Technology Industries
Sixth	1987-1991	Higher Technology, Research & Development, Manpower Training
Seventh	1992-1996	Microelectronics, Bioengineering, Aerospace, Fine Chemicals

(adapted from: http://www.sjsu.edu/faculty/watkins/skoreaplan.htm)

Between 1962 and 1966 the first Five Year Economic Development Plan was implemented. The focus was on constructing an industrial structure that does not require consumption of oil or is heavily dependent on oil. Main industries included synthetic fibres, oil refining, fertilizers and cement. The main strategy was an export-oriented industrialisation. During this period the Korean government established government research institutes marking the beginning of its modern research and development activities.

The second Five Year Economic Development Plan was between 1967 and 1971 with an emphasis on the modernisation of industrial structure and constructing import substitution industries such as chemical, steel and machinery.

Until the mid-1970s labour intensive industries were the main sectors in the expansion of industrial exports. The third Five Year Economic Development Plan was between 1972 and 1976 when export oriented structure, especially for heavy and chemical industries, was built. Steel, shipbuilding, household electronics, petrochemicals and transport machinery received particular attention during this period.

As Chang (1994) noted, the underdevelopment of the capital and intermediate goods industries created the balance of payments problem and Korean policy makers regarded exports as a way to decrease external balance rather than the driver of growth. Private firms were, therefore, encouraged to invest in heavy and chemical industries (Chang, 1994, p. 107-109). The switch towards heavy and chemical industry was necessary to increase the independence of the Korean economy. This is when industrialisation of other parts of Korea, apart from Seoul, was encouraged so that employment opportunities could be created for people in the less developed areas.

The fourth Five Year Economic Development Plan was between 1977 and 1981. During this period, the focus lay on developing industries to compete effectively in the industrial export markets in the world. The strategic industries included electronics, petrochemicals, non-ferrous metal, machinery and shipbuilding that are skilled labour and technology intensive. While government implemented this heavy and chemical industrial policy, the conglomerate, *chaebol*, system evolved as government allowed them to borrow foreign capital and granted them many incentives to encourage investment in heavy industry (Park, 2001, p. 32).

From 1982, the fifth Five Year plan was launched and the emphasis advanced to stability, efficiency and balance. The name of the plan also changed to the 5th Five Year Economic and Social Development Plan. This is when technology intensive industries such as electronics like TV, video and audio recorders, and semiconductor-related products started to be emphasised since there was greater demand in the world market.

The sixth Five Year Economic and Social Development Plan was between 1987 and 1991 during which time the goals of the previous plan were re-enforced. The government tried to accelerate import liberalisation and to lift different kinds of restrictions and non-tariff barriers on imports. The government increased the amount of investment in R&D to over 3% from less than 2.5% in previous years and established the government's own research and development laboratories. This is when universities started to be considered to play an important role in producing human resources (Kim, 2001, p. 151). At the same time, the Korean government began paying attention to small and medium sized firms and the people's welfare. From the 3rd to the 6th economic development plan period the economy of the country grew dramatically and the real GDP per capita growth increased from $ 3,024 in 1972 to $ 13,019 in 1990 (U.S. Bureau of Labor Statistics).

Focus was put on strengthening the competitiveness of industries in world markets, industrially and socially balanced development, internalisation between 1992 and 1996 when the 7th Five Year Economic and Social Development Plan was taking place. Industries the government paid attention to were high technology areas such as fine chemicals, bioengineering, new materials, aerospace and optics.

Chaebols, conglomerates, played a pivotal role in developing high-technology industries in the 1960s, 70s, and in the 1980s by dramatically diversifying their technology sourcing. Many *chaebols* monitored technological changes and obtained advanced semiconductor and computer technologies by setting up outposts in Silicon Valley. *Chaebols* developed successful links with multinationals that brought in important inputs for high technologies in Korea. They invested heavily in developing in-house R&D activities to absorb, assimilate and adapt imported technologies and to consolidate their own innovative activities (Kim, 1993, p. 364).

The focus of end stream of R&D that was on the immediate usage and commercialisation had to be changed when the need for balanced research orientation was realised. *Chaebols* also needed to modify their strategy for R&D to move more towards partnerships with other innovation actors while government research institutes had to focus more on basic research so that more generic and public technologies could be developed (Suh, 2000, p. 49).

In the 1980s there were changes in the economic environment such as the slowing down of the world economy, trade imbalance, losing the ground for low wage based labour intensive industries, unwillingness of advanced countries to do technology transfer to Korea, amendments in copyright and patent laws (Kim, 1993, p. 367). Under this unfavourable environment Korea had to improve its own technological capabilities to innovate independently and to have bargaining power against foreign technology suppliers.

Since the financial crisis in 1997, the Korean government has concentrated on promoting knowledge intensive industry development so that the country can open up completely for trade and capital flows, and to radically reshape the financial and labour market to make it more flexible (Park, 2001, p. 34).

During the rapid economic growth in Korea, the focus was on the Seoul Metropolitan region and in an effort to decentralise industries from this region the government set up seven large industrial estates in the south including Kumi, Kwangyang, Changwon, Pohang, and Ulsan in the late 60s and 70s (Rhee, 1994). While this process was taking place, heavy contributions came from *chaebol* establishing large plants, investing capital borrowed from abroad and using imported technologies (Kim, 1993, p. 366).

Masan and Iri free trade zone was designated to promote foreign direct investment (FDI) although FDI was relatively insignificant during the 70s and 80s. Park (2001, p. 32) argues that this policy of developing industrial estates can be regarded as a strategy to set up national production systems. Spatial structure of the Korean economy was mainly influenced by sectoral and spatial industrial policies.

These industrial decentralisation policies created the spatial division of labour with headquarters of *chaebols* in Seoul and production functions scattered in non-capital regions (Park, 2009, p. 323). Since the Korean government began focusing on high-tech industrial policy in the 1980s, however, re-concentration in the Seoul area occurred. This is supported by the fact that the Korea Development Institute determined the disparities in regional incomes of the 1980s in Korea based on a calculation method covering all economic sectors including social services and the armed forces (Wessel, 1997).

Even with the government's efforts to relieve concentration around the capital region by establishing industrial parks in non-capital regions, regional disparity persists in the knowledge-based industry development due to the fact that high skilled labour, advanced infrastructure for information, financial access and other favourable factors are more readily available in the capital region (Wessel, 1997).

Implementation of competent RSI was necessary for a competent NSI and the development of Regional Innovation Strategies was particularly emphasised after the financial crisis in 1997 (Park, 2001, p. 34). Regional Innovation became more crucial for regional development and the roles of local authorities and the local economic development for globalising economic process became increasingly important.

The national and regional systems of innovation approach can be used to identify ways in which regional and national innovation can be strengthened. By defining key innovation actors as academia, public research sector and industry, Chung (2002) categorised Korean regional systems of innovation into three categories: advanced, developing and less developed based on the number of innovation actors in three major groups. The systems of innovation, however, involve not only innovation actors but also complex processes in the utilisation of science and technology (Yim, 2006, p. 3).

2.2 KOREAN REGIONAL ECONOMIES

The concept of region in Korea originated from province level divisions 'Ju' and 'Mok' in the late 7th century and the current form of 'Do' became the primary division of administration from the early 11th century, the middle of Goryeo dynasty (Beom, 2003, p. 687). Today, the regions are divided into sixteen: 9 provinces that are Gangwond Do, Gyeonggi Do, Chungcheongbuk Do, Chungcheongnam Do, Gyeongsangbuk Do, Gyeongsangnm Do, Jeollabuk Do, Jeollanam Do, and Jeju Do, and 7 metropolitan cities that include Seoul, Incheon, Daejeon, Daegu, Gwangju, Ulsan, and Busan.

The sixteen official regions in Korea have been marked on the map in Figure 2.1:

Figure 2.1 Map of South Korea and the Sixteen Regions

(by Dreamstime.com)

Since the development period started in 1960, there have been serious socio-economic tensions between the Seoul metropolitan region, Seoul, and the rest of the regions, and also between the south-east part of Korea called ‘Youngnam’ that includes Busan, Daegu, Ulsan, Kyungbook and Kyungnam and the south west part of Korea called the ‘Honam’ that includes Gwangju, Jeonbook and Jeonnam in Korea which exist even in the current time. This affected the regional economic development policy implicitly as well as explicitly (Jang, 2011, p. 579).

Even with the involvement of development agencies and relevant ministries, regional disparities did not improve and many scholars (Oh, 1995; Park, 1998; Diamond and Tsalik, 1999; Seong, 2000; Kim, 2003; Campbell, 2004; Bae, 2005; Kim, 2006; Bae and Sellers, 2007) argued that regional policy should move away from the top down decentralisation policies that were applied in the 70s and 80s in order to develop endogenous potentials of the regions. Examples of this in the 1970s are heavy industrial complexes in the central and south-eastern parts of Korea that generated mono-structural industrial complexes dominated by branch plants of *Chaebol* that were operated mainly from Seoul and, public funded research enterprises and Daedeuk science town in Daejeon in the 1980s (Oh, 1995).

The Korean government went through major reform in March 1995 and as a result more autonomy was granted to regional authorities. This enabled regional governments to implement their own economic development policies (Seong, 2000, p. 10). However, the regional authorities remain as mere executive branches of central government. The reasons for this could be attributed to the lack of possibilities to levy taxes that made the realisation of their plans difficult financially, and also the inexperience of regional policy makers since they are used to implementing centrally ordered measures (Seong, 2000; Hassink, 2001). Another reason Seong (2000, p. 26) suggests is that this limited form of decentralisation has been introduced in order to prevent real decentralisation.

The pace of decentralisation has been slow and there are problems arising from it, however, decentralisation in Korea is occurring slowly with regional authorities gaining more powers and being more involved in science and technology policies (Chung, 1999). In an effort to boost more balanced regional development, the Korean government initiated its Balanced National Development Plan (BNDP) between 2004 and 2008 during President Roh Moohyun’s administration.

When the government designed the BNDP, the theoretical framework they adopted was Regional systems of innovation and cluster strategy developed by Porter as a policy consultant (Jang, 2011, p. 579). Although government emphasised the implementation of these strategies, Jang (2011, p. 580) argued that the adopted policy instruments by the government were far from putting emphasis on the networking between industries and regions. Rather, the Korean government endeavoured to realise regional balance by building new cities like multifunctional administrative and innovative cities.

The government wanted to build at least one of these types of cities in each province mainly based on political considerations rather than economic. Consequently, these new types of city were scattered throughout the country. When the government executed the BNDP, however, the same stereotyped policies and instruments were applied to all regions without taking into account each region's special characteristics (Chung, 1999; Jang, 2009).

The goal of regional policy changed from balance to competitiveness when President Lee Myung Bak's administration (2008–2013) came into power in 2008. The administration emphasised that we are living in a knowledge-based era and it is important to enhance regional competitiveness by creating a high value added economic system as well as maximising scale economies in a region (Choe, 2011, p. 5).

During this period, the regions were grouped into 16 considering economic geographical situations in Korea since the groupings were based on the historical, cultural and geographical identification of each region. In order to fulfil the goal of the government, the aims lay in achieving the establishment of economic regions, regional development based on specialisation, decentralisation and local autonomy, and inter-regional cooperation and reciprocal development (PCRD, 2009).

In Korea, central government controls the framework for regional level institutions and therefore it can be said that the country has a regionalised national systems of innovation (Asheim and Isaksen, 1997; Han, 2014).

To identify the links between the growth of regions in Korea and their innovation performance, R&D spending and their GRDP per capita by each region will be considered in the following sections.

R&D Spending by Region in Korea

Table 2.4 displays the amount of money each region in Korea spent on R&D. Between 2005 and 2011, Kyunggi, Seoul, Daejeon have been the top three regions that spent the highest amount in R&D while Gangwon, Jeju are the regions with the least. Although there are one or two ranks difference most of the other regions are in similar ranks.

Although Busan in 2008, Ulsan in 2007 and 2009, Gwangju in 2008 and 2010, Kyungbook in 2007 and Kyungnam in 2009 reduced it slightly, each region increased its R&D spending each year. An interesting fact is that the three top R&D spending regions that are Kyunggi, Seoul and Daejeon represent between 70 and 72% of the total R&D spending of the whole of Korea in each year.

Table 2.4 R&D Spend by Region (unit: one Billion Korean Won)

	2005	2006	2007	2008	2009	2010	2011
Total R&D	24,155	27,346	31,301	34,498	37,929	43,855	49,890
Seoul	4,633	5,000	6,184	7,175	7,304	8,243	9,231
Busan	352	591	870	742	811	839	907
Daegu	376	312	413	508	531	590	678
Incheon	1,180	1,093	1,676	1,406	1,441	1,662	1,983
Gwangju	346	382	502	500	527	521	690
Daejeon	2,920	3,062	3,360	3,948	4,357	5,012	5,570
Ulsan	372	539	353	411	395	452	748
Kyunggi	9,614	11,247	12,265	13,550	15,563	18,313	20,847
Gangwon	156	182	204	258	277	285	340
Choongbook	400	463	598	643	626	783	881
Choongnam	1,090	1,165	1,505	1,726	2,126	2,687	2,943
Jeonbook	260	268	383	387	493	531	656
Jeonnam	173	230	236	329	390	483	533
Kyungbook	1,288	1,554	1,390	1,411	1,575	1,829	2,099
Kyungnam	963	1,207	1,286	1,424	1,404	1,514	1,649
Jeju	33	50	75	80	109	112	135

(Source: $KOSTAT_{a,}$ 2016)

Regional variation using GRPD (Gross Regional Domestic Production) in Korea

To investigate the trend of regional economic development in Korea, data on GRDP has also been gathered in Table 2.5. GRDP is used to measure the size of the economy of a region and this is the aggregate of gross value added (GVA) of all resident producer units in the region. Regions in Korea can apply for the development fund and the government uses GRDP as one of its assessment measures. A region is composed of several sub-regions, some of them better developed than others, and this detailed information is not interpreted using the GRDP alone.

Furthermore, GRDP is used in setting economic policy by measuring economic size, production size, and industrial structure in order to encourage balanced development. Until 2003 when the importance of regional autonomy became an issue in Korea not even basic statistics for the regional level were available. GRDP per capita is very important since if this is accurately estimated at sub regional level, it will be clearer to determine how behind a sub region is compared to others within a region.

The concept of GRDP was first utilised in Korea in 1967 when rapid economic development was beginning to take-off. The method of estimation was slightly different and this was called 'New Village income', and 'the People's income' (Song, 2003, p. 34-36). In 1980, GRDP became censored since the government judged that this created regional conflict between the rich and poorer regions.

The use of GRDP was revived during President Roh Taewoo's administration in 1989 when the official statistical department - Statistics Korea[4] - took charge of the estimation, collection and publication of national and regional data. The Roh administration stressed the balanced regional development. The use of GRDP by the government highlighted how unbalanced the regions in Korea were in terms of economic development. This inequality has persisted and Table 2.5 and Table 2.6 show the GRPD and the GRDP per capita of 16 regions[5] in Korea between 2005 and 2011.

[4] The Ministry of Home Affairs was in charge before. The Statistics Korea began collecting the back dated data and estimated the GRDP from 1985. No GRDP is available between 1980 and 1984.
[5] By creating a new region, Sejong, the total number of official regions in Korea became 17 from July 2012. Since this is outside the research period this thesis covers, 2005 till 2011, only 16 regions will be included in the research.

Table 2.5 displays GRPD by region in Korea for the period covered in this thesis. Seoul and Kyunggi produced dominantly high GRDP that are almost or more than ten times higher than the regions with low GRDP such as Jeju, Gwangju and Daejeon. The GRDP of Korea increased by approximately 65% over the seven years, the whole survey period.

Table 2.5 GRDP in Korea between 2005 and 2011 (Unit: 10 Billion Korean Won)

	2005	2006	2007	2008	2009	2010	2011
KOREA	869,305	966,660	1,043,255	1,105,722	1,141,367	1,265,146	1,330,888
Seoul	208,899	231,224	249,485	263,000	273,199	289,719	303,813
Busan	48,069	52,358	56,193	60,467	60,695	63,737	66,648
Daegu	28,756	32,276	34,388	35,465	36,017	38,580	41,448
Incheon	40,399	47,055	51,638	51,274	53,796	60,708	61,854
Gwangju	18,896	20,614	22,310	22,940	23,834	26,401	27,789
Daejeon	20,030	21,377	22,775	24,034	25,535	27,632	29,684
Ulsan	41,697	45,155	50,082	53,870	52,556	62,852	68,748
Kyunggi	169,315	197,973	212,644	225,736	237,319	266,562	276,155
Gangwon	23,015	25,023	26,878	27,981	29,111	30,628	32,438
Choongbook	26,721	29,761	32,011	33,036	34,837	39,470	42,489
Choongnam	47,497	54,335	59,031	64,067	71,756	83,167	91,816
Jeonbook	25,221	28,065	30,007	31,832	34,739	36,632	39,960
Jeonnam	42,816	42,951	47,730	52,424	51,544	59,901	62,689
Kyoungbook	61,757	63,295	65,990	70,559	72,973	80,839	82,276
Kyoungnam	58,251	66,710	73,044	79,694	83,163	87,419	91,233
Jeju	7,966	8,489	9,049	9,342	10,296	10,899	11,847

(Source: $KOSTAT_b$, 2016)

In order to see per capita economic production and to observe the extent of regional inequality, GRDP per capita by region is shown in Table 2.6. It can be seen at a glance that there is pronounced variation in living standards across regions. The highest GRDP per capita is produced in Ulsan while its neighbouring region Daegu produced the lowest. GRDP per capita between the richest and poorest regions varies by a factor of around four.

The root of this huge gap between Ulsan and Daegu can be found in their strategic main industries. Daegu is a famous textile city in Korea which prospered when Korea was benefitting from low wage labour intensive industry as they exported cheap clothing and fabric in the past. As Korea moved up the value ladder, however, its international competitiveness was lost and Daegu's relative economic position declined. In an effort to revive the economy of the city, since the late 1990s, the leaders of the city promoted high fashion in the hope that the city could emulate Milan in Italy, but the strategy has had limited success (Lewis, 2010).

On the other hand, Ulsan enjoyed the export boom in transportation equipment. Ulsan benefits from the world's largest shipyard, oil refinery, automobile factories and the headquarters of Hyundai, one of the most influential conglomerates in Korea (Evans, 2015).

Traditionally, there has been significant political conflict between the southeast and southwest of Korea. The southeast of Korea, Kyoungsangdo (Kyungbook and Kyungnam), is generally prosperous and politically favoured while the southwest, Jeollado (Jeonbook and Jeonnam), is considered underdeveloped and politically left leaning (Sigma).

One interesting fact of note from Table 2.6, however, is the comparison of the economic output of these two areas. Although Jeollanamdo (Jeonnam) and Jeollabookdo (Jeonbook), the southwest of Korea, is politically marginalised, they enjoy high economic productivity.

On the other hand, Busan and Daegu, in the southeast of Korea, the second and third largest cities, were politically favoured but have suffered from extremely low economic productivity. Busan, like Daegu, is locked into old industrial structures and low innovativeness and has recently been trying to reshape its industrial structure and strengthen its ability to innovate and attract high tech firms (Jang, 2011, p. 591).

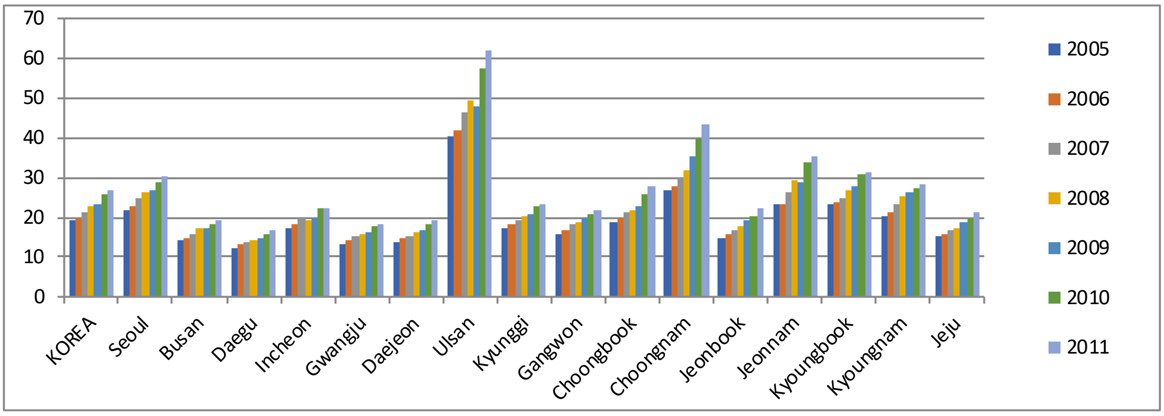
Table 2.6 GRDP per capita by Region in Korea (Unit: One Million Korean Won)

	2005	2006	2007	2008	2009	2010	2011
KOREA	19.1	20.0	21.5	22.6	23.4	25.6	26.7
Seoul	22.0	23.0	24.8	26.1	27.0	28.8	30.3
Busan	14.1	14.7	15.9	17.2	17.4	18.4	19.2
Daegu	12.3	13.0	13.9	14.3	14.6	15.6	16.7
Incheon	17.1	18.1	19.6	19.1	20.0	22.4	22.5
Gwangju	13.3	14.3	15.3	15.7	16.2	17.7	18.5
Daejeon	13.9	14.5	15.3	16.0	17.0	18.3	19.4
Ulsan	40.5	42.0	46.5	49.5	48.0	57.4	62.2
Kyunggi	17.5	18.3	19.3	20.1	20.9	23.0	23.4
Gangwon	15.8	16.9	18.2	18.9	19.6	20.6	21.7
Choongbook	18.6	20.0	21.4	21.9	23.0	25.9	27.6
Choongnam	26.7	28.0	29.9	31.9	35.2	40.1	43.6
Jeonbook	14.6	15.6	16.8	17.8	19.4	20.4	22.2
Jeonnam	23.2	23.5	26.4	29.2	28.9	33.7	35.4
Kyoungbook	23.3	23.9	25.0	26.8	27.7	30.8	31.2
Kyoungnam	20.4	21.4	23.3	25.2	26.1	27.2	28.2
Jeju	15.2	15.6	16.7	17.2	18.9	19.9	21.4

(Source: $KOSTAT_b$, 2016)

According to figure 2.2, it is apparent that Ulsan has always had the highest and Daegu the lowest GRDP per capita. Even with the enactment of balanced regional policies, GRDP per capita between the regions has been diverging rather than converging.

Figure 2.2 GRDP per capita by Region in Korea (Unit: One Million Korean Won)



Real Regional Growth Rates

Table 2.7 displays the annual percentage rate of growth in each region between 2005 and 2011. The more regions that made negative growth can be seen in 2008 and 2009, and many more regions achieved very high growth in 2010. Although there was no region that had negative growth, the growth rate in each region in general was relatively low in 2011 compared to 2010.

Table 2.7 Real Growth Rate in GRDP per capita by Region Korea (%)

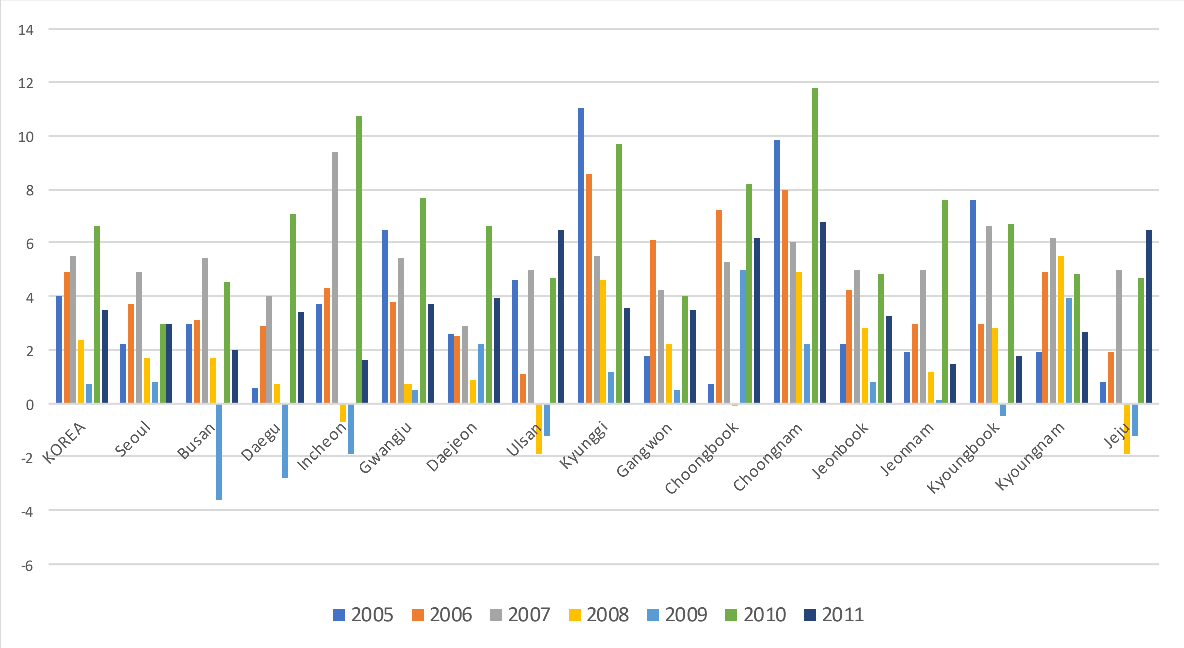
%	2005	2006	2007	2008	2009	2010	2011
KOREA	4.0	4.9	5.5	2.4	0.7	6.6	3.5
Seoul	2.2	3.7	4.9	1.7	0.8	3.0	3.0
Busan	3.0	3.1	5.4	1.7	-3.6	4.5	2.0
Daegu	0.6	2.9	4.0	0.7	-2.8	7.1	3.4
Incheon	3.7	4.3	9.4	-0.7	-1.9	10.7	1.6
Gwangju	6.5	3.8	5.4	0.7	0.5	7.7	3.7
Daejeon	2.6	2.5	2.9	0.9	2.2	6.6	3.9
Ulsan	4.6	1.1	5.0	-1.9	-1.2	4.7	6.5
Kyunggi	11.0	8.6	5.5	4.6	1.2	9.7	3.6
Gangwon	1.8	6.1	4.2	2.2	0.5	4.0	3.5
Choongbook	0.7	7.2	5.3	-0.1	5.0	8.2	6.2
Choongnam	9.8	8.0	6.0	4.9	2.2	11.8	6.8
Jeonbook	2.2	4.2	5.0	2.8	0.8	4.8	3.3
Jeonnam	1.9	3.0	5.0	1.2	0.1	7.6	1.5
Kyoungbook	7.6	3.0	6.6	2.8	-0.5	6.7	1.8
Kyoungnam	1.9	4.9	6.2	5.5	3.9	4.8	2.7
Jeju	0.8	1.9	5.0	-1.9	-1.2	4.7	6.5

(Source: KOSTAT$_b$, 2016)

The data in Table 2.7 are illustrated in Figure 2.3. Choongnam and Kyunggi show prominent high growth in real growth rate. Kyunggi had the highest growth rate of 11.0% and 8.6% respectively in 2005 and 2006 while Incheon had the highest real growth with a rate of 9.4% in 2007. Kyungnam made the highest real growth with a rate of 5.5% in

2008 when it was Choongbook that made 5% in growth rate while many regions suffered from minus growth in 2009. Choongnam was the region showing the highest growth rate with 11.8% and 6.7% in two consecutive years, 2010 and 2011.

Figure 2.3 Real Growth Rate in GRDP per capita by Region in Korea (%)



The extent of the gap in income per capita across regions in Korea can be seen from Table 2.8. The gaps across regions in GRDP per capita do not seem to be converging but rather diverging.

Table 2.8 Increase in GRDP per capita between 2005 and 2011 in Korea by Region and the difference in GRDP per capita between each Region and Korea as a whole

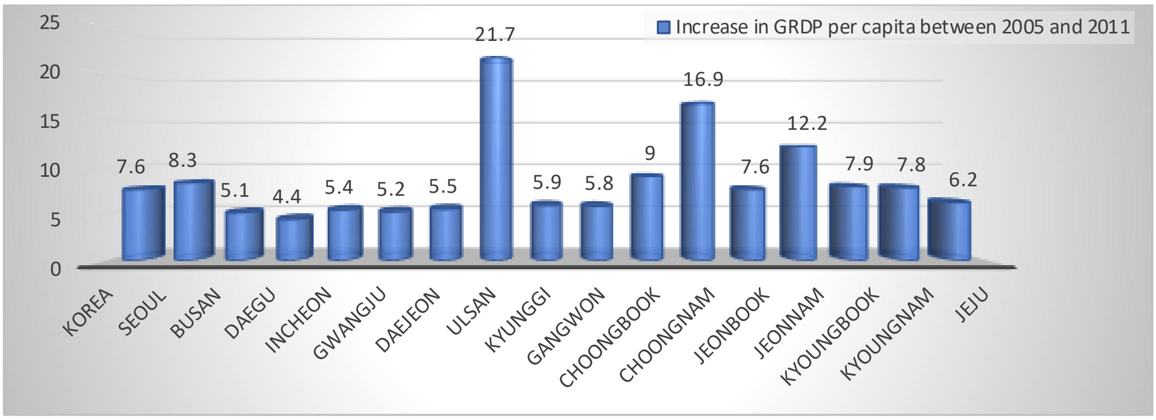
(Unit: 1 Million Korean Won)

REGION	*Increase in GRDP per capita between 2005 and 2011*	DIFFERENCE IN GRDP PER CAPITA PER REGION AGAINST THE ONE FOR KOREA AS A WHOLE						
KOREA	*7.6*	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Seoul	*8.3*	2.9	3.0	3.3	3.5	3.6	2.4	3.6
Busan	*5.1*	-5.0	-5.3	-5.6	-5.4	-6.0	-7.2	-7.5
Daegu	*4.4*	-6.8	-7.0	-7.6	-8.3	-8.8	-10.0	-10.0
Incheon	*5.4*	-2.0	-1.9	-1.9	-3.5	-3.4	-3.2	-4.2
Gwangju	*5.2*	-5.8	-5.7	-6.2	-6.9	-7.2	-7.9	-8.2
Daejeon	*5.5*	-5.2	-5.5	-6.2	-6.6	-6.4	-7.3	-7.3
Ulsan	*21.7*	21.4	22.0	25.0	26.9	24.6	31.8	35.5
Kyunggi	*5.9*	-1.6	-1.7	-2.2	-2.5	-2.5	-2.6	-3.3
Gangwon	*5.8*	-3.3	-3.1	-3.3	-3.7	-3.8	-5.0	-5.0
Choongbook	*9.0*	-0.5	0	-0.1	-0.7	-0.4	0.3	0.9
Choongnam	*16.9*	7.6	8.0	8.4	9.3	11.8	14.5	16.9
Jeonbook	*7.6*	-4.5	-4.4	-4.7	-4.8	-4.0	-5.2	-4.5
Jeonnam	*12.2*	4.1	3.5	4.9	6.6	5.5	8.1	8.7
Kyoungbook	*7.9*	4.2	3.9	3.5	4.2	4.3	5.2	4.5
Kyoungnam	*7.8*	1.3	1.4	1.8	2.6	2.7	1.6	1.5
Jeju	*6.2*	-3.9	-4.4	-4.8	-5.4	-4.5	-5.7	-5.3

Figure 2.4 illustrates that the region with the most increase in GRDP per capita was Ulsan whereas Daegu suffered from the lowest increase.

Figure 2.4 Increase in GRDP per capita in Korean Regions between 2005 and 2011

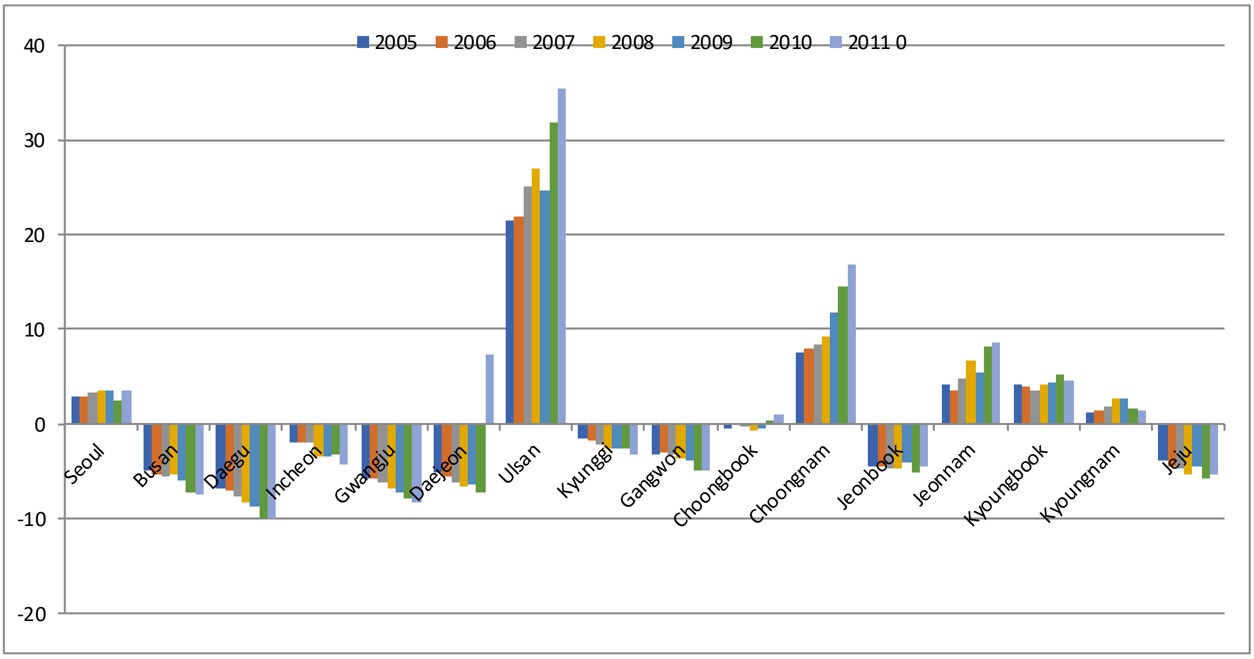
(Unit: 1 Million Korean Won)



Comparing each region's GRDP per capita with the one for the whole of Korea, as Figure 2.5 shows, out of sixteen regions only six regions including Seoul, Ulsan, Choongnam, Jeonnam, Kyungbook and Kyoungnam are the regions that produce higher GRDP per capita than the country as a whole.

Figure 2.5 Difference in GRDP per capita by Region against the One for Korea as a whole

(Unit: 1 Million Korean Won)



In order to identify the relationship between R&D spending and GRDP per capita, Table 2.9 contains the ranks of each region for R&D spending and GRDP per capita.

The noticeable fact here is that although R&D spending of Ulsan is low with the rank between the 9th and the 14th, the GRDP per capita is at the top. Kyunggi, on the other hand, is the region that spends the highest amount in R&D but its GRDP per capita is in the low rank, either the 8th or the 9th. Daejeon, another region that spends a lot in R&D, is low in rank, 13th or 14th for GRDP per capita. Gwangju, Jeonbook, Gangwon, and Jeju show a low ranking in R&D spending and low ranks in GRDP per capita as well. Daegu's rank for R&D spending is slightly lower than middle but the rank for GRDP per capita is the lowest in all years.

Table 2.9 Rank Table for R&D Spending (A) and GRDP per capita by Region (B)

	2005		2006		2007		2008		2009		2010		2011	
	A	*B*	A	*B*	A	*B*	A	*B*	A	*B*	A	*B*	A	*B*
Seoul	2	*5*	2	*5*	2	*5*	2	*5*	2	*5*	2	*5*	2	*5*
Busan	11	*13*	8	*13*	8	*13*	8	*13*	8	*13*	8	*13*	8	*14*
Daegu	9	*16*	12	*16*	11	*16*	10	*16*	10	*16*	10	*16*	12	*16*
Incheon	5	*9*	7	*9*	4	*8*	7	*9*	6	*9*	6	*9*	6	*9*
Gwangju	12	*15*	11	*15*	10	*14*	11	*15*	11	*15*	12	*15*	11	*15*
Daejeon	3	*14*	3	*14*	3	*14*	3	*14*	3	*14*	3	*14*	3	*13*
Ulsan	10	*1*	9	*1*	13	*1*	12	*1*	13	*1*	14	*1*	10	*1*
Kyunggi	1	*8*	1	*8*	1	*9*	1	*8*	1	*8*	1	*8*	1	*8*
Gangwon	15	*10*	15	*10*	15	*10*	15	*10*	15	*10*	15	*10*	14	*11*
Choongbook	8	*7*	10	*7*	9	*7*	9	*7*	9	*7*	9	*7*	9	*7*
Choongnam	6	*2*	6	*2*	5	*2*	4	*2*	4	*2*	4	*2*	4	*2*
Jeonbook	13	*12*	13	*11*	12	*11*	13	*11*	12	*11*	11	*11*	12	*10*
Jeonnam	14	*4*	14	*4*	14	*3*	14	*3*	14	*3*	13	*3*	13	*3*
Kyoungbook	4	*3*	4	*3*	6	*4*	6	*4*	5	*4*	5	*4*	5	*4*
Kyoungnam	7	*6*	5	*6*	7	*6*	5	*6*	7	*6*	7	*6*	7	*6*
Jeju	16	*11*	16	*12*	16	*12*	16	*12*	16	*12*	16	*12*	15	*12*

The rank of each region for the R&D spending and the GRDP per capita seems to be consistent in all years. Thus, by looking at Table 2.9, there does not appear to be a positive relationship between R&D spending and the growth of the region.

2.3 SUMMARY

This chapter began by outlining the path of Korean economic development and highlighted the role of government economic policy. The main features include the introduction of five-year economic development plans, new village movement, and government support for *Chaebols*. Since the financial crisis in Asia that badly hit the Korean economy, the focus of economic development in Korea shifted to promotion of knowledge industries and industrial decentralisation policies were implemented.

Socio-economic tension between Seoul and the rest of the regions is high in Korea and although regional autonomy was introduced in 1995, providing each region with the power to implement their own economic development policies, regional disparities did not improve significantly.

To address this lack of convergence a number of scholars have advocated the use of bottom up decentralisation policies in order to develop the potential of regions rather than the top down decentralisation policies from the 1970s and 80s (Oh, 1995; Park, 1998; Diamond and Tsalik, 1999; Seong, 2000; Kim, 2003; Campbell, 2004; Bae, 2005; Kim, 2006; Bae and Sellers, 2007).

The balanced national development plan was initiated in 2004 and the Korean government endeavoured to promote regional balance by building new cities such as multifunctional administrative and innovative cities. The government subsequently changed their strategy from balance to competitiveness in 2008.

In order to observe the economic disparity across regions, the R&D spending and the GRDP per capita by region have been presented in this chapter, highlighting the pronounced variation in economic output across the country. It was found that there was no positive relationship between the growth of a region and the R&D spending, showing lack of convergence in innovation.

Regional industrial structure and stages of economic development differ across regions and therefore differentiated policies have to be applied to individual regions according to their characteristics. As Todtling and Tripple (2005, p. 11-12) argue it is important for peripheral regions to invest in physical infrastructure, to gather businesses together and to have supporting organisations. For old industrial regions, however, the regions have to unlearn existing knowledge and customs in order to leave the old path and develop a new one. The fragmented metropolitan regions have to have policies that emphasise networking with the various actors and organisations for innovation and they also have to focus on strengthening their competitiveness globally.

From this chapter, it was demonstrated that regions in Korea suffer from inequality. The findings suggest that regions have different levels of innovation performance and consequently they diverge economically rather than converge.

Chapter 3

LITERATURE REVIEW

The Solow (1956) growth model argued that the different levels of development across countries could be explained by differences in the capital accumulation per worker (Fagerberg and Srholec, 2007, p. 2) with technological change determined exogenously. This was in contrast to the idea that endogenous technological differences underlie different levels of development (Gershenkron, 1962; Abramovitz, 1986) and is consistent with Schumpeter's (1934, 1942) views on growth. Following the emergence of this perspective there has been a growing number of works (Freeman *et al.*, 1982; Fagerberg, 1987; Verspagen, 2009) related to the different levels of development and growth performance across countries (Fagerberg and Srholec, 2007, p. 2).

The ability of an economic system to innovate is seen as one of the essential determinants of economic performance from the systems approach view (Michie and Oughton, 2001, p. 165). Interest in innovation as a source of competitive advantage, together with the necessity of developing new policies to address inequalities and divergence among regions, has been increasing significantly over the past three decades which as a result contributed to the amount of research on regional innovation (Asheim *et al.*, 2011, p. 876).

A good example can be found from the survey by Asheim, Smith and Oughton (2011) using the Social Science Citation Index. From the survey, it was found that there was significant growth in the number of articles related to regional innovation; only three articles were published between 1980 and 1989 but more than eighty times, 265 articles, were published by 2009 (Asheim *et al.*, 2011, p. 876).

Since the ground breaking work by Freeman (1987), 'Technology Policy and Economic Performance: Lessons from Japan', it has become an important framework in systems approach literature for technological innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993).

Innovation has been defined by many different authors such as Lionberger (1960), Coleman (1966), Evans (1967), Freeman (1987), Foxall (1988), Afuah (1998), and this is because according to Goldsmith and Foxall (2003, p. 322) the innovation concept appears in various fields of study and social theories. The definition in the Oslo Manual, "*the implementation of a new or significantly improved product (goods or services), or* *process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations*" will be employed in this thesis to meet the purpose of the research (OECD, 2005, p. 46).

As Edquist (2005, p. 186) claims the systemic approach of innovation is a conceptual framework where determinants of innovation are identified rather than a theory where propositions and causal relations are identified.

3.1 SYSTEMS OF INNOVATION

One of the early traditional theoretical frameworks developed to understand the relationship between the economy and science and technology is the linear model of innovation that can be found in 'Science: The Endless Frontier' by Bush (1945) that sets out a linear path from basic research, applied research and development to product innovation and diffusion. Bush emphasises the importance of basic research in the process of innovation saying "*Basic research leads to new knowledge. It provides scientific capital. It creates the fund for which the practical applications of knowledge must be drawn… A nation which depends on others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill"* (Bush, 1945, p. 16).

The concept of the linear model of innovation is, however, seen as limited (Rosenberg, 1994, p. 139)[6] and was overtaken by the systems approach of innovation that explains how knowledge and innovation are generated and diffused (Freeman, 1982, 1987, 1995; Lundvall, 1992; Nelson, 1993; Patel and Pavitt, 1994; Niosi and Bellon, 1994; Metcalfe, 1995; Edquist, 1996; OECD, 1999; Edquist and Hommen, 1999; Lundvall and Maskell, 2000).

The systems of innovation approach was created by Freeman (1982) in his book, '*The Economics of Industrial Innovation*' while the term 'national system of innovation' was first employed to describe and explain Japan's innovation pattern in 'Technology policy and economic performance: Lessons from Japan' by Freeman (1987) for the first time. Freeman (1987, p. 1) defined it as "*the network of institutions in the public and private sectors whose activities and interactions initiate, import, and diffuse new technologies*".

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[6] Kline and Rosenberg (1986) identified two main problems with the linear model of innovation. First of all, the model generalises a causation chain that only applies to a minority of innovation. While it is true that some important innovations come from scientific breakthroughs, firms innovate normally since they feel there is a commercial need for it. They usually review and combine existing knowledge first in the process. Secondly, different stages of the process produce many feedbacks and loops but the linear model ignores these. Failures and shortcomings happening at various stages can lead to a reconsideration of previous steps and as a result, totally new innovations can eventually be produced (Fagerberg, 2005, p. 8-9). According to Smith (1994, p. 2) the linear model of innovation is research-based, sequential and technocratic.

The National Systems of Innovation approach by Freeman (1987) has been further developed mainly by Lundvall (1992) and Nelson (1993), and this concept has been frequently discussed with the emphasis placed on interaction of actors and how these shape social, institutional and political factors (Carlsson *et al.*, 2002; Kim *et al.*, 2007; Fagerberg and Verspagen, 2009; Watkins *et al.*, 2015). Through a number of case studies Nelson (1993) identified that various national systems have big differences in institutional and organisational set-up, R&D investments and performance.

This then expanded to regional systems of innovation that emphasise the effect of agglomeration economies such as knowledge spillovers, human capital, public support etc. (Cooke, 1992, 1998, 2000; Cooke and Morgan; 1994; Saxenian, 1994; Oughton and Whittam, 1997; Asheim and Isaksen, 1997; Cooke *et al*, 1997; Braczyk *et al.*, 1998; De la Mothe and Paquet, 1998; Autio, 1998; Maskell and Malmberg, 1999; Howells, 1999; Acs, 2000; Asheim and Isaksen, 2002; Doloreux, 2003; Asheim and Gertler, 2005; Rodriguez-Pose and Cresceni, 2008) that influence innovation performance.

Although the focus of the conceptual framework of regional innovation differs in terminology, the region specific roles of factors such as competitive cooperation, culture and access to human resources, regional institutions and the interaction among actors and the subsequent learning benefitted from close proximity are treated as important in explaining systems of innovation at local or regional levels (Ptak and Bagchi-Sen, 2011, p. 422).

An innovative region that has a good knowledge base and competences can attract innovation oriented players such as firms, research institutes and business parks (Swan *et al.*, 1998; Feldman, 1999; Niosi and Bas, 2001). Furthermore, regional governments as key players can promote the interactive collaboration among regional stakeholders and identify the key innovation assets and strategic priorities for the long term (Rodriguez-Pose *et al.*, 2014; Mongkhonvanit, 2014).

Physical proximity of actors in a network and subsequent tacit knowledge transfer greatly affect learning and innovation (Amin and Wilkinson, 1999, p. 125). According to

Boschema (2005, p. 4), however, a region can be trapped in innovational lock in if RSI relies too much on inward sources of knowledge generation and transfer.[7]

Sectoral and technological systems of innovation (Pavitt, 1984; Carlsson and Stankiewicz, 1991, Carlsson, 1995; Breschi and Malerba, 1997; Malerba, 2002) that focus on innovation in sectors then is followed. Other than national and regional specification of systems of innovation that rely on a spatial dimension to define their boundaries, technological systems that use a certain technology or the sector in which it is used as their system boundary was first mentioned by Pavitt (1984) and later emphasised by Carlsson and colleagues, arguing these are unique to the field of technology. The sectoral approach has been developed by Carlson and Stankiewicz (1991) although the concept was further developed by Malerba (2002) with the focus on a group of firms' development and manufacturing the products in a particular sector together with generation and utilisation of technologies in that sector.

National, regional and sectoral perspectives may be categorised as variants of a single generic systems of innovation approach (Edquist, 1997b, p. 11-12). Systems that are embedded in national systems of innovation are linked to other regional systems of innovation and the systems also overlap with technological and sectoral systems of innovation (Carlsson and Stankiewicz, 1991; Malerba, 2002; Asheim *et al.*, 2015). In general, therefore, these variants complement each other (Edquist, 2005, p. 184).

An important systems of innovation variant is the Triple Helix model (Etzkowitz, 1993, Etzkowitz and Leydesdorff, 1995, 1997; Leydesdorff, 2006; Todorovska and Stankovic, 2012) that is based on the dynamic interactive relationship among its components that include university, industry and government. Furthermore, this analytical framework serves as a source of empirical guidelines for policy makers, universities and managers in businesses to make the collaboration of triple helix actors stronger and increase regional development (Ranga and Etzkowitz, 2013, p. 3).

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[7] The reasons behind this argument are that first of all, the potential for leaning is increased by cognitive distance while it can limit the absorptive capacity of firms. Second of all, cognitive lock in can easily happen by cognitive proximity in the sense that the knowledge creation can go against the organisation's well-being. Thirdly, the risk of involuntary spillover can be increased by the cognitive proximity. Knowledge cannot always be perfectly appropriated and as a result knowledge may spill over across organisations and competitors are reluctant to share knowledge in this circumstance (Boschema, 2005, p. 4-5).

The central focus of the systems of innovation approach lies in innovation and learning processes and the importance of learning acknowledges that innovation is about producing new knowledge or newly combining existing and new knowledge elements (Carlsson et al., 2002; Edquist, 2005; Bergek *et al.*, 2005). Because of this focus, the systems of innovation approach is differentiated from other approaches that consider technological changes and other innovations as exogenous (Edquist, 2005, p. 18).

In order to characterise and compare different systems of innovation, system boundaries, actors and networks, institutions, knowledge, dynamics and policy implications are used in investigation (Coenen and Diaz Lopez, 2010). All systems of innovation, however, treat the learning processes where actors involved experience a learning-by-doing or learn from exchange of knowledge as important (Cohen and Levinthal, 1990; Ariño and de la Torre, 1998; Ahuja, 2000). Due to their systemic, non-linear, interactive and evolutionary character, systems of innovation are always defined as complex systems (Todtling and Trippl, 2012; Uyarra and Flanagan, 2013; Schrempf *et al.*, 2013).

The systems perspective of innovation is based on the idea that firms do not normally innovate alone but through interaction with customers, suppliers, competitors and other public or private organisations i.e. universities, schools and government ministries (Fagerberg, 2005, p. 20). Edquist (2005) emphasises R&D and education in his discussion of innovation while O'Sullivan (2005) highlights the importance of the relationship of finances with innovation.

The systemic approaches of innovation are useful frameworks for understanding scientific and technological developments, and the systems emphasise linkages among actors involved in innovation (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 2005). The strengths of systems of innovation approach can be demonstrated by the fact that it takes a holistic and interdisciplinary perspective, and historical and evolutionary perspectives. Furthermore, interdependence and non-linearity is emphasised as well as the role of institutions while the approach can embrace product and process innovation together with sub categories of these innovations (Freeman, 1987, 2002; Lundvall, 1992; Nelson, 1993; Edquist, 2005).

These main variants of systems of innovation will be studied in detail later. Table 3.1 lists the main literature of these systems of innovation:

Table 3.1 Innovations and Main Relevant Literatures

SYSTEMS OF INNOVATION	MAIN LITERATURE
National Systems of innovation	Freeman (1987), Lundvall (1992), Nelson (1993), Patel and Pavitt (1994), Niosi and Bellon (1994), Metcalfe (1995), Edquist (1996), OECD (1999), Lundvall and Maskell (2000)
Regional Systems of innovation	Cooke (1992, 1998, 2000), Saxenian (1994), Oughton and Whittam (1997), Asheim and Isaksen (1997), Braczyk et al. (1998), De la Mothe and Paquet (1998), Autio (1998), Maskell and Malmberg (1999), Howells (1999), Acs (2000), Asheim and Isaksen (2002), Doloreux (2003)
Sectoral Systems of innovation	Carlsson and Stankiewicz (1991), Carlsson (1995), Breschi and Malerba (1997), Malerba (2002)
Triple Helix Model	Etzkowitz (1993), Etzkowitz and Leydesdorff (1995 & 1997), Leydesdorff (2006); Todorovska and Stankovic (2012)

3.1.1 Components and Activities of Systems of innovation

It is generally agreed that the main components in systems of innovation are organisations and institutions (Edquist, 2005, p. 188). Edquist and Johnson (1997, p. 46) specified the meaning of 'organisations' as "*formal structures that are consciously created and have an explicit purpose"* (i.e. firms, universities, schools, training organisations, research organisations, financial organisations such as banks, and government organisations/departments).

Edquist and Johnson (1997 p. 47) also defined 'institutions' as "*sets of common habits, norms, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups, and organizations"* (i.e. patent laws, remit of universities). Organisations are players or actors who have specific objectives and strategies and the set up of organisations and institutions vary among different systems of innovation.

From the systems perspective view, systems of innovation are a set of interlinked actors and this naturally leads to a focus on the working of the linkages of the system. System structure will facilitate certain types of interaction and outcomes with strong complementarities that exist between the components of a system (Edquist, 2005, p. 190). Innovation comes from increasingly complex interactions at the regional, national and international levels among individuals, firms and other knowledge institutions.

By arguing that there lacks a system level of explanatory factors in the national systems of innovation, Liu and White (2001, p. 1093-1094) identified five activities in systems of innovation through focusing on activities related to the creation, diffusion and exploitation of technological innovation in a system. These five activities are R&D, implementation, end-use, education and linkage.

Furthermore, within systems of innovation, a number of functions have to be served in order to support the growth of an industry and Johnson and Jacobson (2003, p. 2-3) suggested creation of new knowledge, guidance of the direction for search process, resource supply, creation of positive external economies, and facilitation of the formation of markets as those functions.

Although there is no agreement on which functions or activities should be included in a system of innovation, according to Edquist (2005, p. 189-199), research and development, competence building – education and training, formation of new product markets, user demand articulation, creation and change of organisations, networking around knowledge, creating and changing institutions, incubating activities, financing innovation, and consultancy services can be expected to be important in most systems of innovation.

Lundvall (2005, p. 12), however, argues that while research and development, competence building, incubating activities, financing innovation and consultancy services may be organised differently by different national systems but formation of new product markets, user demand articulation, creation and change of organisations, networking around knowledge, creating and changing institutions are difficult to be seen as activities and also difficult to see as they are organised by any particular type of organisation. Lundvall (2005, p.13) further lists other activities or functions such as competition, openness to international trade and capital flows, labour market dynamics, social welfare systems and quality of social capital influence innovation.

Thus, different scholars suggest varying lists of activities and functions of systems of innovation but the definition the Oslo manual proposes seems to overarch most of the forelisted elements. According to the Oslo manual innovation activities are defined as *"all specific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovation. Innovation activities also include R&D that is not directly related to the development of a specific innovation"* (OECD, 2005, p. 47).

The innovation process is strongly influenced by governments through the financing and steering of public organisations that are involved in knowledge generation and diffusion directly, and through the provision of financial and regulatory incentives to all actors of the systems of innovation (OECD, 2001).

By highlighting the systemic nature of innovation processes, Fagerberg (2005, p. 20) emphasises that firms do not usually innovate in isolation but in collaboration and interdependence with other organisations.

3.1.2 Addressing the Problems

The generally agreed components of systems of innovation are institutions and organisations but due to the fact that the systems of innovation approach is related with conceptual diffuseness problems can occur. The concept of innovation can be used as institutional rules whilst it can also be used as organisational actors (Edquist, 2005), and Edquist (2005) pointed out that the boundaries of the systems, and what should be included in the systems, were not defined by the originators of the systems of innovation approach.

For example, Lundvall (1992, p. 13) argued that *"a definition of the systems of innovation must be kept open and flexible"* and Nelson and Rosenberg (1993, p. 5-6) proposed *"no sharp guide to just what should be included in the systems of innovation, and what can be left out"*.

Moreover, according to Edquist (1997b, p. 2), systems of innovation is not a formal theory that provides specific propositions with regard to causal relations among variables and, therefore, it has to be termed as a conceptual framework or an approach. It can, however, form conjectures for empirical testing although this has been done to a limited degree. There are scholars including Edquist arguing that systems of innovation have to be more conceptually clarified and have to be made more theory-like since it is under-theorised (Edquist, 2005, p. 186).

Similarly, in terms of regional systems of innovation, it is used to analyse the way regional clusters work and to create supportive systems of innovation at a regional level in the capacity of a policy tool (Park, 2001, P. 34). The limitation we have to consider here with regional systems of innovation being a policy tool is that it is dangerous to generalise the potential of regional systems of innovation. This is because, as Park (2001, p. 37) argues, the development of regional innovation policies and instruments are based on the successful cases. Well-known successful cases can be found from Silicon Valley (Saxenian, 1994) in USA, Emilia-Romagna (Piore and Sabel, 1984) in Italy, and Baden Wurttemberg (Cooke and Morgan, 1994) in Germany.

3.2 NATIONAL SYSTEMS OF INNOVATION (NSI)

In this section, the relationship between innovation and the development of economics will be examined by focusing on the elements that are considered to be important in the working of systems of innovation at the national level. Furthermore, the history of the development of the concept of National systems of innovation will also be studied through various sources of literature. This will be followed by a discussion of regional systems of innovation.

3.2.1 Innovation and Economic Development

A century ago, Torstein Veblen wrote in his book 'Imperial Germany and The Industrial Revolution' about Germany's industrialisation and pointed out the nature of technology and the conditions for technological catch up etc. (Torstein Veblen, 1915, p. 73-82). Half a century later, neoclassical economists shared the optimistic view of Veblen who argued that it is possible for the poorer economies to make technological and economic catch-up (Fagerberg *et al.*, 2009, p. 6). This was based on the freely available assumption of, so called, 'public good' for everyone everywhere. Therefore, neoclassical growth theory proposed by Solow (1956) was interpreted as the convergence of global economy will occur automatically presuming market forces are left to do their job (Fagerberg *et al*, 2009, p. 6).

On the other hand, there were economists, such as Gerschenkron (1962), who were inspired by Schumpeter's work from the 1960s who did not have a positive view on this. These economists argue that technological catch up is not automatic but needs much effort, together with organisational and institutional change, to succeed and emphasised the generation of various capabilities of firms, industries, and countries to get out of the low development trap (Ames and Rosenberg, 1962).

Based on these development aspects, the systems of innovation approach was advanced by Freeman (1987) and this analytic framework has been extensively used to discuss systems of innovation within nations (Lundvall, 1988, 1992; Nelson 1988, 1993; Edquist, 1997). Innovation is endogenous and this concept emphasises the importance of enhancing the linkages among various actors, particularly in relation to knowledge creation, diffusion and usage, to improve a country's innovative performance (Feinson, 2003, p. 18).

In his article 'The National System of Innovation in historical perspective', Freeman (1995, p. 5) explains that the first person who used the expression of 'national systems of innovation' was Lundvall in his book, '*National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*' in 1992. Lundvall and his colleagues agreed the original idea of national systems of innovation is rooted in Friedrich List's conception of 'The National System of Political Economy' (1841) which, according to Freeman, may as well have been called 'The National System of Innovation' (Freeman, 1995, p. 5).

Freeman (1995, p. 7) identified that List (1841)[8] not only recognised many modern national systems of innovation features such as education and training institutions, science and technology institutes, interactive learning, knowledge accumulation, but also greatly emphasised the interdependence of tangible and intangible investment and the linkages of industry to the formal institutions as well as the role of state to coordinate and carry through long term policy. It is, therefore, the needs of policy makers and scholars of innovation, representing an evolutionary process incorporating observation with economic theory, that laid the background of NSI (Lundvall, 2002, p. 214).

Freeman (1995, p. 8), however, argues that the emergence of the importance of research and development is the new development in the whole concept of national systems of innovation that List did not foresee while he was able to identify the responsibilities of government for education and the development of industrial infrastructure as the key elements of the system. Further importance in the system, according to Nelson (1993), is the set up of actors and their collaboration in the science and technology sector, and therefore, Nelson had particular interest in universities and institutions that carry out research and development (Fagerberg and Verspagen, 2009, p. 219).

[8] List (1841) was, however, not able to recognise the importance of in-house R&D in industry, multinational corporations, multiple production points throughout the world and establishment of R&D facilities outside their base (Freeman, 1995, p. 8).

National systems of innovation is treated as a potential system to study the underlying reasons for the widening gap in economic development between advanced and catching up countries by many economists and policy makers. Furthermore, this system is viewed as a strong conceptual framework to bridge that gap and develop policies (OECD, 1997, 2002; Feinson, 2003; Godin, 2008; Li, 2009; Makkonen, 2014).

Analysis of the national systems of innovation framework has the purpose of understanding the overall configuration of the systems of innovation, notably regarding the reallocation of financial support to R&D, incentives for collaboration among firms and between public and private institutions and the reduction of regulatory obstacles that make mobility of human resources difficult (OECD, 1992, p. 18).

Lundvall (1992) and Nelson (1993) each employ different approaches to national systems of innovation (Edquist, 1997, p. 4). While Lundvall (1992) takes a more theoretically oriented approach and finds a way to develop an alternative to the neoclassical economics tradition emphasising the interactive learning, user-producer interaction and innovation in his book '*National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*', Nelson (1993) heavily uses empirical case studies rather than theory in his book '*National Systems of Innovation: A comparative Study*' (Edquist, 1997, p. 4).

Furthermore, comparing Lundvall (1992) and Nelson (1993), Schrempf *et al.* (2013, p. 6) noted that Nelson (1993) pays attention to the way actors set up and how and why they collaborate whilst keeping a deep interest in the workings of institutions in the science and technology sector, especially universities carrying out R&D. Lundvall (1992), however, stresses the role of interaction in production and the dissemination of new and valuable knowledge, moving more towards a broader view of the national institutional environment from a sectoral view.

Embracing the views of Nelson and Lundvall, Edquist (1997, p. 14) proposed a more general definition of national systems of innovation that is *"all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovations"*. He argues that it might be dangerous to exclude some potential determinants since these might prove to be very important once the current state advances.

Thus, it is impossible to understand national systems of innovation by focusing on the activities of any of its components in isolation, as the systemic interaction of organisations including market, price and other non-price mechanisms, and differences across nations make up the innovation and economic performance of countries and regions (Lundvall, 2002; Simmie, 2004).

The national systems of innovation approach, therefore, provides a theoretical and empirical framework that is more comprehensive than the traditional neoclassical approach, including in the policy field, where it goes beyond market failure approach and provides more opportunities for policy intervention. This approach is arguably more democratic than the traditional approach as policy makers cannot design the system top-down because policies are part of the complex and interactive system (Schrempf *et al.*, 2013, p. 9).

3.2.2 Are the Regions Across the Nation Equally Developed?

According to Cozzens and Kaplinsky (2009, p. 77), innovation and inequality co-evolved as innovation reflects and reinforces inequalities. Through the comparative analysis of the relationship between the NSI of the states and BRICS[9], Scerri and Lastres (2010, p. 2-3) identified that the mutual self-reinforcing mechanisms between innovation and inequality can be sourced from entrenching and deepening structural inequality of incomes, wealth and the life chances of different sections of populations. This becomes the path dependent vicious circle of innovation widening inequality especially in the type and spread of human capabilities and learning capacities.

Path dependency according to Nelson and Winter (1977) is the concept used to explain the reason why technological change displays high regularities and develops within particular boundaries. Although path dependency is considered as an important key to economic growth, it is always accompanied by the inefficient lock in risk (Grabher, 1993; Schienstock, 2011). Scerri and Lastres (2010, p. 2) argue that inevitable state intervention is required to break this path dependency.

[9] Brazil, Russia, India, China, and South Africa

The same view of post-Keynesian economists is shared by many including Myrdal (1957) who argues that growth is a spatially cumulative process and regional inequalities tend to be widened because of this. Looking at different nations, the national systems of innovation approach is not homogeneous and, therefore, innovation activity is highly uneven amongst nations in specialisation and also in its intensity (Howell, 1999). This contradicts the idea of neoclassical economists who thought disparities among nations and regions would be reduced with growth due to the diminishing returns to capital based on the work of Solow (1956).

When regions face short or long term economic adversity, some regions are able to recover from it while others fail. In this regard, Christopherson, Michie and Tyler (2010, p. 3) identified the importance of 'regional resilience'. They argue that for a region to be resilient it has to be able to keep economic success for the long term facing the inevitable adaptation due to changes in international competition and consumer demand as well as other similar shocks to the system.

According to Christopherson, Michie and Tyler (2010, p. 9) we should not presume the same drivers of change are at work everywhere and the appropriate drivers will react and produce outcomes that are required. Although different factors influencing a region to adapt and adjust carry relevant importance across regions and over time, *"a strong regional systems of innovation, strength in factors that create a 'learning region', a modern productive infrastructure, a skilled innovative entrepreneurial workforce, a supportive financial system providing patient capital and a diversified economic base, not over-reliant on a single industry* (Christopherson, Michie and Tyler, 2010, p. 6-7)*"* have been the kind of factors helpful in the past.

Scholars who have found that key systems of innovation are more sub-national than national (de la Mothe and Paquet, 1998; Cooke, 2005; Sanz-Menendez and Cruz-Castro, 2005) stress the stickiness of knowledge, the importance of face-to-face communication in its transmission and that differences across nations and regions are likely to persist across time and space in a path-dependent way. Industrial structure, inter firm relationships, R&D intensity and the link between industry, the science base, and innovation activities are the contributing factors for this (Michie and Oughton, 2001, p. 167).

Driver and Oughton (2008), therefore, emphasised that while macroeconomic influences are similar across regions, the way innovation responds to firms' capabilities in terms of prior investment in innovation and training are different across regions. Accordingly, differences in growth rates tend to persist over time partly because of cumulative causation.

3.3 REGIONAL SYSTEMS OF INNOVATION (RSI)

While the systems of innovation approach emerged in the 1980s, the re-discovered concept of industrial districts were used in explaining the success of post-Fordist regions (Asheim *et al.*, 2015, p. 3) such as Baden-Wurttemerg (Cooke and Morgan, 1994), Emilia-Romagna (Piore and Sabel, 1984) and Silicon Valley (Saxenian, 1994), distinguished by flexible production systems that identified external economies of scale (Pyke *et al.*, 1990; Asheim, 2000; Asheim *et al.*, 2015).

The regional systems of innovation approach inspired by successful cases of regions with strong endogenous development potential, inter-regional networks not only made it possible to understand the uneven geography of innovation but also made the application to various macroeconomic contexts possible (Park, 2001, p. 32). Main elements and actors of systems of innovation, such as R&D activities, public support and education and training systems, are different across nations and across regions within a nation as well (Oughton *et al.*, 2002, p. 101).

3.3.1 Theoretical Explanations of Regional Disparities

Spatial economics and economic geography have been developed since the 19th century and have originated from different traditions, and from a variety of different analysts (Asheim *et al.*, 2015). Their work focused on the features of different types of agglomeration economies, and their analysis was undertaken within the traditional analytical framework of agglomeration phenomena, which had emerged as a fusion of the insights of Marshall (1890) and Hoover (1948).

In fact, this contemporary discussion goes back to Adam Smith in the 18th century. Adam Smith's main concern in '*The Wealth of Nations*' (1776) was to explain the different progress of wealth in different nations but he also included a long discussion of the rise and progress of cities and towns since the fall of the Roman Empire (Asheim *et al.*, 2015).

A region becomes distinctive as it evolves through time to an institutional repository of a certain negotiated, evolving, collective social order. This establishes, to some extent organisationally, the institutional routines, norms and values and based on this, actors may come to trust each other collectively (Cooke *et al.* 1997).

What then is a 'region'? Niosi (2010, p. 28) emphasises that any discussion of regional systems of innovation has to start from a definition of 'region'. Cooke (2001) proposed two definitions. A region is defined, first of all, as innovative networks that are geographically defined, administratively supported arrangement of innovation and they actively interact with regional firms' innovative outputs. The second definition of region by Cooke (2001) emphasises the cultural aspects of the region and does not need to have a determined size but is homogenous in specific criteria and there exists some kind of internal cohesion. Thus, the meaning of region, as a cultural entity, is explained better by the embeddedness that highlights the regional systemic interconnectedness and interdependency (Parto and Doloreux, 2004).

In the RSI approach, the importance of geographic proximity for knowledge transfer makes the regional perspective on systems of innovation legitimate (Asheim *et al.*, 2015, p. 9) and makes geography important (Granovetter, 1985, p. 504) since there is spatial bias of social networks that facilitate knowledge circulation.

The importance of collaboration in innovation of firms is further emphasised by Todtling and Trippl (2005). Focusing on the kinds of linkages and networks, and the extension of knowledge spillovers, well performing regions have been studied in terms of *milieu* (Camagni, 1991), knowledge spillovers (Audretsch and Feldman, 1996), and clusters and knowledge based industries (Cooke, 2002).

These studies have been the foundation on which a new policy model that emphasises knowledge based industries, building research excellence, high tech, stimulation of spin offs and attraction of global firms has emerged. The knowledge economy (Nonaka and Takeuchi, 1995), location, proximity and knowledge spillovers (Audretsch and Feldman, 1996) and the cluster approach (Porter, 1998) are some of the concepts that underlay this.

As Edquist (1997, p. 20-21) argued, innovation should be an evolutionary, interactive, non-linear process involving cooperation among actors. Regional systems of innovation have links to national and international actors and, therefore, regions can gain access to knowledge and technologies through external links (Camagni, 1991; Todtling and Trippl (2005).

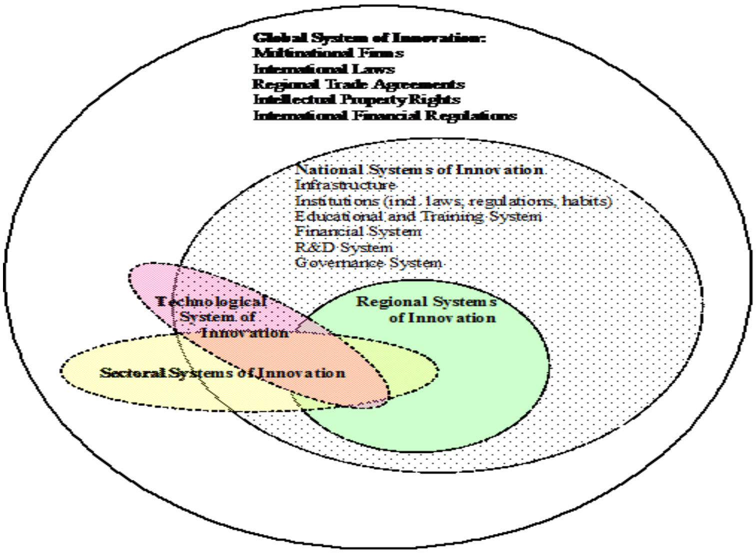
It is important to understand that different innovation activities influence competitiveness in each region which means that not all regions can benefit from the same policy measures. Consequently, different innovation policies need to be designed and applied. Todtling and Trippl (2005, p. 7) point out that the regional systems of innovation approach provides a useful framework for policy design.

Considering the aforementioned aspects, Cooke (1998) explains that RSI is a system in which firms and other organisations such as research institutes, universities, innovation support agencies, chambers of commerce, banks and government departments are systematically engaged in interactive learning through an institutional milieu characterised by embeddedness. According to Asheim *et al.* (2015) geographic proximity for knowledge exchange and role of a region is important, and interactive learning can serve as the rationale in applying a systems perspective at the regional level.

The aim of the RIS, therefore, is to integrate traditional, context-linked, regional knowledge and codified, world-wide available knowledge in order to stimulate regional endogenous potential. Thus, the RSI can be thought of as the institutional infrastructure supporting innovation within the productive structure of a region (Cooke *et al.*, 1998, p. 1581).

As Figure 3.1 below demonstrates, regional systems are interconnected with national, sectoral and technological systems and they may complement each other (Frenz and Oughton, 2005, p. 33). For example, regional policy for science, technology and innovation would be impossible without a national approach to innovation. Due to a number of reasons, such as historical accumulation of human capital in specific regions and deficiencies elsewhere, however, national policies may only benefit some cities, metropolitan areas, or provinces (Niosi, 2010, p. 37).

Figure 3.1 Coexistence of Different Systems of innovation



(Frenz and Oughton, 2005, p. 33)

The importance of the regional context of innovation flows from Marshall's work on industrial districts (Becattini, 1990; Brusco, 1990), and later work on clusters (Porter, 1990; Baptista and Swann, 1998; Maskell, 2001), innovative *milieu* (Camagni, 1991; Maillat, 1998; Crevoisier, 2004), Regional systems of innovation (Cooke, 1992; Braczyk *et al.*, 1998; Asheim and Isaksen, 2002), learning regions (Asheim, 1996), and the Triple Helix model (Etzkowitz and Leydesdorff, 1995).

There are discussions if the innovativeness of regions is favoured by Marshall's specialisation or by Jacob's diversification (Van der Panne and van Beers, 2006, p. 2). Jacobs' diversification (1969) is based on the idea that it is better if the regional structure is more diversified because new ideas and knowledge spillovers are triggered by diversity providing valuable resources required for innovation. The idea of Marshall's specialisation (Asheim *et a*l. 2011a, p. 3), however, is that when a region has production structures that are geared to a particular industry, the region has a tendency to be more innovative in that particular industry as it enables knowledge to be spilled over among similar firms.

Marshall, together with many other economists, also emphasised the external economies that are created from having many firms in the same industry locating in the same industrial district as an important factor for various industries (Freeman, 2002, p. 196). According to Oughton and Whittam (1997, p. 3), collective external economies are realised through cooperation, not competition, and these are external to the firm but internal to the network. They further argue that the successfully realised collective external economies reduce entry barriers and increase the chance of survival of participating firms, which create market structures characterised by a larger number of small firms (Oughton and Whittam, 1997, p. 6).

Thus, factors causing large differences in innovation across regions within a nation are as follows: external economies, R&D (Government and Business), R&D spillovers, pools of skilled labour, agglomeration economies, collective external economies (pooling fixed costs, trust/cooperation), local socio-cultural institutional context and clusters (Asheim, 2007).

3.4 SECTORAL SYSTEMS OF INNOVATION (SIS)

The earlier sections dealt with systems of innovation approach that have spatial dimensions as their boundaries. The other variant of systems of innovation approach is the sectoral systems of innovation and this uses a technology, or the sector where this technology is used, as the system boundary.

It was Pavitt (1984) who used the notion that particular sectors have different technological trajectories. Schrempf *et al.* (2012, p. 16) explain that although Malerba (2002) developed the concept of sectoral systems of innovation further, the technological approach to systems of innovation goes back to Carlsson and Stankiewicz (1991).

It is not difficult to witness success and failure within the same sector depending on the technological characteristics of products with one product family doing well while others are not. These differences can be analysed using sectoral systems of innovation. The concept of sectoral systems of innovation draws its elements mainly from the evolutionary and systems of innovation literature and includes some elements of traditional industrial organisation analysis (Marlerba, 2002, p. 250). Learning, knowledge, competences and transformation are the key concepts that play a central role in evolutionary literature, and relationships and networks are the central elements of innovative and production process in the innovation literature (Malerba, 2002, p. 251).

A sector is defined by Marlerba (2002, p. 250) as a set of activities that unify some linked product groups for a given or emerging demand and that share common knowledge. The set of heterogeneous agents conducting market and non-market interactions compose a sectoral system of innovation and these agents are individuals and organisations that can be firms or non-firm organisations (i.e. government agencies, non-firm financial institutions, universities, and so on).

There are market and non-market interactions between, and institutions such as rules and regulations influence these interactions (i.e. competition, cooperation, communication). A sectoral system changes and transforms over time through co-evolutionary processes of its various elements and the building blocks of a sectoral system are knowledge and technology, actors and networks, and institutions (Marlerba, 2004). These building blocks are expected to interact in order to generate variety through selection and co-evolution.

A specific knowledge base, technologies and inputs characterise sectors. The boundaries of sectoral systems are defined mainly by links and complementarities among artifacts and activities, and these links and complementarities are the main sources to transform and grow sectoral systems (Malerba, 2004).

Malerba (2002, p. 252) points out that this broad definition of the sectoral systems of innovation may have different levels of disaggregation depending on whether it is broad (i.e. high tech or low tech) or narrow level (i.e. computer software), and this leads to the problem of deciding unit of analysis when we consider the actors of a sectoral system.

Although sectoral systems of innovation are useful in analysing a sector systematically through analysis of the linkages and interactions among different actors, Schrempf *et al.* (2012, p. 16) criticised the approach on the grounds that the boundaries of a sectoral systems of innovation are based on existing products and, therefore, problems can occur when new products appear. Compared to NSI and RSI approach SSI is weakly developed with a smaller overall impact.

National institutions can affect the sectors differently and a positive regulation in one sector can hamper another. Moreover, institutions in the sectoral systems of innovation approach lack the evolutionary nature of systems perspective, especially when it is compared to the spatial systems of innovation approach. The criticism of the concept of sectoral systems of innovation springs from its apparent inability to explain the appearance of new technologies and incremental changes (Schrempf *et al.*, 2012, p. 19).

3.5 TRIPLE HELIX MODEL

The Triple Helix model of innovation was proposed by Etzkowitz and Leydesdorff (1995). University, industry, and government relations are analysed in terms of three interlocking dynamics: institutional transformations; evolutionary mechanisms; and the new position of the university. The Triple Helix treats the three spheres, university, industry, and government, as having equal importance in a country's innovation network.

The importance of the triple helix model that highlights collaboration among university, industry, and government as the centre of knowledge production and innovation is increasingly acknowledged by both scholars and policy (Etzkowitz and Leydesdorff, 2000; Todorovska and Stankovic, 2012).

Rickards (1985) argues that the basic characteristic of the Triple Helix innovation model is to bring together different perspectives and actors and to benefit from their interactions in order to provide understanding of the innovative process and its key determinants. The Triple Helix model does not assume geographically delineated systems as National or Regional systems of innovation do and it provides underlying structure and dynamics to the various levels of systems of innovation (Leydesdorff and Zawdie, 2010, p. 2).

Using the Triple Helix model, we can learn the dynamic underpinnings of innovation by focusing on interacting institutional spheres in the innovation process. The model also offers suggestions on a policy to make environments for further technological innovation and sustainable development in a national systems of innovation (Park and Leydesdorff, 2010).

Lundvall (1999), however, argues that this underlying model of innovation is analytically different from the national systems of innovation (NSI) approach since in NSI it is firms that are perceived as having the leading role in the innovation process.

There are three variants that Etzkowitz and Leydesdorff (1997) proposed that can form the evolution of systems of innovation when they collaborate. The Triple Helix I is a static model in which the government governs or directs universities and industry and the relationship between them. The Triple Helix II is a laissez faire model in which separate institutional borders and there are highly subscribed relations between government, industry and universities. The Triple Helix III is the interaction model that generates a new knowledge infrastructure through overlapping institutional spheres, and hybrid organisations appearing at the interfaces. Most countries and regions are trying to attain some form of Triple Helix III as a normative model or ideal for development (Todorovska and Stankovic, 2012, p. 6).

In order to understand the Triple Helix model from the viewpoint of a developing country it is necessary to analyse and grasp its implementation risks and pitfalls in developed countries (Todorovska and Stankovic, 2012, p. 8). Developing countries should take these lessons as public policy benchmarks in order to improve the existing Triple Helix innovation embryos (Dunning and Lundan, 2008).

3.6 GAPS IDENTIFIED

More advanced countries initially applied the first conscious national policies made to strengthen their systems of innovation, but the approach has been applied to catching up countries to inform strategies for the development of their economies (Ptak and Bagchi-Sen, 2011, p. 424).

Systems of innovation in catching up countries, however, open up specific issues around governance and business conditions, educational levels and infrastructure (Aubert, 2004; Freeman, 2004; Furman and Hayes, 2004). These countries tend to have less scientific research and development than advanced countries (Bernardes and Albuquerques, 2003; Arocena and Sutz, 2005; Goni and Moloney, 2017) and their economic structure may exhibit strong heterogeneity, low levels of initial complexity, and weak vertical integration. Moreover, in catching up countries, capital inflows that are an important requirement for innovation may be constrained by limited and volatile financial markets (Ernst, 2002).

Moreover, Fagerberg and Srholec (2008, p. 31) identified from recent empirical evidence that governance in advanced economies is often well organised while catching up economies tend to have complicated, overlapping governance and decision-making systems. They further explain that there is a strong correlation between economic growth and national management of the NSI, how open the economy is, and the quality of governance in general.

Thus, although there is considerable theoretical and practical experience accumulated in the innovation policy and management area in developed countries, the majority of them do not apply to developing countries due to the challenges facing these countries as mentioned above. Moreover, inappropriate business and governance infrastructure and insufficient education contribute as a stem for these challenges. Aubert (2005, p. 22-28), therefore, suggests that developing countries fall into a vicious cycle of systemic impediments to creating sustainable systems of innovation.

With increasing internationalisation, though, the disadvantages of catching up economies can be offset by advantages these economies have (Intarakumnerd *et al.*, 2002, p. 1454).

Investment from advanced economies can be attracted by lower resource costs including labour, and the speed to catch up can be high because the technology they adopt from advanced economies can be purchased at lower cost and leapfrogged. Catching up economies can also take advantage of increasingly international knowledge flows and they can extract and build on this knowledge. Huge R&D costs can be reduced through technology transfer to catching up economies through moving product, process, and service from advanced economies (Ptak and Bagchi-Sen, 2011, p. 424).

These views, however, have been contradicted by Chang (2002, p. 1) who argues that the catching up countries had experienced great pressure from advanced countries and international institutions[10] to employ so called 'good policies'[11] and 'good institutions'[12] that they control. Moreover, Chang (2002 p. 1) claims that today's advanced countries did not develop based on those policies and institutions they recommend, or even force on catching up countries themselves. Rather, they protected their tariff and used subsidies to develop their industries without even having such 'basic'[13] institutions.

Asheim and Gertler (2004, p. 291) argue the RSI is not sufficient on its own to stay competitive within a globalising economy. Understanding regional systems of innovation requires consideration of failures as well as successes. Development of a more comprehensive approach for the system, therefore, requires localised learning as much as non-localised learning that relates to the accumulation of knowledge that hold the competitiveness of regions as well as the globalisation of firms (Parto and Doloreux, 2004, p. 7).

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[10] The institutions include International Monetary Fund, the World Bank, the World Trade Organisation
[11] Especially free trade
[12] Strong patent law is a good example
[13] Chang (2002) lists the democracy, central banks, patent law, or professional civil services as examples of such institutions

3.7 A REVIEW OF THE LITERATURE
- INDUSTRIAL AND INNOVATION POLICIES IN KOREA

Neoliberalism emphasises the limited role of the state in economic development and during the transition peiord to a market economy from a centrally planned socialist economy. The state needs only to maintain macroeconomic stability and let prices to be set in competitive markets freely.

According to Chang and Rowthorn (1995), however, the state's role as an agent of economic change is important, arguing that the state needs to act as an enterpreneure and conflict manager simultaneously during a time of major change. In order for a state to perform industrial policy, there should be an organisation such as large private or quasi-private organisations alongside the state bureaucracy that can implement the state's entrepreneurial vision (Chang and Rowthorn, 1995). Effective achievement of the developmental objective by the organisations is dependent on the interaction of the state with them.

Furthermore, in an economy that is developing or in transit, the values of assets belonging to different members of the society are affected and this consequently makes winners and losers. Chang and Rowthorn (1995), therefore emphasise the importance of the state role as conflict manager to manage this situation smoothly and further facilitate changes in structure required for rapid economic growth.

Based on the valuable arguments by Chang and Rowthon above, this section will examine whether Korea was able to play this role during the development of the Korean economy.

Research and Development

During Korea's industrialisation phase in the 1960s, the focus of science and technology policy was on establishing basic technological infrastructure, including the Korea Institute of Science and Technology (KIST) and Korea Advanced Institute of Science (KAIS) (OECD, 1996). Korean science and technology policy then focused on building Government Supported Research Institutes (GRIs) for the field of heavy and chemical industries expanding the research and education in that field too during the 1960s.

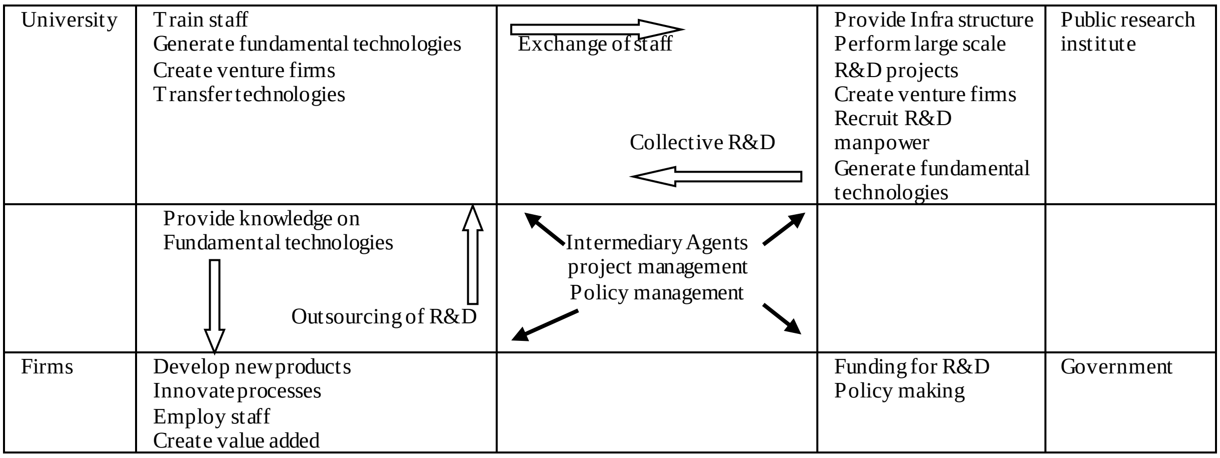
GRIs were set up as special non-governmental corporations that have high levels of managerial autonomy to strengthen the weak technology in private industries and assist them with adapting new technologies. Additional GRIs were created in 1970s as follows: Korea Research Institute for Chemical Technology, Korea Institute of Machineries and Metals, Korea Research Institute of Standard Science, Korea Research Institute of Shipbuilding and Oceans, Systems Engineering Research Institute, and Electronic Technology Research Institute (Watkins and Ehst, 2008, p. 114-115). Another GRI, the Korea Aerospace Research Institute, was set up in the 1980s.

GRIs assisted firms to learn how to use technologies from advanced countries until the 1980s and then focused on helping firms developing globally cutting edge technologies from the late 1980s. The problem GRIs then faced was a lack of understanding of the actual needs of local firms and this made the local firms favour the type of turnkey foreign plants and licences from foreign firms that were more experienced (Watkins and Ehst, 2008, p. 116)

The national systems of innovation evolved alongside industrial development in the 1980s and in 1982 the National R&D programme was launched to develop public and welfare technologies together with the industrial generic technology development programme (Chung and Suh, 2007, p. 139). The National R&D programme was launched also to provide financial and technical assistance to private firms for them to challenge and develop risky technologies. Since the 1980s, national systems of innovation changed significantly as private firms dramatically increased investment in in-house R&D and this is when the major role in R&D and innovation moved from the government to private firms. In the 1990s, further industrial restructuring took place in Korea and small and medium-sized firms started to carry out more R&D activities (Park, 2001, p. 33).

Within the National Systems of innovation, universities play three main roles: education and training; production and accumulation of knowledge; and promoting the utilisation of knowledge acquired by R&D (Lee and Seong, 2009). Lee (2014, p. 4) argues that while in developing economies the main focus is on building human capital via scientific and technological education and training, in the advanced economies the main focus is on research and development.

Figure 3.2 Collaboration between Universities and Firm under NSI in Korea



(adapted from Lee and Seong, 2009)

Table 3.2 shows that total expenditure on R&D has been increasing continuously over the past ten years or so. In 2011, universities accounted for 10.1% of total R&D, GRIs account for 10.3%, while private firms account for the largest share of R&D activity with 75.3%.

Table 3.2 National R&D Expenditure and Percentage Shares of R&D Agents in Korea

(Unit: billion Korean Won, %)

Name of Agents	2000	2003	2005	2010	2011	AGR[14]
Total R&D expenditure	13,848	19,068	24,155	43,855	49,890	12.4
- Public R&D institutes (PRIs)	14.7	13.8	13.2	14.4	13.4	11.4
- GRIs	10.7	10.3	10.0	11.1	10.3	12.0
- Universities	11.3	10.1	9.9	10.8	10.1	11.2
- National universities	4.0	4.1	3.9	4.5	4.1	12.7
- Firms	74.0	76.1	76.8	74.8	76.5	12.2
- Private firms	70.7	73.0	75.0	73.5	75.3	13.0

(reproduced from Lee, 2014, p. 8, the data from www.kistep.re.kr)

Table 3.3 shows the proportion of patent production arising from government R&D expenditure by R&D agents (PRIs, Universities, firms). It can be seen that universities were producing the same share of patents from government R&D as large firms in 2006 but increased their share to exceed that of large firms in 2008 and 2010.

[14] Percentage of average annual expenditure growth in R&D during 2000-2011

Table 3.3 Percentage of Patent Production from Government R&D Expenditure by R&D Agents in Korea

	2006	2008	2010
University	1.1	2.2	1.9
Public Research Institutes	0.9	0.9	1
Small and Medium Firms	0.8	1.6	1.5
Large Firms	1.1	1.2	1.3
Average	0.9	1.3	1.3

(adapted from Lee, 2014, p. 8, the data from www.kistep.re.kr)

Sohn and Kenney (2006, p. 996) consider that there is weak cooperation between industry and universities because firms in Korea believe that inventive activities should be performed internally.

A factor underlying collaboration between firms and universities is firms' need of university assistance in R&D activities. However, firms in Korea question the marketability of the inventions of universities while universities perceive that industrial research is not challenging or creative. Sung *et al.* (2009) identified the sources that firms use for their technological innovation in order of importance from customers (35%), to competitors (20%), machinery suppliers (14.2%), part suppliers (13.9%), universities (12.3%) and so on. Lee (2014, p. 9) argues that universities are not considered to be an important source of innovation but they gradually become a more important source of technological innovation as the economy becomes more knowledge intensive.

Korean policy makers indeed thought it desirable for universities and industries to have a close relationship, and government funded universities set up R&D centres towards the end of the 1980s.[15] The centres supported university and industry cooperation by providing contract R&D, training technicians sent from private firms, and technology consultation for regional industries (Sohn and Kenney, 2006, p. 996).

The Special Entrepreneurship Act was reformed in 1998, and high technology entrepreneurship through technology transfer from university to industry was fostered. Sohn and Kenney (2006, p. 997) argue that after this, Korean industry became more willing to cooperate with universities as it was difficult for the internal R&D departments to keep up with the fast changing technological evolution and also the importance of scientific knowledge grew dramatically. The systemic strength of Korea is the fact that

[15] Science Research Centres, Regional Research Centres, Engineering Research Centres

the universities produced a large pool of talented trained scientists and engineers together with the fact that there were informal routes of information flow among institutions and industries.

According to the report by KOTRA (2007), the benefit to innovation oriented investment projects from policy support was made possible by including R&D projects in the policy target. Such policy support includes tax incentives to reduce tax burdens, financial incentives to facilitate access to innovation funds for new investment projects, other indirect market incentives to facilitate access to innovation funds for new investment projects and other indirect market incentives that aim to indirectly improve the profitability of businesses (Giroud *et al.,* 2012, p. 6).

In general, governments like to promote and attract R&D activities within their national boundaries and a nation's capacity for innovation is the result of combined individual firms' capabilities as well as linkages amongst those firms (Lundvall, 1992, p. 4). Cantwell and Mudambi (2000) identified that long-term measures under the umbrella of a country's national systems of innovation are likely to yield higher returns than short-term incentive measures aimed at attracting R&D activities.

In a developing-country context, the transition to new economic and social forms will be expected to be partial, uneven, and incomplete (Todorovska and Stankovic, 2012, p. 3). It is, therefore, necessary to create awareness among innovation actors to work in a systemic manner because innovation does not occur in isolation and the benefits arising out of successful innovation have profound effects beyond their origins. The history of the development of R&D in Korea can be summarised in Table 3.4:

Table 3.4 History of National R&D in Korea

	History
1960's/1970's	- High dependency of R&D activities on imitation and importation of technologies from the advanced countries in an effort move on to industrialized economy from agricultural based economy
1980's	- Introduction of a systematic national R&D funding system - catalyze industrial restructuring through domestic innovation - Initiation of the National R&D program in 1982 by the Ministry of Science and Technology – Enable the nation to meet socio economic needs in a knowledge based society

1990's	- Review and evaluation of ongoing R&D programmes – government assist for the limited resources to be more efficiently used - Expansion of public R&D – induce private firms' investment in R&D and encourage collective R&D among industries and universities and government sponsored research institutes - Government and industries funded a large scale R&D project, the HAN[16] Project, in 1992
21st century	- Emphasis on cutting edge technologies i.e. biotechnology, nanotechnology, aeronautics and also on conventional industrial technologies i.e. textile, shipbuilding - Importance on establishing a creative R&D atmosphere, transparent R&D management systems - Follow up project of the HAN, the 21st Century Frontier R&D Programme adapted new management systems - Other important national projects include The Creative Research Initiative, The National Research Laboratory, Biotechnology Development Programmes, and Space and Aeronautics Programme

(Rearranged using the report by the Ministry of Science and Technology, 2003)

The Korea Institute of Science and Technology (KIST) was established in Seoul in 1966 with the expectation of providing the foundation for a high technology industrial cluster - Daeduk science town. In 1973 the KIST was transferred to Daeduk from Seoul.

Since 1990, with the increasing number of firms and universities that carry out research and development, the effectiveness of Government sponsored Research institutes in industrial technology development was questioned by a number of policy makers and scholars (Yim, 2006, p. 3). Kim *et al.* (1999, p. 281) suggested that these criticisms arose because many research projects were overlapping, there was poor quality of R&D project management and a low level of the productivity of research and development. Yim (2006, p. 13) argued that these problems occurred because the related government authorities and managers in the top level in the government-sponsored research institutes did not agree on their institutional missions. Moreover, the government monitored and controlled the projects rather excessively while their finance support was not stable.

As remedial action, the government shifted the research funding system from lump sum funding to a project based system for research funding in 1996. Although the system provided positive aspects such as benefitting more creative researchers, there were also some drawbacks. The first one meant government sponsored research institutes had to change their research focus to application oriented projects from basic research in order

[16] The Highly Advanced National Project

to obtain more contracts and secure the labour costs. Moreover, because the budget the institutes received from government was limited, the research institutes could not afford to employ permanent and experienced researchers (Yim, 2006, p. 13).

Korea relied on foreign technology imports due to the lack of technological ability at the outset of its economic development (Kim, 1993, p. 262). The country promoted its independence from multinationals in management control and had a low proportion of direct foreign investment and foreign licensing while encouraging technology transfer through the procurement of turnkey plants in the early years together with imported capital goods. Korean firms were then quick to assimilate imported technologies and were able to expand and upgrade with little assistance from foreign firms. This enabled Korea to be independent of foreign multinationals and to be effective in obtaining technological capabilities in mature industries.

After the Asian financial crisis in 1997, the government changed the management system of government sponsored research institutes to a research council system hoping to improve effectiveness of research and also to operate the institutes efficiently. The government sponsored research institutes became more independent of the relevant ministries' (excessive) control. In 1999, five new research councils were created under *the Act on the Establishment, Operation and Fostering of the Government-Funded Research Institutions:* Korea Research Council of Fundamental Science and Technology (KRCF); Korea Research Council for Industrial Science and Technology (IstK); Korea Research Council for Public Science and Technology (KORP); Korea Council of Economic and Social Research Institutes and Korea Council of Humanities and Social Research Institutes (Yim, 2006, p. 14).

The research councils are overseen by the Prime Minister's office but have autonomy in operation, management and decision making. This system enabled stronger leadership by the directors of the councils, creating an atmosphere of competition among government sponsored institutes, universities and industries as a performance based system was in place. However, arguably the competitive environment created too much competition and the number of researchers who were unsatisfied with their job became high, as did labour turnover. Moreover, in this new system, there was too much government interference with the Board of Directors of the councils, and the councils had little power in budget allocation that did not have clear criteria in allocation (Yu *et al.*, 2002)

From 2003 President Roh Moo-hyun's administration pursued a balanced national development policy and the Ministry of Science and Technology sought to create a more balanced systems of innovation that promoted collaboration among industries, universities and public research organisations. The Roh government established a five year comprehensive regional science and technology promotion plan comprising of development of local competences in strategic technologies, creation of regional centres for technological innovation, development of local science and technology human resources, establishment of regional science and technology information systems, nurturing a culture conducive to science and technology innovation and increasing R&D investments of local governments (OECD, 2012, p. 93).

In 2004, the Ministry of Science and Technology (MOST) took charge of the supervision, from the Prime Minister's office, of the three research councils in science and technology while the other two research councils were merged to form the National Research Council for Economics, Humanities and Social Sciences (NRCS) in 2005. KRCF was moved to the Ministry of Education, Science and Technology and the IstK was moved to the Ministry of Knowledge Economy while KORP was dissolved in 2008. These two councils, KRCF and IstK, were transferred to the Ministry of Science, ICT and Future Planning in 2013 when President Park Geun-hye's administration inaugurated. They subsequently merged and became the National Research Council of Science and Technology (NST) (NST, 2014, p. 1).

Fifteen years after the introduction of research councils, they are settled in two councils, NRCS and NST that are supporting 23 and 25 research institutes respectively and they are supervised by the Prime Minister's Office and the Ministry of Science, ICT and Future Planning (NST, 2014, p. 1).

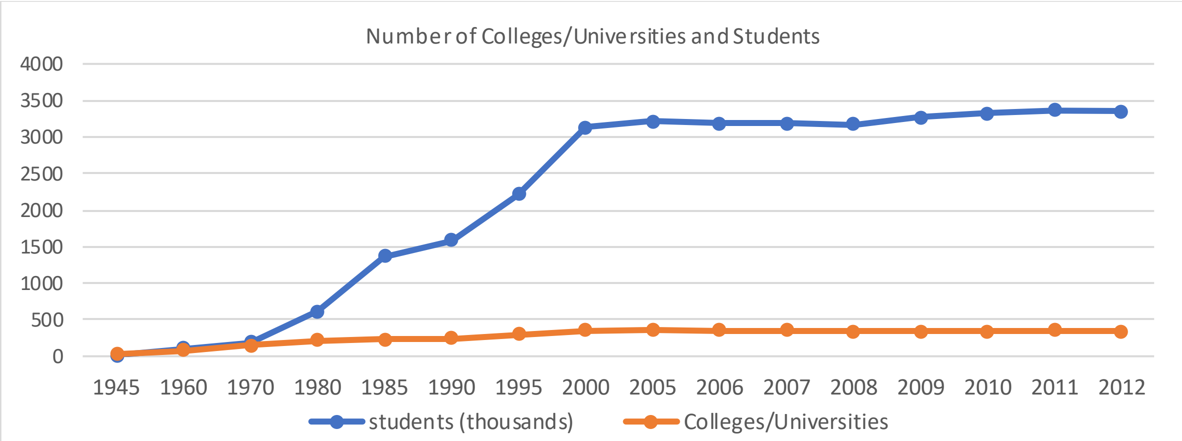
Human Capital

The acquisition of technological ability served as the foundation in forming the human resources in Korea. The proportion of the Korean government's investment in education rose dramatically from 2.5 percent in 1951 to 22 percent in the 1980s. There are other developing countries that show rapid growth in education but Korea is distinctive in that the timing of the expansion of the education sector at all levels was sufficiently early to support economic development.

Even with the low per capita income, educated human resources became a solid foundation for the subsequent adaptation of technology and development of original technology that were imported (Kim, 1993).

The number of colleges and universities and their students dramatically increased, however, as Figure 3.3 illustrates, despite an increase from 81 colleges and universities with 108,000 students in 1960 to 235 universities with 1,366,000 students in 1985, and to 345 universities with 3,319,000 students in 2012, the quality of education and research environment deteriorated. Korea failed to produce sufficient highly trained scientists and engineers needed to be sustainable on the world stage (Kim, 1993).

Figure 3.3 Number of Colleges/Universities and Students



(Own creation using data from $KOSTAT_d$, 2017) [17]

[17]

	Students (thousands)	Colleges/Universities
1945	16	29
1960	108	81
1970	192	152
1980	611	214
1985	1,366	235
1990	1,581	241
1995	2,213	304
2000	3,130	349
2005	3,209	360
2006	3,186	352
2007	3,183	348
2008	3,174	344
2009	3,261	345
2010	3,319	345
2011	3,361	349
2012	3,354	343

While the Korean government was able to form the human resources necessary for economic development, Kim (1993) argues that it made a mistake in underestimating the role of research. In higher educational institutions in developing the national system of industrial innovation, basic research is much ignored in universities and research institutes (Suh, 2000, p. 31).

Korea's economic catch-up relied on technology transfer, applied research and development, which is quicker and easier than basic research. Perhaps this was right at the start but Korea did not make a timely and smooth transition to bring basic research into the mix. By mentioning that RSI in advanced nations are operated around technology intensive universities, Chung (2002, p. 489) emphasises that for stronger systems of innovation in Korea the government needs to focus on facilitating universities for R&D activities especially.

Since changing the teaching-oriented old education system was difficult, the government introduced a dual system so that all universities under the Ministry of Education remained teaching oriented and the Ministry of Science and Technology established research oriented science and technology schools in order to establish a new research tradition in university education.

As Christopherson, Michie and Tyler (2010, p. 7) argue, a skilled workforce enables a region to be a learning region and therefore contributes to be a part of a successful regional systems of innovation. Thus, the role of higher education in the economic development in the regional and national level has always been recognised as important but interest in this has hugely increased (Schofer *et al.*, 2000; Schwartzman, 2008; OECD, 2008; Pillay, 2010 & 2011; Pinheiro, 2012). Furthermore, the role of higher education has become wider including technological invention, knowledge spillovers, and innovation (Pinheiro & Pillay, 2016, p. 162). In the past, higher education did not receive much attention in terms of economic development for a long time (Psacharopoulos, 1985; Psacharopoulos & Woodhall, 1985) and often investments in higher education were considered as regressive according to the World Bank (1991).

From their research, Pinheiro and Pillay (2016, p. 151) noted that Korea, together with Finland, has the highest gross enrolment rates of higher education participation. This is supported by the data from Statistics Korea ($KOSTAT_d$, 2018) showing that the percentage of high school graduates going to third level education has increased from 9.5

% in the 1980s to 27.1% in 1990s and to 62% in 2000s. Between 1996 and 2016, Korea streangthened its research capacity and ranked 12th in output and 15th in citation in the world (SCImago).

According to their findings there is a strong and close relationship between economic development and education.

Between 1960 and 1980 when economic development was ongoing the Korean government linked education with economic development. The important government roles in regional and national level include mobilising knowledge capabilities so that innovation was produced and effective knowledge transfer by supporting universities was promoted (Huggins and Kitagawa, 2012, p. 2). This is in line with the argument by Florida (1999) that it is necessary for communities surrounding universities to be able to absorb and exploit university generated science, technology and innovation.

Thus, the higher education system in Korea is deliberately connected with the economic system although education is mainly private. The majority of universities in Korea are private and only a fifth of students are taken by state universities. Furthermore, there are technical colleges that offer two year diploma courses and the majority of them are private. Most of these colleges have close partnerships with local firms and the students from these colleges receive detailed and customised occupational training.

The Korean government emphasised the sciences and set up vocational schools which later became junior colleges (Lee, 2004, p. 157). Following the educational reforms in the mid-1990s, higher education institutions increased in numbers by 58% between 1990 and 2004, and student numbers also more than doubled during this period as did the number of academics. The government increased the education budget in order to place high importance on education. There has been a 29 fold increase in the government education budget, higher than GDP which increased 20 fold during the period between 1963 and 2005 (Data.worldbank.org$_b$).

Undoubtedly, education was an essential element in the fast economic growth in Korea for the past four decades (Lee *et al.,* 1994, p. 276). Korea produced large numbers of university graduate engineers to fulfil the early stages of industrialisation. More recently, the emergence of the information-based economy policy has shifted towards prioritising quality. The critical factor in obtaining top quality scientists and engineers, however, is developing an advanced education system.

In order to encourage universities to become more focused on research and development, the Korean government is providing the universities that have excellent research performance with additional funding. The government established two research-oriented universities, KAIST[18] in 1971 and GIST[19] in 1995, in order to produce world class engineers. The universities receive government preferential funding enabling them to attract the best students in the country. POSTECH[20] is the representative university of the same initiative in the private sector (Yim, 2006, p. 16).

The extraordinary feature of Educational development during the industrialisation of Korea was the speedy growth of high quality education at all levels (Lee, 2004; Park, 2013).

Higher education in Korea was, however, concentrated in large cities, especially the capital, Seoul. In 2003 the Korean government introduced a Regional Innovation Strategy in an effort to bring about balanced regional development (Lim, 2006, p. 2). The government funded project - *'the New University for Regional Innovation'* (NURI) – was introduced for local universities in order to tackle inequalities.

The aim of this project is to increase the employment rate for graduates of local universities, encouraging diversification and specialisation, and emphasising the necessity of local universities taking more important roles as regional innovation centres. The fundamental idea behind this project is to strengthen the relationships between local government, research institutions, and firms.

In terms of research and innovation, there have been weak relations between universities and industry in the past in Korea. The highest percentage, more than 70 percent, of R&D is carried out by firms, followed by research institutes and universities, 14 and 10 percent, respectively (Data.worldbank.org). Since firms are the main players of R&D in Korea, it is unlikely that universities will overtake the leading role provided by firm-based R&D

[18] Korean Advanced Institute of Science and Technology
[19] Gwangju Institute of Science and Technology
[20] Pohang University of Science and Technology

in the near future, especially in terms of non-basic research as firms currently focus on product and market development when carrying out R&D.

Realising that universities have to play an important role in basic research and training future researchers, the Korean government decided to promote a 'selection and concentration' strategy to use public R&D funds efficiently and to enhance Korea's competitiveness (Lee & Song, 2007, p. 57). Furthermore, in the age of the knowledge-based economy, policy makers recognise the need for cooperation between government research agencies, universities, and the private sector (Suh & Chen, 2007). For the purpose of promoting active cooperation between these three actors, the Korean government introduced a contract-based education system linking industry and academia, and school enterprise systems that make the research conducted applicable in the real world (Pinheiro & Pillay, 2016, p. 157-158).

The regional innovation committee, a regional governance system, consisting of the main stakeholders has been set up to link universities and industries in main cities and provinces. Although there was financial support from central and local government, collaboration among them was weak. Park and Leydesdorff (2010) identified that policy mechanisms had a negative impact on inter-institutional collaboration between universities and industry. They further identified that this is due to the fact that the new national science and technology research policies evaluated domestic scientists and research groups based on the number of international publications rather than the level of external cooperation with both private and public sector partners.

Pinheiro & Pillay (2016, p. 158-159) argue that the education system in Korea has not been able to produce either the necessary quantity nor quality of outputs for a knowledge-based economy which resulted in a high unemployment rate whilst employers complain that there are not enough well qualified middle level technicians. They argue that this is because private institutions dominate and there has been a weak planning system for human resources.

Korean government intervention in economic policy and education has brought rapid economic development in Korea. Pinheiro & Pillay (2016, p. 159), however, argue that higher education in Korea played little role in innovation and research and that although the quality of the higher education system in Korea is a serious issue, it did satisfy the demands of rapid industrialisation by providing a large amount of human capital.

In Chung (2006), Hesse[21] emphasised that revolutionary discoveries and the generation of innovation requires a culture of scientific freedom and trust. However, Chung (2006) argues that universities in Korea, where 72.6 per cent of research takes place through doctoral degrees, fail to provide this kind of culture since they are not in receipt of enough funds, the research facilities are poor and they are highly orientated towards teaching.

According to Sohn and Kenney (2009, p. 995), researchers in Korean universities played the role of consultants rather than funded researchers or co-investigators. Industry only demanded the ample supply of well-educated graduates from universities, not the production of knowledge that can be commercialised.

With the realisation of the fact that for a strong foundation of a nation's long-term development basic research is necessary, the Korean Science and Engineering Foundation and the Korea Research Foundation sponsor basic research. Universities that have prominent capabilities in research are appointed as centres of excellence that include Science Research centres, Engineering Research Centres and Regional Research Centres. Cooperative research between universities and industries in a region is promoted by Science Research Centres and Engineering Research Centres (Yim, 2006, p. 15).

In 1988 as an affiliate of Korea Science and Engineering Foundation, the Korea Basic Science Institute was established. It has headquarters in Daedeok and Ochang and 10 regional offices that are used to provide its distinctive research support throughout Korea (KBSI). Furthermore, the Korean government established the Korea Institute for Advanced Study in 1996 to endeavour to promote research excellence in basic science.

The institute that is designed to invest in theoretical basic sciences was the very first of its kind in Korea (KIAS). In order to facilitate basic research, Korea Basic Science Institute (KBSI) that maintains over 300 sets of research equipment for universities to use jointly was established in 1988 by the government. Furthermore, The Asia-Pacific Centre for Theoretical Physics was set up as a regional centre for basic research in 1997 (Yim, 2006, p. 15).

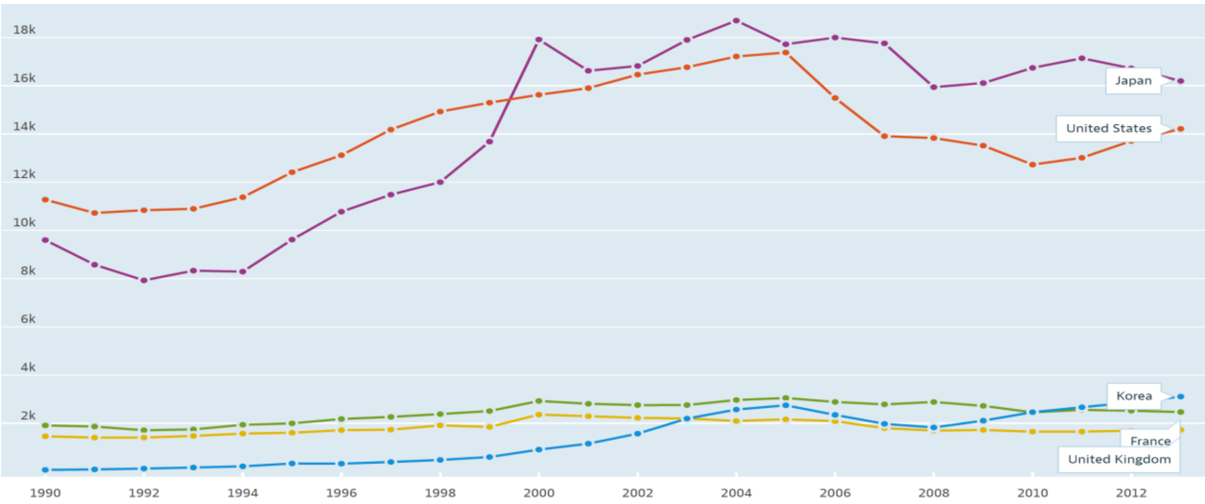
[21] The deputy secretary general of Germany's Alexander von Humboldt Foundation

Public Support

Korea's development was characterised by autonomous technological development and it has been based on international aid, export promotion, industrial development, national territory construction and encouragement of savings. In the 1980s, Korean firms emerged as major Original Equipment Manufacturers (OEM) following the reverse engineering phase in the 1960s and 1970s (Giroud *et al.*, 2012, p. 4).

Whilst Korean firms operated OEMs, they strived to develop their own design and brands which took them to the upgraded status of Original Design Manufacturers (ODMs) with their own technology, design and global brands (Giroud *et al.*, 2012, p. 4). As Figure 3.4 shows, the total number of patents reported in Korea exceeded that of the UK in mid-2002 and France in mid-2004. Furthermore, Korea was in the fourth highest position following Sweden, Finland and Japan in terms of domestic R&D expenditures as a percentage of GDP among OECD countries in 2007 (Lee and Rugman, 2009).

Figure 3.4 Number of Patents Reported: Korea and Other OECD Countries



(Source: OECD, 2016)

As Porter (1990, p. 685) has pointed out, Korea made changes in its institutional framework and introduced industrial, technology and regional policies in order to transform its economy from low technology, labour intensive, mass production types of industry, to high technology, capital and skill-intensive flexible specialisation types of industry. This transition shifts the emphasis from hierarchical control to decentralised governance. According to Hassink (1999, p. 136), the slow pace reformation resulted in the financial crisis in 1997 and this crisis made the decentralisation more favourable.

Government policy shifted from industrial policy towards technology policy and this increased R&D expenditure levels. As Table 3.5 shows, the proportion of total R&D expenditure in the private sector compared to government sector in Korea increased to 80 per cent versus 20 per cent in 1987, and from 32 per cent versus 68 per cent in 1971 (Kim, 1993, p. 370).

Table 3.5 The Proportion of Total R&D Expenditure in the Private Sector Compared to Government Sector in Korea

	1971	1976	1981	1987
R&D expenditures Government vs. Private	68:32	64:46	42:58	20:80

(adapted from Kim, 1993, p. 370)

During the 1970s and 80s the government changed its R&D policy to promote technology-based industries from mature industries and technological innovation, moving away from the assimilation of production technology was encouraged. When the private sector lackedthe ability to initiate local R&D efforts, or market incentives to do such activities, the government took the initiative. This trend however changed and the private sector played a larger role in R&D helping to maintain competitiveness in the world when the country lost its comparative advantage in the labour intensive industries (Kim, 1993, p. 367).

The tax incentives that the Korean government introduced is a major indirect way of producing funds for corporate R&D. Reduced tariffs on imports of R&D equipment and supplies, the deduction of annual non-capital R&D expenditures and human resource development costs from taxable income, accelerated depreciation on industrial R&D facilities and the exemption of real estate tax on R&D related properties (Kim, 1999, p. 208). The government also introduced the Technology Development reserve fund in 1973 that allows firms to use a maximum of 3 per cent of total sales of the current year within three years in all technology development related activities (Mani, 2002, p. 103-104).

The Korean government continued making an effort to strengthen Korea's basic research capability by establishing joint research institutes in state universities that are used by other universities and corporate R&D centres. Since the universities did not have high capability in R&D, public R&D institutes have been the backbone of advanced R&D in Korea (Kim, 1993; Shim and Byeon, 2015; Ryu *et al.,* 2016).

Even with the Korean government's increasing involvement in technology there are still weaknesses in the systems of innovation such as relatively weak research in universities, poor interplay between universities and the private sector, low numbers of technological spin offs, and weak diffusion mechanisms to transfer the results of research by public research establishments to industry, especially SMEs (Hassink, 2001, p. 1380).

Hassink (2001, p. 1380) argues authors judge the strength of Korean SME-oriented-innovation support differently. Part of the reason for the different judgements is that there is no sufficient or efficient systematic evaluation in place (Chung, 1999). Local and regional authorities should have stronger involvement (OECD, 1996; Park, 1998) and, Kim and Nugent (1999) and Park (1998) suggest SMEs should have a stronger voice within agencies that are mostly established by the central government.

In the 1980s the government introduced two funding schemes for private R&D: National R&D projects under the Ministry of Science and Technology on new technology focusing on future problems, and Industrial Base Technology Development Projects under the Ministry of Trade and Industry on existing technology focusing on current problems (Suh, 2000). Due to the financial crisis in 1997 and a subsequent decrease in R&D expenditure by firms, the Korean government has increased its public R&D budgets, encouraged the development of a technology-based SME sector, and implemented targeted measures (OECD, 2009, p. 9). These measures have been successful and have led to an increase in the number of corporate R&D labs, and additional support to SMEs (Giroud *et al.,* 2012, p. 5).

This phenomenon during the recovery period from the financial crisis can be explained by the dirigiste model by Cooke (1992, p. 369) where the institutional infrastructure and parts of industry are more functionally integrated into national systems of innovation. Organisations within this type of RSI conform more closely to the linear model.

Cooperation

The importance of interactive learning has been mentioned earlier and networking, therefore, has become an effective innovation technique. As has been much discussed, since firms seldom innovate on their own one of the critical elements is collective learning. Innovation and technology can be diffused better among firms through localisation and networks and this results in regional competitive advantages (Park, 2001, p. 36).

Government strategies used to encourage collective learning and innovation networks include removing legal and regulatory obstacles that prohibit the formation of cooperative networks, and offering incentives for collaborative research between universities and industry. In order to promote cooperation between public R&D institutes and industry, the government introduced various schemes in the 1980s with the purpose of involving universities in government projects. Although the schemes produced limited results, and some large firms walked away from receiving funds in order to keep their research confidential, some significant outputs were produced (Kim, 1993, p. 371).

Cooperation between universities and industries may be weak due to the fact that universities in Korea are teaching oriented and therefore cannot attract research funds from the private sector. Kim (1993, p. 371) argues that this is the biggest weakness of the Korean national industrial systems of innovation. In an effort to promote cooperation between the universities and industry, the government offered 255 national research programmes in 1984 but universities only took part in 6 of them. Thus, cooperation between university and industry for R&D has been relatively low.

Although the technology development promotion act of 1972 promotes cooperation between corporates, such cooperation responding to direct R&D subsidies offered by National Research Programmes took place only in 1982 (Kwong *et al.*, 2001, p. 203). By the middle of 1989, some 986 small and medium-sized firms were involved in forming 46 industrial research cooperatives. The government offered tax incentives for the purpose of R&D cooperation. National Research Programmes and Industrial Base Technology Development Programmes were used to invite R&D cooperatives to carry out joint research with public R&D institutes but lack of appropriate R&D facilities and researchers prevented the research cooperatives from taking advantages of the subsidies (Kim, 1993, p. 372 & 374).

Chung (2002, p. 489) points out that there are problems arising from weak interactions between innovation actors arguing the weakness is due to public research institutes not being distributed evenly across regions. He further emphasises the necessity of support from the central government in the formulation and implementation together with financing of RSI.

Access to Innovation Funds

Having access to financial resources determines whether a firm can carry out R&D activities. Schumpeter (1934, p. xxvii) argued entrepreneurs produce innovations using finance through bank credit rather than using savings or goods they currently have. According to a study by Hall (1992, p. 20), however, firms that are R&D intensive possess comparatively less debt than the firms that are less R&D intensive. The findings also found that R&D activities are hindered when a firm has financial constraints meaning that there is a positive relationship between cash flow and R&D investment.

Hall and Lerner (2010) reviewed the literature on the impact of R&D and the financial markets of different countries and identified that the theoretical foundations are the information asymmetry between entrepreneurs and inventors or the moral hazard issue caused by the division between the management and the ownership of firms. They explain that small firms tend to have more sensitivity to financial constraints compared to larger firms and suggest that small firm policies are required such as government funding, fiscal incentives on the start-ups and innovation development (Hall and Lerner, 2010, p. 23).

In the process of development of the Korean economy, however, there has been a strong intervention by government initially by focusing on industry and gradually moving on to selection and concentration of them. Although those that were chosen by the government enjoyed public policy support, the rest suffered from a lack of support as the government set industrial priorities and mobilised and coordinated resources accordingly (Westphal, 1990, p. 41).

3.8 SUMMARY

This chapter began with a general introduction of systems of innovation followed by the introduction of the main concepts of systems of innovation: national systems of innovation, regional systems of innovation, sectoral systems of innovation and the Triple Helix model.

The main components of systems of innovation are organisations and institutions while creation, diffusion and exploitation of technological innovation within a system are related to functions of innovation (White and Xielin, 2001, p. 1093). The key innovation activities involved in systems of innovation are R&D, implementation for manufacturing use, end use, education and linkages to put together complementary knowledge (Edquist, 2005, p. 190-191).

It is important to remember that there are strong complementarities as well as interaction among components. The systemic interaction of organisations including market, price and other non-price mechanisms, and differences across nations, therefore, make up the innovation and economic performance of countries and regions (Lundvall, 2002; Lichtenthaler, 2007; Vaona and Pianta, 2008). Innovation activities are very uneven among nations with heterogenous national systems of innovation approach (Howell, 1999; Sternberg and Krymalowsy, 2002).

Growth is, according to post-Keynesian economists such as Myrdal (1957), Perroux (1950, 1955), Kaldor (1967, 1970, 1972), Baumol (1967), Oates *et al.* (1971), Dixon and Thirlwall (1975), a partially cumulative process and inequalities across regions within a nation tend to be widened. This contradicts the idea of neoclassical economists as differences across nations and regions are likely to persist across time and space in a path-dependent way and these differences in growth rates tend to persist over time partly because of cumulative causation (Driver and Oughton, 2008).

Spatial economics and economic geography have been developed since the 19th century and a region becomes distinctive as it evolves through time to an institutional repository of a certain negotiated, evolving, collective social order (Cooke *et al.* 1997, p. 480). Thus, each region requires different innovation activities for competitiveness together with the need to set and apply different innovation policies. This is why not all the less favoured regions can benefit from role models (Todtling and Trippl, 2005, p. 2). Thus, the RSI can be thought of as the institutional infrastructure supporting innovation within the productive structure of a region (Cooke, 1998; Hassink, 2001; Rantisi, 2002; Freel, 2002; Woolfe, 2009).

While national and regional systems of innovation have spatial dimensions as their boundaries, sectoral systems of innovation use a technology as the system boundary. As a whole, national, regional and sectoral systems of innovation overlap and interconnect and they may complement each other.

Furthermore, the Triple Helix model is a recent analytical framework for innovation but it does not assume geographically delineated systems like national or regional systems of innovation. The Triple Helix features the interaction of Triple Helix into systems of innovation format and treats the three spheres, university, industry and government, as having equal importance in a country's innovation network. This is seen as a holistic approach to innovation based on the networking of diverse organisations and disciplines (Todorovska and Stankovic, 2012, p. 4).

From the literature review so far, a number of gaps have been identified in terms of the Korean case. When looking at R&D activities, Korea has the highest percentage of GDP spending on R&D among the OECD countries. In 2010, industry funded 72% of the gross domestic expenditure on R&D in Korea while only 20% was funded by the government (OECD, 2012). Although this is relatively high government sector expenditure on R&D, the outputs from universities and research publications is low in comparison to international standards.

With regard to the development of human capital, unlike many advanced countries where human capital is positively associated with innovation, the MSc education system in Korea is not geared towards creativity and innovation. Rather it is more oriented to train personnel ready to be placed in workplaces.

Furthermore, the Korean government introduced the Balanced National Development Plan adopting regional systems of innovation and cluster strategy as the theoretical framework between 2004 and 2008 but the adopted policy instruments by the government did not place emphasis on networking between industries and regions.

Thus, there is much value in the National and Regional Systems of Innovation approach. The approach opens up more variables, deals with more complexity, can be applied to a range of economies, and, as the above review of industrial and innovation policy in Korea has shown, it can be applied to Korea to shed light on its recent economic performance and regional disparities in innovation.

Chapter 4

METHODOLOGY

In social science, there has been continuing discussion over quantitative versus qualitative research methods (Bryman, 1984; Sechrest and Sidani, 1995; McLoughlin, 2007). Quantitative research methods have been described as a method used in social research that applies natural science, particularly a positivist approach to social phenomena (Sechrest and Sidani, 1995, p. 78).

Quantitative research methods are frequently mentioned as being empiricist or positivist. Concepts can be operationalised through questionnaire items, the distance between observer and observed means the objectivity can be maintained, employing the same research instrument in another context makes replicability possible and the emergence of path analysis and related regression techniques eases the causality problem (Bryman, 1984, p. 77).

Quantitative methods are used when quantifying the problem by generating numerical data and this method is applicable where hypotheses can be identified and tested using empirical data. Furthermore, quantitative methods are arguably more structured than qualitative methods but analysis of quantitative data can be complemented by qualitative analysis (Bryman, 1984, p. 85-87).

It is, therefore, important to pay attention to how correct and persuasive are the available data. This is because according to Sechrest and Sidani (1995, p. 85) it may be possible or can be impossible to convince other people that you are correct, while at the same time we can be highly persuasive when completely wrong. When, therefore, both methods are used complementarily the meaning of the data set can be probed and this can be used to verify the purposes of research.

Qualitative methods, however, are different in many ways. Denzin and Lincoln (1994, p.14) note that 'qualitative' refers to an emphasis on process and an in-depth understanding of perceived meanings, interpretations and behaviours as opposed to the measurement of the quantity, frequency, and intensity of variables. The social world is seen from the view of an actor and close involvement is required. The underlying philosophy of qualitative methods is typically related to phenomenology and symbolic interaction. Furthermore, data collection methods of qualitative research are arguably more sensitive to the complexity of social phenomena than quantitative data collection methods (Bryman, 1984, p. 78).

In terms of research techniques, the appropriateness of survey methods is emphasised by Bryman (1984, p. 81) who takes the quotation by Warwick and Lininger that *"The sample survey is an appropriate and useful means of gathering information under three conditions; when the goals of the research call for quantitative data, when the information sought is reasonably specific and familiar to the respondents, and when the researcher himself has considerable prior knowledge of particular problems and the range of responses likely to emerge."* Examples of survey research that satisfy these conditions are public opinion, voting, attitudes and beliefs, and economic behaviour. The Korea Innovation Survey in this respect is an appropriate way of collecting the information on innovation.

Furthermore, in various social science studies case study research is considered as a useful tool. Case studies can be quantitative or qualitative. They strengthen our pre-gained knowledge from previous research and literature.

In the qualitative research part of this thesis, industry case studies will be presented. This is because when an in-depth and a holistic investigation is needed, case study research is considered as a robust research method since it is possible to understand and explore complex issues through in-depth analysis (Zainal, 2007, p. 1).

Case studies are an empirical inquiry and investigate a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used (Yin, 1984, p. 23). The goal of the case study that has been identified by Yin (1984, p. 10) is to expand and generalise theories (analytical generalisation) and not to enumerate frequencies (statistical generalisation). The sources of evidence for case studies include primary and secondary documents and systematic interviewing.

As has been identified above from the distinction between quantitative and qualitative research methods, each method is suitable for use in this thesis in understanding and researching innovation of firms at the national and regional levels.
By emphasising the contribution of methodological pluralism to good science, Sechrest and Sidani (1995, p. 80) argue these two approaches are complementary from an epistemological standpoint. At the same time, quantitative and qualitative methods may each be most suited to particular research problems – horses for courses.

Mixed methods that combine quantitative and qualitative are becoming more recognised as valuable and they explain both methods are all empirical and are dependent on observation since we do not know which is more correct or suited to particular research questions or problems and that sometimes they can be used in combination. This coincides with increasing attention focused on 'triangulation' in social science (Jick, 1979; Bryman, 1984; Zainal, 2007) enabling the researchers to potentially capitalise on the respective strengths of the two approaches.

Mixed method is defined as "*the type of research in which a researcher or a team of researchers combines elements of qualitative and quantitative research approaches e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques for the broad purpose of breadth and depth of understanding and corroboration*." (Johnson *et al.*, 2007, p. 123)

There are different mixed methods design types in social science studies: exploratory designs, explanatory designs, embedded designs, convergent designs and hybrid designs (Creswell and Plano Clark, 2011, p. 54). According to Creswell and Plano Clark (2011, p. 55), the exploratory design type is the most common type of design in which researchers collect qualitative data first, analyse it and then build quantitative follow-up. On the other hand, in explanatory designs, quantitative data is collected and analysed and then qualitative follow up is built on top of those findings. Greater priority is given to the quantitative data in explanatory design which is mostly used when initial quantitative data need to be explained by qualitative data.

In this thesis, the combination of quantitative and qualitative methods will be used as the overarching methodology to look into the data collected through innovation survey and also from exploratory case study. The gaps and hypotheses are identified through literature review. The factors that shape innovation will be identified based on the theories of innovation. An initial quantitative analysis followed by case studies is carried out with a view to gaining a deeper understanding of the processes underlying the empirical results from the quantitative data and regression analysis.

When researchers examine large numbers of firms, individuals or cases quantitatively the behaviour of any particular firm, individual or case is obscured and when researchers examine a few individuals qualitatively the power to generalise the results is lost. However, this does not mean that mixed method research is perfect for every research problem nor does it reduce the value of the research done entirely by quantitative or qualitative methods alone (Morgan, 1998; Burke *et al.*, 2007; Harrison and Reilly, 2011; Harrison, 2012).

4.1 QUALITATIVE ANALYSIS

In the qualitative analysis section of this thesis, two industry case studies will be carried out and these will be used to explore relationships from the quantitative analysis in more depth to shed light on underlying innovation processes in Korea.

Case study research method is defined by Yin (1984, p. 23) as *"an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used."*

In a case study, case selection is important and therefore defining the population is also important since, as with hypothesis testing and quantitative research, the population informs sample choice (Eisenhardt, 1989, Wilmot, 2005). As Vidich and Shpiro (1955, p. 31) argue *"Without the survey data, the observer could only make reasonable guesses about his area of ignorance in the effort to reduce bias."*, the qualitative data is valuable in understanding the underlying relationships found from the quantitative data (Jick, 1979, p. 604).

Based on the fact that each region has their own elements contributing toward innovation, I wanted to discover what role different actors play in the industry in their region as they develop. Focus is concentrated on finding out what elements are considered to be most important in the process of innovation. In order to gain deeper understanding of the systems of innovation in Korea, the activities and relationships within and between organisations was analysed through fieldwork in Korea focusing on their behaviours, structures and processes.

4.1.1 Qualitative Analysis-Case Studies

For the case studies, I wanted to look into a high-tech industry and a low-tech industry in Korea focusing on innovation performance and activities and relationships within and between organisations. Game industry is chosen since it is one of the main high-tech industries, and footwear industry is chosen as it is a main low-tech industry in Korea. Seoul is selected because it is the capital of Korea and where game industry is prospering and Busan is chosen because it is the second capital of Korea and is the home of the footwear industry in Korea. Although Seoul is the capital and Busan is the second capital in Korea their economic standing is far from this ranking.

For the qualitative research, interview data together with secondary data were collected through the field work. Interviews were conducted with innovation actors in these industries and regions.

The fieldwork involved collection of primary data via semi-structured interviews with relevant people in governments, universities, and firms as well as secondary data on innovation activities. The evidence from the case studies will be used to provide insight into the results from the quantitative data analysis using the 2008, 2010, and 2012 Korea Innovation Survey.

Relevant people in the computer gaming industry in Seoul and the footwear industry in Busan from government, universities and firms were identified by recommendations from people in the field but mainly by internet search. The people I wanted to meet were government officials involved in policy making for technological innovation and those in government responsible for actually implementing the policy, university professors who have been dealing or working with game/footwear industries, including those working in relevant business incubation parks of universities and business people working in the computer gaming and footwear industries. Emails were sent requesting an interview and follow up telephone calls were made to arrange meetings. During the email and telephone communication the nature of my thesis and the reasons behind my interview request were explained.

While preparing the fieldwork, I constructed three semi-structured interview questionnaires; each designed for one of the company, university, and government sectors. Semi-structured interviewing is preferable when you are in the position that you will not get more than one opportunity to interview someone (Bernard, 1988). This method provides interviewers with comparable reliable qualitative data. It involved open-ended questions that can be prepared in advance. Since interviewees can have freedom to express their opinions in their own way it is possible for interviewers to identify new ways of looking at and understanding the topics in question.

During a three week period, interviews were carried out in Seoul during the first week (24/3 – 27/3, 2015), in Busan during the second week (31/3 – 3/4, 2015) and in Seoul with the people who were not available in the first week during the final week (47/4 – 10/4, 2015). Due to the confidentiality of commercial information, most firms were not willing to accommodate my visit as they were reluctant to disclose information about their innovation activities. As a result, I managed to visit only one commercial company in each industry/region.

In accordance with the ethics policy of SOAS[22], prior to arrival, I introduced myself by phone and email. Interviewees were informed that their identity would not be disclosed without their permission or published in the dissertation to encourage them to speak freely and provide as much information as possible. All the interviews were tape recorded after asking for the permission of the interviewees and notes were taken simultaneously.

Most of the interviewees attended the interviews with secondary data such as booklets, leaflets, or presentation slides introducing their organisation and institutions and explaining their jobs, plans and achievements. The tape-recorded interviews were then transcribed and translated into English on my return to England. Every effort was taken to avoid any omissions and errors in this process by going through the notes I took and re-checking the recording against the transcripts of the recordings.

[22] School of Oriental and African Studies, University of London – where I undertake my PhD course

4.2 ECONOMETRIC ANALYSIS

In analyses of multifactor data, regression analysis became one of the most widely used statistical tools (Chatterjee and Hadi, 2012, p. 13). This is because regression analysis provides a simple way of investigating functional relationships among variables. Chatterjee and Hadi (2012, p. 13) view regression analysis as a set of data analytic techniques that enable the examination of the interrelationships among variables.

Since my research is based on the hypotheses that innovation is influenced by a number of variables and I also want to examine the innovation performance of firms (around 11,000 firms) using the Korea Innovation Surveys for 2008, 2010 and 2012, multiple regression analysis is one technique that is commonly used in the literature on innovation. In the econometric analysis in this thesis, therefore, cross section multiple regression analysis will be used.

CROSS SECTIONAL ANALYSIS

The quantitative analysis I am going to use is for testing the relationships among dependent and independent variables. The dependent variables used are binary (dichotomous). Traditionally, analysis on binary dependent variable, ordinary least squares regression or linear discriminate function analysis used to be used. As these two methods are based upon strict assumptions, in the case of OLS, measurement level, linearity, normality and homoscedasticity, Logistic regression was introduced as an alternative in the late 1960s and early 1970s. (Cabrera, 1994; Cleary & Angel, 1984; Cox & Snell, 1989; Peng *et al*., 2002).

Pohlmann and Leitner (2003) argue that an analyst can choose from discriminate function, Ordinary Least Square (OLS), Logistic or Probit regression analysis if a dependent variable has a binary outcome although they emphasise that Ordinary Least Squares and Logistic regression are the most commonly used models in this case. From their analysis, Pohlman and Leitner (2003) identified that if the analysis is carried out in order to classify cases on the dependent variable outcome and test the relationships, both models can be used. If, however, the probability estimation of the outcome event is the purpose of the research then logistic regression is the better model. The results of logistic regression are comparable with OLS ones in many ways although it provides more precise probabilities and predictions of the dependent outcome.

The characteristics of logistic regression can deal with every kind of relationships since non-linear log transformation is applied to the predicted odds ratio. In logistic regression, the probability of an outcome is estimated and the event is coded as '1' if the outcome occurs and '0' if not. Odds ratio is the change in the odds of Y when X makes one unit change holding other variables constant. Although multivariate normality produces more stable results as the independent variables do not necessarily have to be multivariate normal in logistic regression (King, 2008, p. 379).

Furthermore, it is not necessary for logistic regression to have variances that are homoscedastic for every level of the independent variables and it can deal with categorical, nominal and ordinal, data as independent variables as well as allowing interactions between independent variables to predict the dependent variables.

4.2.1 The Data - Quantitative

How could innovation be quantified and measured? Frequently used measures in innovation analysis include R&D data, patent data, bibliometric data and survey data (Smith, 2005, p. 152). The issues involved in using R&D data in measuring innovation, however, include the difficulty of deciding what to include as R&D. Often it is classified according to multiple criteria and measures an input only, not innovation output (Kleinknecht *et al.*, 2002). Furthermore, bibliometric analysis is primarily related with the dynamics of science rather than innovation (Smith, 2005, p. 153).

The patent system collects detailed information about new technologies (Smith, 2005, p. 158), but Kleinknecht *et al.* (2002) argue that patent indicators miss many non-patented inventions and innovations. Among the questions they raise is the proportion of patents not converted into commercially viable products and processes and the fact that some firms will not commercialise the patent but use it to prevent competitors patenting or innovating.

R&D data and patents can be used as excellent indicators of firm investment for innovation activities in-house but Smith (2002, 2005) argues that they are not sufficient to capture innovation as a diffusion process. This is because in the knowledge-based economy, the development of distributed knowledge bases is an essential feature (Arundel, 2006, p. 1-2).

There have, therefore, been attempts to create new or better designed indicators aimed directly at capturing and measuring innovation (Smith, 2005, p. 160). The OECD tried to develop a manual that can serve as the foundation of common practice in innovation survey and the Oslo manual was produced in the early 1990s (OECD, 2012). The national systems of innovation as well as others including the chain-link model[23] which emphasises the process of innovation and the examination of interactions and exchange of knowledge provided the general conceptual foundation for the Oslo Manual (2005, 3rd edition), OECD's innovation manual. The Community Innovation Survey is based on the Oslo Manual. On page 33, the Oslo Manual (2005, 3rd edition) states that *"The framework used in the Manual thus represents an integration of insights from various firm-based theories of innovation with those of approaches that view innovation as a system."*

The European Commission, Eurostat and Directorate General Enterprise jointly implemented the Community Innovation Survey that can measure innovation output and can be comparable internationally. Their data are collected at highly micro-aggregated levels and this data is available in micro-aggregated type for analysis. Because of these features, the survey data can be used in producing a wide range of micro level studies of innovation process and their effects (Arundel, 2007, p. 54).

Innovation survey is divided into subject approach type that emphasise innovating agent and, object approach type where the emphasis lies in the technology, the output of the innovation process itself (Archibugi and Pianta, 1996, p. 455).

While the Science Policy Research Unit (SPRU) database developed by the Science Policy Research Unit at the University of Sussex is a good example of the result of taking

[23] This model is often contrasted with the linear model of innovation. The important implications of the model are firstly, the meaning of novelty includes not only completely new products or process but also small changes, and secondly, non-R&D inputs in innovation is considered to be important as well (Smith, 2005).

object oriented approach to innovation indicators, the Community Innovation Survey is considered to be the most important example of subject approach (Smith, 2005; Dogson *et al.*, 2008; Paas and Poltimae, 2012; Tinguely, 2013). It focuses on the technological innovation leading to detailed sub-categories, attempting to estimate expenditures not only on R&D but also non-R&D activities (Smith, 2005, p.165).

Community Innovation Survey is designed to grasp the systemic dimension of innovation focusing on the linkages of innovation and incorporates the innovation measurements of inputs and outputs (DBIS, 2017). Through CIS constraints faced by firms in their innovation efforts can also be identified. The basic format of Community Innovation Survey, therefore, has spread to many other countries including Korea where it has informed the Korea Innovation Survey.

While CIS has been carried out every 2 years since 2005 before when it was carried out every 4 years, KIS was conducted every two years since the first introduction of the survey in Korea in 1996 until 1998 from when it has been conducted every 3 years except between 1999 and 2001 when there was no survey. KIS was carried out separately for the Manufacturing and Service sector and was carried out in different years from each other but from 2012, KIS for both, manufacturing and service, sector has been surveyed in the same year. In this thesis, the Korea Innovation Survey data will be used for analysis.

4.2.1.1 Korea Innovation Survey for the Manufacturing Sector

The Korea Innovation[24] Survey for the manufacturing sector is used to identify the measures of innovation and the innovation activities of manufacturing enterprises during the previous two to three years. I decided to use the Korea Innovation Survey since it is the most comprehensive innovation survey available in Korea. STEPI (Science and Technology Policy Institute) carried out the very first innovation survey in 1996[25] and has continued to carry out the survey on a regular basis.

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[24] Innovation in the paper refers to technological innovation.

[25] Science and Technology Policy Institute (STEPI), the government-funded research institution, commission the survey to statistic firms. The survey was commissioned to Korea Data Service in 2008, 2010 and to Gallop Korea in 2012.

The survey was nationally recognised as official statistics (number 39501) by Statistics Korea – the Korean official/government statistical agency - in 2003. In an effort to make the survey more easily comparable internationally, the survey for the manufacturing and service sectors were carried out together from 2012. The history of the Innovation Survey in Korea is noted in Table 4.1:

Table 4.1 History of Korea Innovation Survey

Survey Year	Title of The Survey	Period Covered
1996	Korea Innovation Survey 1996	1993 – 1995
1998	Korea Innovation Survey 1998	1996 – 1997
2002	Korea Innovation Survey 2002: Manufacturing Sector	2000 – 2001
2003	Became officially recognised by Statistics Korea (No. 39501)	
2003	Korea Innovation Survey 2003: Service sector	2001 – 2002
2005	Korea Innovation Survey 2005: Manufacturing Sector	2002 – 2004
2006	Korea Innovation Survey 2006: Service sector	2003 – 2005
2008	Korea Innovation Survey 2008: Manufacturing Sector	2005 -2007
2009	Korea Innovation Survey 2009: Service Sector	2006 – 2008
2010	Korea Innovation Survey 2010: Manufacturing Sector	2007 – 2009
2011	Korea Innovation Survey 2011: Service Sector	2009 – 2010
2012	Korea Innovation Survey 2012: Manufacturing/Service Sector	2009 – 2011
2014	Korea Innovation Survey 2014: Manufacturing/Service Sector	2011 – 2013
2016	Korea Innovation Survey 2016: Manufacturing/Service Sector	2013 – 2015

(Own arrangement referring to the Science and Technology Policy Institute (STEPI))

The concepts of the survey questions are based on the Oslo manual[26] that has two objectives. One of them is to produce comparability among existing surveys and the other is to assist those new to the field (Godin, 2005). The manual was adopted by 12 OECD member countries and has become a very important guideline internationally in collection and data usage on innovation related activities in industries (OECD, 1996). This enables international comparison.

The purpose of the Korea Innovation Survey is to monitor and measure firms' innovation activities and to provide data that can inform policies to promote innovation and to strengthen international competitiveness. This thesis will also consider the effect of the macroeconomic environment on innovation and therefore the data this research uses are Korea Innovation Survey (KIS) 2008, 2010 and 2012. As the period these surveys cover includes the financial crisis in 2009 in Korea the before and after crisis effects can be observed.

[26] The first version of the manual was published in 1992 and the second version in 1997.

The Community Innovation Survey (CIS)[27] in Europe that has informed the KIS and the questionnaire ask firms a series of questions about their innovation activities including product, process, organisational and marketing innovation. These four elements, product, process, organisational and marketing innovation, have been covered by the Green Paper on Innovation (1995, p. 7) in defining the innovation.

The surveys allow firm and regional level analysis. Product and process innovation will be used at the firm and regional level, and organisational and marketing innovation will also be used at the regional level to measure innovation.[28] Detailed sub-innovation measures will be discussed in the subsequent chapters.

4.2.1.2 Overview of Korea Innovation Survey

SAMPLE FOR KIS 2008, 2010 AND 2012

The population of KIS 2008 includes all manufacturing firms that have more than 10 employees established before 2005 and carried out manufacturing activities during 2005 and 2007. The firms' Korean Standard Industry Code (KSIC) version 8 must fall between 15 and 37 but the Tobacco industry (KSIC no. 16) was excluded. The population for the survey in 2010 included firms that were established before 2007 and carried out manufacturing activities from 2007 and 2009. The firms' Korean Standard Industry Code version 9 must fall between 10 and 33 but the Tobacco industry (KSIC no. 12) was excluded. The population for the survey in 2012 included firms that were established before 2009 and carried out manufacturing activities from 2009 and 2011. The firms' Korean Standard Industry Code version 9 must fall between 10 and 33 but the Tobacco industry (KSIC no. 12) was excluded.

The sample of KIS 2008 was drawn from the population that is the total registered firms as of 2005 taken from the Korean Statistical Information Service (KOSIS) that amounted to 47,267 in total. The sample of KIS 2010 was drawn from the population that is the total registered firms as of 2007 taken from the Korean Statistical Information Service that amounted to 41,485 in total. The sample of KIS 2012 was from the population that

[27] The CIS has been carried out for all EU countries while the format of CIS has been adapted and adopted by many other countries including Australia, Argentina, Canada, China, and Hungary (Smith, 2005).

[28] According to the definitions provided in the Oslo manual (OECD, 1997) and the Community Innovation Surveys

is the total registered firms as of 2009 taken from the Korean Statistical Information Service totalling 43,810.

The sampling method employed for all three surveys was the multiple stage stratified sampling. At first, the sample was stratified by industry type followed by the second stratification by size as captured by the number of permanent employees: 10~49 employees, 50~99 employees, 100~299 employees, 300~499 employees, and more than 500 employees.[29] The Neyman distribution method was used in the sampling distribution. For the final stage, random sampling was applied in order to select the final sample of firms.

Taking the expenses and time frame involved the allocated sample size was decided as 3,000 for KIS 2008, 4,000 for KIS 2010 and 4,016 for KIS 2012.

4.2.1.3 Sample Calculation

The Neyman allocation method that was employed in sampling distribution is to determine what sample size to allocate to an industry in order to maximize the precision of the survey. The formula of the Neyman allocation is as follows:

$$n_i = n (N_i S_i) / [\Sigma (N_i S_i)]$$

n : total sample size	*n_i : sample size for stratum i*
N : population size	*N_i : population size for stratum i*
S : standard deviation	*S_i: standard deviation of stratum i*

(Ha *et al.*, 2010, p. 26)

For the 2008 survey, the total population of the firms was 47,267. The extracted sample size for the survey was 6,314 firms and this is 2 to 2.3 times more than the allocated sample size of 3,000. Out of these firms 5,381 firms were identified as eligible for the survey and 3,081 valid responses were obtained after the data cleaning i.e. closed/paused business, engaged phone line, wrong phone number or missing numbers. This produced a response rate of 57.26%[30] against the eligible firms to take part in the survey of 5,381 (Kim *et al.*, 2008, p. 30).

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[29] Since I have not checked whether sales would provide a more consistent measure of size, employment is used as a measure of firm size as in the literature (examples include Acs and Audretsch, 1987; Chun et al., 2015).

[30] (Total valid responses/number of eligible firms to take part) x 100

For the 2010 survey, the total population of firms was 41,485. The extracted sample size to carry out the survey was 15,231 and this is 3 to 4 times more than the allocated sample size of 4,000. Out of these firms 7,692 were identified as eligible for the survey. The target sample size of 4,000 firms participated in the survey and 3,925 firms were valid respondents after data cleaning. This produced a response rate of 51.03% against the eligible firms to take part in the survey of 7,692 (Ha *et al.*, 2010, p. 2).

In the case of Survey 2012, out of a total of 43,810 firms, the extracted sample size to carry out the survey was 34,100 and this is 8.5 times more than the allocated sample size of 4,016. Out of these firms 21,836 were actually contacted and 17,052 firms were identified as eligible for the survey.[31] In total 4,105 firms participated in the survey and 4,086 were found to be valid respondents after the data cleaning. This produced a response rate of 24.1% against the eligible firms to take part in the survey of 17,052 (Ha *et al.*, 2012, p. 27).[32]

For all three surveys, the sample was selected in order to represent the population as closely as possible but there are reasons why this is not always the case. Some groups can be over or under represented. In order to scale up the survey data to the population weights were calculated based on the type of industry and the size of firms as follows:

$$W_{ij} = N_{ij} / n_{ij}$$

W_{ij} : weight of the i^{th} industry and the j^{th} size
N_{ij} : population size of the i^{th} industry and the j^{th} size
n_{ij} : sample size of the i^{th} industry and j^{th} size (Ha *et al.*, 2010, p. 30)

[31] The eligible firms were calculated using the following equation: Number of the eligible firms = {[contacted firms (21,836)]-([firms with wrong phone number or firms did not answer the call (2,223)] + [phone engaged (611)] + [bankrupted or closed firms (109)] + [(less than 10 employees, changed industry type etc. (1,841)]}

[32] However, if we take only the firms that agreed to take part in the survey that amounted to 6,716 firms, the response rate becomes 61.1%.

4.2.1.4 Sample Breakdown by Region

Based on the sample calculation mentioned in the previous section, the total number of firms in each region, number of firms in the sample and the proportion of the sample firms out of the total in the regions are shown in Table 4.2. As the proportion of the sample firms demonstrates, the proportion of sample firms are relatively equally distributed across regions:

Table 4.2 Sample Breakdown of 2008/2010/2012 Survey

REGION	Number of Total manufacturing firms in the region			Number of Firms in the sample			% of sample firms in the region		
	2008	**2010**	**2012**	**2008**	**2010**	**2012**	**2008**	**2010**	**2012**
Seoul	6,472	3,481	3,763	537	550	425	8.3	15.08	11.29
Busan	3,560	2,561	3,589	220	246	322	6.2	9.61	8.97
Daegu	2,799	2,297	2,828	149	159	279	5.3	6.92	9.87
Incheon	4,253	3,218	3,599	251	287	400	5.9	8.92	11.11
Gwangju	1,248	716	845	64	57	76	5.1	7.96	8.99
Daejeon	773	487	693	61	64	72	7.9	13.14	10.39
Ulsan	1,096	1,043	982	70	113	93	6.4	10.83	9.47
Kyunggi	13,531	15,077	13,503	819	1,192	1,106	6.1	7.91	8.19
Gangwon	598	382	529	37	49	51	6.2	12.83	9.64
Choongbook	1,416	1,481	1,710	103	149	164	7.3	10.06	9.59
Choongnam	1,614	1,877	1,955	127	204	205	7.9	10.87	10.49
Jeonbook	1,025	912	1,119	69	93	115	6.7	10.20	10.28
Jeonnam	985	730	817	68	85	75	6.9	11.64	9.18
Kyungbook	3,231	2,596	3,308	202	257	288	6.3	9.90	8.71
Kyungnam	4,504	4,431	4,406	296	405	400	6.6	9.14	9.08
Jeju	162	196	163	8	15	15	4.9	7.65	9.20
Whole of Korea	47,267	41,485	43,810	3,081	3,925	4,086	6.5	9.46	9.33

4.3 SUMMARY

In this chapter, the research methodology employed in this thesis was discussed. For the purpose of identifying the relevant variables in the firm, and regional level systems of innovation in Korea, the mixed method that uses both quantitative and qualitative methods are employed.

While quantitative methods are used in social research that applies natural science, particularly a positivist approach to social phenomena (Sechrest and Sidani, 1995, p. 78), the underlying philosophy of qualitative methods is typically related to phenomenology and symbolic interaction and the quantitative observations may rely on rational analysis that directs to verification by qualitative observation (Bryman, 1984, p. 78).

In the qualitative research part of this thesis, industry case studies for the computer gaming industry for high-tech, and footwear industry for low-tech, were proposed and carried out using the case studies that contain detailed information collected through interviews during the fieldwork. The cases were used to explore relationships from the quantitative analysis in more depth to shed light on underlying innovation processes in Korea.

As for the quantitative research method, data from the Korea Innovation Survey, the most comprehensive innovation data available in Korea for 2008, 2010 and 2012 were used. The questionnaire was designed using relevant theories to inform question design and wording. Many questions have closed binary responses that are answered either ‘yes’ or ‘no’ generating mostly binary variables.

In the analysis, therefore, logistic analysis will be used for cross section analysis. The sampling frame for the surveys is stratified by firm size, industry and region allowing regional analysis with controls for firm and industry.

Chapter 5

THEORIES OF INNOVATION AND RESEARCH HYPOTHESES

This section will focus on theories of innovation and the development of research hypotheses.

The flow of theories of innovation starting from Schumpeter that leads to evolutionary theory, followed by Bush's linear model, Solow's neoclassical theory, Freeman's national systems of innovation, Penrose and the development of the resource based view, and the development of national systems of innovation to, for example, regional systems of innovation will be studied.

This will then be followed by the identification of important elements of national systems of innovation and regional systems of innovation looking into the relevant theories from which research hypotheses of this thesis will be drawn.

5.1 CONCEPTUAL FRAMEWORK AND HYPOTHESES

Modern evolutionary economics has its roots in the older type of evolutionary economics found in the core works by Schumpeter (Anderson, 2012, p. 9). Schumpeter believed economic change is driven by innovation, market power and entrepreneurial activities. His main interest was identifying how capitalist systems are affected by market innovation. The famous term 'creative destruction' was coined by Schumpeter in 1942 in his book '*Capitalism, Socialism and Democracy'* and this became an important concept to explain different dynamics of industrial change (Naqshbandi and Singh, 2015, p. 42).

Schumpeter's interest also stretched to the size of firms and their links to the production of innovation. In his early work, often referred to as Schumpeter Mark I, he stated that small firms are in a better position to innovate as larger firms would be constrained by their bureaucratic structures. However, in his later work – now termed Schumpeter Mark II – he changed his view and argued that larger firms are in a better position to innovate because of their monopolistic power (Naqshbandi and Singh, 2015, p. 42)

In the 1940s and 1950s, a linear model developed by Vannevar Bush, Director of the US Office of Scientific Research and Development, was often dominant in the new science councils that advised governments (Freeman, 1995, p. 9). The linear model of innovation was developed as the first theoretical framework for historically understanding science and technology and its relation to the economy (Godin, 2005, p. 641).

The linear model posits that innovation begins with basic research followed by added applied research and development and ends with production and diffusion. This model has been very influential and consequently many science policies carried a linear conception of innovation for many decades as well as an increase in academics studying science and technology (Mowery, 1983).

In the linear model, technical progress was considered to be an endogenous variable via research and development expenditure while mainstream economics (for example the Solow model, 1956) assumed that technical progress was exogenous and these two theories developed in parallel with little discussion between them (Cowen and Tabarrok, 2010, p. 511).

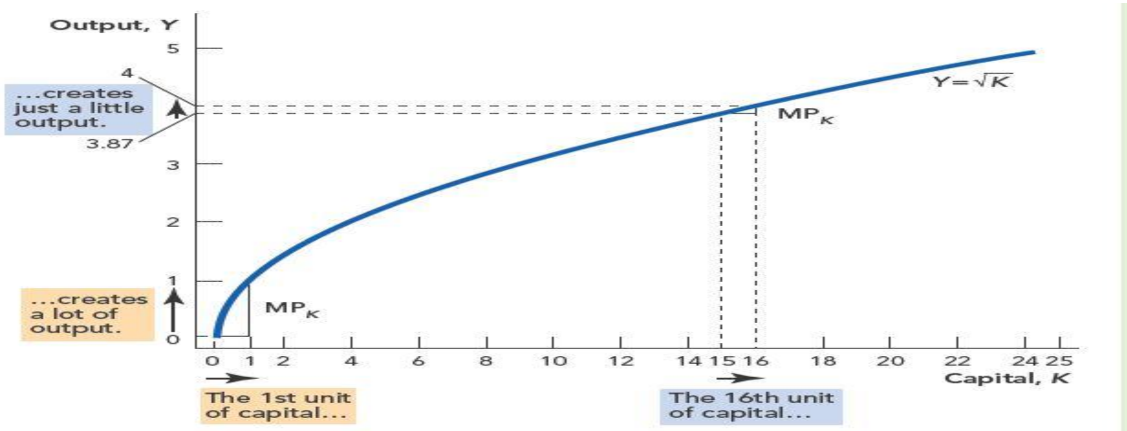
The American economist Robert Solow applied the production function model to the study of growth problems. Solow began with a production function of the Cobb-Douglas type:

$$Y = A K^{\alpha} L^{(1-\alpha)}$$

This equation represents total output, Y, which may be considered as GDP as a function of total factor productivity (A), capital input (K), labour input (L), and α and (1- α) are the output elasticities of capital and labour, respectively. These values are constants determined by the available technology. If there is an increase in either A, K or L, an increase in output will take place. While capital and labour inputs are tangible, total factor productivity appears to be more intangible as it can include factors ranging from technology to the knowledge of workers (human capital) (Cowen and Tabarrok, 2010, p. 510).

Although technological change is considered to be an essential contributor to the production of the output this was treated as a mere residual by the Solow model (Zaman and Goschin, 2010, p. 29). This residual is that part of the increase in output that is not explained by increases in capital and, labour (and natural resources, if these are also included as a factor).

Figure 5.1 The Iron Logic of Diminishing Returns



Source: Reproduced from Cowen and Tabarrok, (2010, p. 511)

If growth is due to capital accumulation as the Solow model suggests, growth will be very strong when countries first begin to accumulate capital and will slow down as the process of accumulation continues based on the iron logic of diminishing returns as shown in

Figure 5.1. When all countries have reached a steady state, each country will have the same standard of living.

These predictions have been tested by many studies and while there are some cases of convergence there are many cases where the predictions have not been supported by the evidence. Cowen (2010) argues that the US growth rate was lower, at least on a per capita basis, in the nineteenth century than in the twentieth century. The Soviet Union under Stalin saved a higher percentage of national income than the US due to their higher savings rate. Furthermore, because the Soviet Union started from a lower level of capital, theoretically, it should have caught up very rapidly but did not. Moreover, with the exception of a few countries such as Taiwan, Korea, Singapore and Hong Kong, less developed countries are not in general catching up with developed countries. In many cases, the gap is in fact increasing.

During the 1950s and 1960s, many industrialised and semi-industrialised countries showed that the rate of technical change and economic growth depended more on efficient diffusion than being first in the world with radical innovations and as much on social innovations as on technical innovations (Freeman, 1995, p. 10). An example can be found from the extraordinary success of Japan followed by the technological and economic catch-up of South Korea in the 1960s and in contrast, the collapse of the socialist economies of Eastern Europe (Freeman, 1995, p. 11).

The inability of neoclassical theories to explain patterns in innovation and growth, together with Freeman's early work led Freeman and others to develop a new approach to innovation – national systems of innovation. Thus, an alternative to neoclassical theory is evolutionary economic theory (Maurseth, 2001, p. 3). This emerged as a result of dissatisfaction with many of the equilibrating notions of neoclassical economics. From the viewpoint of the neoclassical economists, institutions are created through economic agents' maximising behaviour and they see prevailing institutions as an equilibrium configuration (Lundvall, 2007, p. 21).

Evolutionary economists take the view that institutional structures evolve over time. Nelson and Winter developed the evolutionary economic theory inspired by Schumpeter as an alternative theory to neoclassical (Nelson, 2007, p. 5). The evolutionary theory observes no one company is the same as others and the situation is not moving equilibrium.

Nelson and Winter recognised the institutional complexities of modern market economies that Schumpeter failed to recognise (Nelson, 2007, p. 5). In the process of attacking the limitations of equilibrium concept, the neoclassical and the early evolutionary theorists did not pay enough attention to the institutional assumptions.

Neoclassical and evolutionary theories have been distinguished in terms of how they see good economic performance. While neoclassical theory proposes that performance has to be judged against how close it is to a theoretical optimum, there is no theoretical optimum in evolutionary theory since economic performance is seen in view of the rate and nature of progress (Nelson, 2007, p. 3).

Thus, Nelson and Winter (1990) argue the basic factors of the neoclassical explanation include a competitive industry and the sector is presumed to be equilibrium in terms of supply and demand and maximisation of profit. The high degree of diversity, therefore, is hidden or even non-existent. Evolutionary economics, however, focus on diversity and selection. The diversity originates from the investment in R&D and human capital, and the evolution process happens when a selection process among diverse entities that lead the economy into new directions takes place (Nelson and Winter, 1974, p. 903).

Although both theories view individual and organisational economic actors as pure objectives, the actors' rationality in evolutionary theory is bounded. The neoclassical view assumes that the actors confront the situation fully understanding the choice of sets and the optimal choices are given. But this assumption is misleading if the economic context is changeable due to external and internal conditions (Nelson and Winter, 1974, p. 887). Even when the actors cannot comprehend the operating context perfectly, they do cope and this involves the usage of past routines that resulted in satisfaction. The actors also have the capability to do something new to innovate when they see an opportunity, or when what they have been doing turned out to be inadequate in a changed context (Nelson, 2007, p. 2).

Furthermore, the neoclassical theory assumes that the acquisition and mastery of doing things in new ways is easy and even automatic. By giving an example of the communist economy, however, Nelson (2007, p. 13) emphasises that even if investment is high the return to the investment is low and development is ineffective without effective assimilation. Under evolutionary theory, it is assumed that due to cognitive inabilities to recognise the opportunities, resources, managerial skills, capabilities, production routines and other complementary assets, low level productivity firms may not realise highly profitable investment opportunities (Coad, 2007, p. 11).

Thus, according to the prediction of evolutionary theory only the fitter firms can expand their operations whilst the weakest ones die out (Nelson and Winter, 1990; Dosi and Grazzi, 2006). Under this theory, firms use complex production routines to produce outputs. Over time, firms accumulate resources and these can be developed and become the foundation for firms' competitive advantage (Dosi *et al.*, 2000).

Based on neoclassical economics, Solow (1956), who developed neoclassical growth theory, viewed that stocks of labour and capital are determining factors for economic growth while by extending neoclassical economics, Romer (1986) argued knowledge is important in generating growth and its spillovers to third party firms. Endogenous growth theory, introduced by Romer in 1986, was a refinement/development of the neoclassical/Solow model.

This theory is also referred to as new growth theory (Krugman, 1991) that assumes increasing returns to scale which is related to new knowledge or technology (Cooke, 2006, p. 1). The theory emphasises that a key factor in growth is the creation of technological progress and in this respect, human capital, knowledge and learning by doing is also emphasised. This theory aimed to explain why there is a divergence in incomes between countries, and emerged during the second major period of research into economic growth theory during the 1980s as a response to criticism of neoclassical growth theories (Cooke, 2006).

Romer and the endogenous growth theory suggest that economic knowledge begins from a process of selecting various ideas and the spillover process is automatic. Audretsch and Keilbach (2004, p. 606), however, emphasise that the process is not automatic at all. It is rather driven by economic agents.

Knowledge is distinguished from other types of economic goods. In particular, knowledge has increased asymmetries, high uncertainty and transaction costs (Aubert *et al*, 2004, p. 921). This means that knowledge is not the same as economic knowledge and based on an evolutionary understanding this implies that knowledge diversity is not generated automatically by investment in research and development and human capital.

As Cowan and Jonard (2001, p. 327) propose, knowledge is created when new knowledge is received by agents and combined with their existing knowledge stocks.

According to Arrow (1962), the distribution of the creation of new ideas by individuals or economic agents differs across agents, and as Cowan and Jonard (2001, p. 327) argue, the creation and diffusion of knowledge are network dependent activities. In this respect, Rogers (1995, p. 187) believed that the diffusion process of innovation depends on human resources and also the innovation has to be adopted widely in order to be sustainable, introducing the ‘diffusion of innovation theory’. In his theory, Rogers tried to emphasise the determining factors for the members of a particular culture to adopt an idea or an innovation and at what pace.

Building on the theoretical distinction between knowledge creation and knowledge diffusion, empirical work, including the Oslo Manual of 2005, has drawn a distinction between innovation that is new to the market or world, radical innovation, and innovations that are new to a firm or region, incremental innovation.

Innovation is often produced out of collaboration and interaction with other firms, the ability to absorb enables a firm to gain external knowledge sources to produce innovation (Freeman, 1987). Further to Freeman’s idea, Cohen and Levinthal (1990, p. 129) put forward the concept of absorptive capacity that refers to the capability of firms to recognise the importance of new and external information, absorb it and apply it to commercial ends.

Furthermore, the economic opportunity that takes place from new knowledge is determined by the institutional context (Freeman, 1987). This means that there are different kinds of risks involved in different regimes that innovative firms confront and they develop the connections these risks have with institutions common in certain areas and nations (Casper and Whitley, 2002; Ranzl *et al.*, 2006; Boettke and Coyne, 2009).

A new paradigm, open innovation, has been introduced by Chesbrough (2003) as an innovation model based on the idea that firms should and also be able to use external ideas and paths to market together with internal ones when they want to advance their technology. Taking the example of the US where firms made heavy investment in internal R&D for fruitful outcome of innovations, Chesbrough (2003, p. xx) explains that the factors influenced closed innovation process has been breaking up as time passes.

The higher number of knowledge workers and greater availability of private venture capital paved the way for open innovation. According to Naqshbandi and Singh (2015, p. 47), the reason behind this is that safeguarding the proprietary ideas and expertise became difficult due to the increase in number and mobility of knowledge workers. Furthermore, new firms and commercialisation of new ideas, that might not have been attracted in corporate research labs, have been financed increasingly more with private venture capital.

Although this new paradigm has been receiving much coverage in the academic literature, Trott and Hartmann (2009, p. 715) argue that many scholars in the area of R&D management and innovation management criticise that this paradigm does not represent more than presenting the same concepts and findings presented over the past forty years in the innovation management literature in new packaging. This argument can be backed up by the network model of innovation that highlights the external linkages in the process of innovation (Rothwell and Zegveld, 1985, p. 70). Open innovation, therefore, is not a new approach but an extension and development of previous work.

According to Penrose (1959), effective and innovative management of resources enable firms to create innovation and economic value. In her famous work '*The Theory of the Growth of the Firm*', Penrose (1959, p. 85) emphasised that the incorporation of the dynamics of tacit knowledge and a set of other capabilities within the firm play an important role.

Penrose is an exceptional economist who reacted to Schumpeter's invitation through his two important books '*The Theory of Economic Development and Business Cycles*' and '*Capitalism, Socialism and Democracy*' for a theory of the innovative enterprise that failed to receive any attention for over three decades after he passed away (O'Sullivan, 2005, p. 245).

Thus, the idea of conceiving a firm as a bundle of resources is rooted in Penrose's groundbreaking approach to the study of the theory of the firm (Penrose, 1959, p. 5) which argues that a unique character of each firm is given by heterogeneous not homogenous productive services available from its resources. This concept of resource heterogeneity of a firm became the foundation of the resource based view (Kostopoulous *et al.*, 2002, p. 3). The resource based view of firms has heterogeneous strategic resources and a heterogeneous way of controlling them. Barney (1991, p. 101) argues this is because of resource and market imperfections, and resource immobility.

The basic unit of the resource based view of the firm is resources and capabilities (Wernerfelt, 1984) such as financial, human, technological, commercial, physical and organisational assets utilised by firms for the purpose of developing, manufacturing and delivering products and services to customers (Barney, 1991, p. 102).

Based on this view, there are a number of critical resources for innovation and they are financial resources (Teece and Pisano, 1994; Harris and Trainor, 1995; Lee *et al.*, 2001), technical resources, and intangible resources (Barney, 1991). Financial resources include internal and external funds while technical resources include IT systems and engineering equipment. Intangible resources include human capital and knowledge (Barney, 1991, p. 101).

Recent research has tended to focus on intangible resources since they satisfy the necessary requirements for obtaining sustainable advantage that make it difficult for competitors to imitate (Barney, 1991; Amit and Schoemaker, 1993; Hitt *et al.*, 2001). As an extension of the resource based view, this trend led to the emergence of knowledge based views of the firm placing a special emphasis on the level of tacit or explicit knowledge stock of a firm (Kogut and Zander, 1992; Nonaka, 1994).

Firms, according to the resource based view, therefore, have to be capable of creating knowledge not only within their boundaries but also from facing huge volumes of new ideas in their external environment so that rigidity can be prevented and innovative behaviour encouraged. In this way, firms can be updated with current technological developments by their competitors in the market (Leonard-Barton, 1995).

According to this approach, there is a positive relationship between organisational knowledge and innovative capacity. The idea that a firm level innovation is based on an organisational learning process is commonly found in literature on the innovative enterprise. For example, O'Sullivan (2005, p. 246) argues that firms' growth is built on a dynamic process of organisational learning that occurs within firms.

5.1.1. Extension of National systems of innovation to Regional systems of innovation

The evolutionary, capability and learning based theories of the firm made understanding the changes in technology and organisation that contributed to the firm growth easier. In his book '*Technology Policy and Economic Performance: Lessons from Japan*' based on evolutionary economics, Freeman (1987) developed the concept of National systems of innovation (NSI).

The roots of the National systems of innovation approach can arguably be traced from Adam Smith (1770) who emphasised firms expand by division of labour which results in specialisation and capability enhancement through learning by doing (Singh and Gill, 2016). This concept was diffused further through the book of Dosi *et al.* (1988) on technical change and economic theory that contain contributions by Freeman, Nelson, and Pelikan.

Nelson and Winter's work, '*An evolutionary theory of economic change*', in 1982 provided the theoretical background for National systems of innovation. In the late 1980s and early 1990s, as the national systems of innovation literature developed, the systems approach started to provide a framework that unifies a large volume of related research on national innovation performance. Moreover, as Asheim *et al.* (2011, p. 876) have noted the national systems of innovation approach provided the theoretical framework for the analysis of regional innovation performance and the development of the regional systems of innovation approach.

As opposed to the neoclassical theory the national systems of innovation, by adopting a holistic view of innovation, provided a new approach to innovation and its governance and stimulation (Fagerberg and Verspagen, 2009, p. 221-222). In the national systems of innovation framework, interaction between actors is emphasised and the way social, institutional and political elements shape this interaction is analysed (Lundvall, 2005). This concept is, therefore, widely used to study their production and systems of innovation in different countries and is usually used as the analytical framework (Cooke *et al.*, 1997; Braczyk *et al.*, 1998; Koschatzky, 2000).

In the evolution of theories of regional economic growth and development, there has been a shift in the emphasis from exogenous to endogenous factors (Stimson *et al.*, 2011, p. 1).

One of the first economists who analysed the role of innovation in a local or regional context, although his work was neglected for over a century until his ideas revived in the 1980s, was Marshall (Oughton and Whittam, 1997; Ashiem *et al.*, 2012).

Marshall, known as the father of the 'industrial district' concept (Belussi and Caldari, 2009, p. 336), argued that even with the growing importance of economies of scale, small firms can still compete with large ones if they agglomerate. An industrial district is where firms concentrate but not in terms of simply 'localised industry' which according to Marshall an industry concentrated in certain localities (Marshall, 1920, p. 268).

In regional economic development, technology is a prime driver and regional science literature has shown how technology is directly related to traditional concepts of agglomeration economies in regional economic development, and to new or repackaged older concepts of entrepreneurship, institutions, and leadership (Marshall, 1920; Brusco, 1982; Piore and Sabel, 1984; Best, 1990; Cooke, 1992; Cooke and Morgan, 1994; Oughton and Whittam, 1997; Morgan, 1997).

Building on Marshall's work a number of scholars have highlighted the importance of the spatial concentration of economic activity for regional economic performance, productivity and growth. With the emphasis on economic agglomeration, the 'space' concept has been revived since its elimination by the neoclassical school (Harrison, 1992; Head *et al.*, 1995; Martin and Sunley, 2002).

As a result, the development of 'new economic geography' by Krugman (1991, p. 484), unlike the neoclassical perspective, emphasises the role of the spatial concentration of economic activity, in general, and innovation activity (Krugman, 1991; Martin, 1999) in particular. This model, therefore, allows interregional differences that are largely ignored by neoclassical theory and this model also assumes 'centripetal forces' (Krugman, 1991). Mossay (2006, p. 2) agrees that this theory postulates the 'core-periphery' equilibria and persistent regional differences in productivity as a result of increasing spatial concentration and specialisation of economic activity and labour migration.

Innovation is stimulated and influenced by actors and internal, external factors of the firm (Dosi, 1988; Freel, 2003; Tether and Tajar, 2008), and according to Cooke *et al.* (2000) the social aspect of innovation includes collective internal and external learning of a company. Examples of the external collaboration partners include other firms, finances, training and knowledge providers. Thus, systemic promotion of learning processes within region to secure regional competitive advantage became important and the concept of regional systems of innovation (RSI) emerged from Cooke in 1992 (Asheim and Gertler, 2004).

From the point of view that innovation in regional systems of innovation is localised and locally embedded, innovation emerges from the socio institutional environment (Storper, 1997). Regional systems of innovation, therefore, is characterised by cooperation for innovation activity, knowledge creation and diffusion among organisations like universities, R&D institutes and technology transfer agencies together with the innovation supportive culture from which firms and systems evolve as time passes (Parto and Doloreux, 2004, p. 10).

Andersson and Karlsson (2002), and Maillat and Kebir (2001) emphasise that policy strategies could be in the direction of promoting accessibility to the regional systems of innovation development and also local comparative advantage development that is associated with specific local resources. Specific targeted policy measures in the regional systems of innovation framework is needed in order to improve performances and capabilities in local firms and to improve the business environment (Parto and Doloreux, 2004, p. 10).

In this respect, Baden Wurttemberg and Emilia Romagna are often mentioned as successful regional economies (Cooke and Morgan, 1993; Perulli, 1993; Bianchi and Giordani, 1993; Digiovanna, 1993; Francisco, 2007) that have thick institutional set ups and receive national and supranational support and these regions became the motivation of establishing technopoles, science parks, and innovation supports agencies since the late 1980s. Regions became more and more important for innovation policy and this is believed to be the consequence of the convergence of regional and technology policy that has the aim of supporting the innovative capabilities and competitiveness of SMEs since 1980s (Hassink 2001, p. 1375).

5.1.2 Using RSI in Examination of Regional Disparities

The NSI and RSI approach emphasise that the advancement and competitiveness of nations and regions depends on innovation nowadays (Sternberg and Krymalowsy, 2002; Toedtling *et al.*, 2006; Leon, 2008; Zenka *et al.*, 2014). Frenz, Michie and Oughton (2004, p. 1) also emphasise that innovation is vital for macroeconomic performance to be successful and identified the importance of collaboration in order for innovation to be fostered.

There have been efforts to identify the reasons why some regions produce more radical innovation when others produce more incremental innovations (Henderson, 1993; Chandy and Tellis, 1998 & 2000; Subramaniam and Youndt, 2005; Atuahene-Gima, 2005). Regional systems of innovation have been categorised as: institutional regional systems of innovation; an entrepreneurial regional systems of innovation based on the characteristics of the system level and the actor level (Asheim, 2007; Ylinenpaa, 2009). Institutional regional systems of innovation are arguably better suited for incremental innovations while entrepreneurial innovation provides better conditions for radical innovation due to their systemic features (Asheim, 2007, p. 226).

The reason why some regions carry out dynamic economic activity driven by innovation can be explained by a wide range of institutions including having a well-structured financial system, government programmes public research systems (King and Levine, 1993, p. 514), education and training, and university research (Nelson, 2007, p. 6).

Within regional systems of innovation, the set of actors such as private and public organisations, formal institutions and other organisations produce pervasive and systemic effects from which firms in the region are encouraged to develop specific forms of capital to strengthen innovative capability and competitiveness (Gertler, 2003, p. 79). Due to a lack of networks and knowledge exchange among actors (Fritsch, 2003, p. 5), however, different types of regions face frequent typical systemic challenges such as strengthening a region's institutional infrastructure (Isaksen, 2001, p. 107).

Thus, regional resources are important in innovation capability stimulation. Each region's competitive advantages can be built when firm specific competencies and learning processes are based on localised capabilities that include institutions, skills, specialised resources and share of common social and cultural values (Maskell and Malmberg, 1999, p. 3).

The scope of regional systems of innovation varies depending on issues such as empowerment of the regions, size and so on (Braczyk *et al.*, 1998; de la Mothe and Paquet,1998; Cooke *et al.*, 2000). Cooke (1992, p. 368-370) proposed three modalities as modes of regional innovation that assist the application of the concept to a broad range of regions and to have clearer relationships between regional and national systems of innovation.

As shown in Table 5.1, these are grassroots, networks, and dirigiste regional systems of innovation that are also termed as territorially embedded regional systems of innovation, regionally networked systems of innovation, and regionalised national systems of innovation by Asheim (2007, p. 230).

Table 5.1 The Types of Support for Regional Systems of Innovation Defined by Cooke

	Grassroots	Network	Dirigiste
Initiation process	Local (town, district level)	Multilevel (local, regional, federal, supranational level)	Central government
Funding	Locally funded (local bank, government, chamber of commerce, grants, loans)	Diverse (Banks, government agencies, firms)	Centrally determined
Research	Highly applied/Near market	Mixed (pure and applied, blue skies and near market)	Basic/fundamental
Technical specialisation	Low	Flexible	High
Co-ordination	Low (localised nature of the initiation)	High	Very high (guidance by national authorities) Low in reality (lack of co-ordination between national and local initiatives at the regional level)
Example	North central Italian industrial districts, Southern California	Baden Wurttemberg, North Rhine Westphalia	Rhone-Alpes, Singapore, Slovenia

(produced using Cooke, 2004, p 11-13)

In the grassroots model, firms become ‘embedded’ in close vertical and horizontal relationships with nearby firms, and within a rich, thick local-institutional matrix that supports and facilitates private and socially organised production, transmission and propagation of new technologies (Cooke, 1992; Schmitz, 1992; Cooke and Morgan, 1994). Firms' capability to do so is based on shared language, culture, norms and conventions, attitudes, values and expectations that generate trust and facilitate the all-important flow of tacit and proprietary knowledge between firms (Grabher, 1993; Amin and Thrift, 1994).

This means that a set of characteristic practices emerges and rapidly spreads to many firms within the region, becoming in turn a part of the shared conventions characteristic of the local production cluster (Storper, 1997, p. 5). Such regions can be regarded as learning regions that are characterised by innovative activity based on localised, interactive learning, and cooperation promoted by organisational innovations in order to exploit learning-based competitiveness (Amin and Thrift, 1995; Mitchie and Sheehan, 2003).

The network model is commonly regarded as the ideal type of RSI (Asheim, 2007, p. 231). The system is characterised by mixed supply and demand interaction and in this regional cluster of firms surrounded by a regional supporting institutional infrastructure. Regionally networked systems of innovation that have been created with increased cooperation with local universities and R&D institutes, or through the establishment of technology transfer agencies, may offer access to knowledge and competence that can supplement locally derived competence of firms (Braczyk *et al.*, 1998; Cooke *et al.*, 2004).

In this type of model, a region needs to maintain and strengthen the diversified and versatile industrial and technological base of the region which can be seen as an important resource for continuous innovation activities in different sectoral and technological interfaces. Furthermore, it is crucial to have a strong educational and research infrastructure in order to integrate large firms into the regional economy (Cooke, 1992, p. 379).

In a dirigiste model, parts of industry and the institutional infrastructure are more functionally integrated into national or international systems of innovation. The collaboration between organisations within this type of RSI conforms more closely to the linear model since the cooperation primarily involves specific projects to develop more radical innovations based on formal analytical-scientific knowledge (Asheim, 2007, p. 233-234).

Technology transfer activities in this innovation model are animated mainly from outside and above the region itself. Initiation of actions is typically a product of central government policies. Funding is largely centrally determined although the agencies in question may have decentralised locations in the regions. The level of co-ordination in such an RSI is very high, at least potentially, since central government plays a leading role, and the level of specialisation is also likely to be high (Cooke, 1992, 2004).

Porter (1990) suggested a dirigiste kind of system might work better if a country is in an investment-driven stage of development. Asheim (1995, p. 14) provides a good example of this model that is the clustering of R&D laboratories of large firms and governmental research institutes in planned science parks and technopoles, normally located in close proximity to universities and technical colleges, but according to evidence, typically they have limited linkages to local industry.
Networked RSI can assist various types of industries in different life cycle phases while grassroots RSI is usually found in mature industries. Dirigiste RSI is more likely to be found in emergent industries (Asheim, 2007, p. 234). Asheim (2007, p. 237) argues that in order to understand the role and workings of different types of RSI in a globalising economy, it is necessary to explore governance structures and supporting regulatory and institutional frameworks regionally as well as nationally.

I have decided to go with the regional systems of innovation approach to develop my hypotheses since through this approach, detailed features of the internal organisation of firms, inter firm relationships, the role public sector plays and its policy, institutional set ups can be explored at a regional level.

5.1.3 Elements of RSI and the Development of Research Hypotheses

A system's innovative performance is shaped by the actors and their activities and interactions together with socioeconomic environments in which these actors work together (Eggink, 2013, p. 9). The analysis in this thesis will focus on the elements that have been identified as important in the NSI and RSI approaches that have informed the Oslo Manual and Innovation surveys.

The core elements that come from the NSI and RSI approaches are research and development, human capital, public policy, access to innovation funding and cooperation as well as region and size of a firm:

Research and Development

Based on the views of a growing number of scholars (Nelson, 1982a; Nonaka, 1995; Afuah, 2003) who see the product development process through a knowledge utilisation and creation perspective, Hernard and McFadyen (2005, p. 504) suggested the knowledge creation theory (Nonaka, 1994; Simon, 1991; Cohen and Levinthal, 1990) is an appropriate one.

For the creation of new knowledge, firms combine and exchange stored knowledge. It is, therefore, important for firms to have accumulated knowledge in order to generate new knowledge so it can become the foundation of future innovations since according to Kogut and Zander (1992, p. 383) knowledge is not newly generated in abstraction from the current abilities of firm but accumulated knowledge.

An example of knowledge creation activities can be found from the basic and applied research initiatives for innovation (Henard and McFadyen, 2005, p. 505). According to the Frascati Manual[33] (2015) which sets out the guidelines for collecting and reporting data on research and experimental development, R&D is defined as *"creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge"* (OECD, 2015, p. 44).

Basic research, that is also called pure or fundamental research, is experimental or theoretical work conducted without any particular application or usage of view, basically in order to gain new knowledge of the fundamental phenomena and observable facts (OECD, 2015, p. 29). This is driven by the curiosity or interest of a scientist in a scientific question.

The importance of basic research was raised by Bush after World War II by pointing out that the fundamental driver of new technologies is pure research (Stokes, 1997; Godin,

[33] For statisticians and science and innovation policy makers in the world, the OECD's Frascati Manual is an essential tool.

2006; Hoffman 2015). Bush (1945, p. 18) treated basic research as "performed without thought of practical ends producing "general knowledge and an understanding of nature and its laws".

The OECD (2015, p. 45) defines basic research as *"experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view".* The main motivation is not to create or invent something but to advance human knowledge. No immediate commercial value is attached to the discoveries that result from basic knowledge where the immediate purpose is to generate understanding for its own sake.

On the other hand, applied research is aimed at solving practical problems of the modern world or to find particular commercial objectives and not to gain knowledge for knowledge's sake (Godin, 2005, p. 645). Applied research is defined by the OECD (2015, p. 45) as *"original investigation undertaken in order to acquire new knowledge".* Applied research is primarily geared to specific, practical aims or objectives.
According to Hoffman (2015, p. 243), however, basic and applied research is produced by research scientists in multiple ways and they are sometimes contradictory. Research that is considered to be basic in one case can be considered as applied in another and sometimes their boundaries can collapse altogether.

While basic research requires long term investment in the creation of knowledge compared to the applied one and the consequences are less predictable, applied research is traditionally characterised as relatively immediate practical, supposedly profitable ramifications (Rosenberg, 1990; Salter and Martin, 2001). The other view on this, however, is that investment is made in basic research because it can produce profitable technology or product that can be licensed out or that can be sold with good profit (Henard and McFadyen, 2005, p. 504).

The ability of firms to exploit knowledge is a critically important component for innovation activities and using the firm's accumulated knowledge information and newly discovered information is effectively evaluated (Cohen and Levinthal, 1990, p. 128). Scholars such as Griliches (1986) and Mansfield (1980) argue that internal investments in basic research are very important activities in product development and a strong determining factor of firm productivity in general.

Based on the empirical evidence in the USA, however, Rosenberg (1990) suggested that private enterprise economies fail to provide appropriate incentives for investment in knowledge production. The reasons can be found from the high degree of uncertainty and uninsurable risk together with the presence of free riders as neoclassical economics presumes that the knowledge is available to everyone once it is produced.

In many cases private firms, especially small firms, are motivated to conduct research and development by the provision of public support (Beise and Stahl, 1999; Stiglitz and Wallsten, 1999; Gonzalez and Pazo, 2008; Busom and Ferandez-Ribas, 2008; Mason and Brown, 2013).

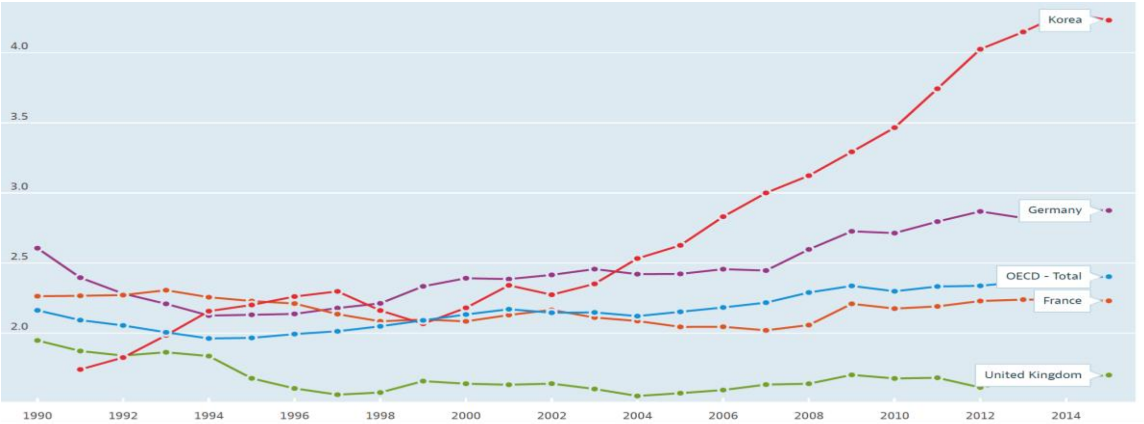
During the 1950s and 60s, technical change and economic growth rate depended more on diffusion than radical innovation and on social innovation. Although basic science was still treated as very important, technology and diffusion was gaining growing interest (Freeman, 1995, p. 10). This phenomenon was found in Japan in the 1950s and 60s, and Korea in the 1970s and 80s when they had extraordinary success in technological and economic catch up by performing at first copy, imitation and import foreign technology but their economies are now explained more by R&D intensity, especially concentrating on fast growing civil industries like electronics.

In most National systems of innovation (NSIs), particularly in low and medium income countries, the investment in R&D is generally modest and is usually conducted by public organisations. The few countries that make heavy investment in R&D are all rich countries and much of their R&D is conducted by private organisations. These include large countries like the USA and Japan but also include small and medium sized countries like Sweden, Switzerland, including Korea (Edquist, 2005, p. 193).

As the OECD (2013) showss, Korea demonstrated exceptional economic growth and industrialisation. Korea has been among the countries that spent the highest government budgets in R&D. Almost 75% of Korean R&D is conducted by business and 88% of it is from the manufacturing sector as of 2010. Korea acknowledges the importance of science and technology and is devoted to technology based economic development by making high levels of expenditure in research and development, producing a highly educated labour force (OECD, 2013).

We can see from Figure 5.1 that Korea spent 1.74% of GDP in research and development in 1991 that has continuously increased during the past two decades and the percentage of GPD spending on R&D reached 4.23% by 2015. Korea has the highest percentage of GDP spending on R&D among the OECD countries.

Figure 5.2 Percentage of GDP Spending on R&D: Korea and Other OECD Countries



(Source: data.oecd.org$_b$, 2016)

As of 2010, 72% of the gross domestic expenditure on R&D in Korea is funded by industry while only 27% is government funded. Although this is relatively high government sector expenditure on R&D, the outputs from universities and research publication remains low in comparison to international standards. The research is very much geared to applied and development oriented focusing on industrial technologies. By 2012, however, with great emphasis of the government on high risk and high return research the rate of basic research has increased to 35% (OECD.org$_a$, 2016).

H1. Research and Development activities, internal and external, have a positive influence on producing innovations.

Human Capital

Innovation is generated partly by the development of human capital and local labour markets, and the mechanisms for knowledge transfer across organisations (Asheim *et al.*, 2011, p.886). Innovation actors use ideas, information, capabilities, skills, information, and technologies that flow within systems of innovation and therefore, human capital and competence are important resources for systems of innovation as a whole (Seppanen, 2008, p. 10).

Edquist (2005, p. 192) explains that the enhancement of human capital is created by competence building such as training and education that is usually carried out in schools and universities as well as in firms and specialist training organisations.

Learning is a central function in systems of innovation and the associative organisations form the regional learning system that is a part of the regional systems of innovation (Cooke *et al.*, 1997, p. 484). The most important learning processes for innovation are interactive and partially emanate from routine activities such as learning-by-doing, learning-by-using and learning-by-interacting, or the experience-based mode of learning (Lundvall, 1992; Jensen *et al.*, 2007). Encompassing these processes, a regional milieu for continuous learning may emerge, which includes an efficient and embedded culture of knowledge sharing and circulation (Kautonen 2006, p. 270).

Knowledge spillovers, especially from university to industry, is not an automatic process and there is complex interdependence between basic and applied research for the knowledge spillovers from university to industry (Lee, 1995; Lehrer, 2007). The characteristics of universities are in the process of changing in order to respond to the transformation of society and new demands. Universities are no longer devoted to basic research but to combine basic and applied research (Bentley et al, 2015, p. 1).

In many regions, universities are viewed as the core of the knowledge base, acting as key elements of systems of innovation supporting science and innovation based regional growth and it occupies the centre of the knowledge economy (Huggins *et al.*, 2008, p. 2). Universities have different capabilities to transfer their knowledge effectively and at the same time regional businesses also have considerably different capabilities in absorbing such knowledge effectively (Florida, 1999; Huggins and Kitagawa, 2012).

This refers to the fact that there is a greater need for lagging firms or regions to innovate but they have lower capacity to absorb funds for the promotion of innovation or to engage in innovation related activities in cooperation with research partners (Oughton *et al.*, 2002; Frenz *et al.*, 2004).

Traditionally basic research has been a fundamental mission to universities and it has been considered as a primary contributor to innovation and economic growth in the linear model of innovation after World War II, and universities in this process act as the institutional locus for public funding (Mowery and Sampat, 2005; Foray and Lissoni, 2009).

Thus, together with the wider education and training system, R&D personnel and qualified staff, the creation and renewal of knowledge and skilled labour is seen as a central part of the learning process within regions (Asheim and Gertler, 2005, p. 294). As Seppanen (2008, p. 5) identified, employees are an important subgroup of human capital and in this thesis the proportion of MSc and higher degree holders and the proportion of research staff among permanent employees is used to represent human capital.

H2. Having high proportion of Master or higher degree holders have a positive association with producing innovation.
H3. Having staff especially devoted to research is necessary to drive innovation and therefore the proportion of research staff among permanent employees is expected to have a positive impact on innovation.

Public Policy

In neoclassical economy theories, research on market failure has been accumulated since Arrow (1963) and there is no one 'best practice' innovation policy approach which applies to any type of region (Cooke *et al*, 2000; Isaksen, 2001; Todtling and Tripple, 2005).

There is a positive relationship between innovation and growth, and closing the innovation and technology gaps is required for reduced income gaps across regions. However, Oughton *et al.*, (2002, p. 98) argue that reducing regional innovation gaps is difficult due to what they term the 'regional innovation paradox'. On page 98 in Oughton *et al.* (2002), the regional innovation paradox is defined as *"the apparent contradiction between the comparatively greater need to spend on innovation in lagging regions and their relatively lower capacity to absorb public funds earmarked for the promotion of innovation and to invest in innovation related activities, compared to more advanced regions".* In order to resolve this innovation paradox, policies that boost the capacity of regions to absorb investment funds for innovation activities are needed (Oughton *et al.*, 2002, p. 102).

Atkinson (1991, p. 561) argues that the political system of the government, decentralisation, strong regional institutions and governance, a strong industrial specialisation in the region, sociocultural homogeneity and thus trust relationships, large economic restructuring problems and strong commitment from regional political leaders are factors contributing to regional innovation policies.

One of the main strengths of the regional level innovation support is the 'garden argument' (Paquet, 1994, p. 11). According to this approach, the economy is regarded as a garden with a variety of trees and plants, and a single gardener or government cannot apply one single rule to them. Growth, therefore, is best orchestrated when it goes down to its sources at the level of cities and regions (Hassink, 2001; Goldfarb and Henrekson, 2003; Brady and Davies, 2004).

Driver and Oughton (2008) emphasise that "*in general, firms and regions are better placed to innovate if they have built up the right resources and if they have processes in place to renew resources and capabilities*". While traditional economics focused on evaluating the region's capacity to utilise existing resources, the systems of innovation perspective helps to evaluate their capacity to create new resources and to build new competence in the economy (Driver and Oughton, 2008, p. 206).

The region is an important level of governance of economic processes between the national level and above the local or municipal level (Asheim, 2007, p. 229). It is, therefore, the responsibility of local governments in cooperation with the central government to use and develop the regions and national territory effectively, increase their competitiveness and preserve the land and the environment (Krugman, 1991; Richardson *et al.*, 2011).

Thus, there are different types of strengths and weaknesses in different types of market economies and therefore coordinated market economies are strongest in diversified quality production (Asheim, 2007, p. 235). Innovation can be supported by government's continual reformation and update on regulations and institutional framework in the area where innovation activities take place (OECD, 2007).

Emphasising the role of innovation policy in innovation development and growth, Link and Link (2009) identified that the development of basic research and R&D programmes are ensured by the innovative activities of government. They took the examples of government initiatives in the US that provide support for innovation activities and these examples include innovation research programmes, setting up university research parks, support for voluntary industry standards, research joint ventures and advanced technology programmes (Cecere, 2013, p. 190).

A government can encourage innovation by providing R&D funding in cutting edge technology development and the actual R&D activities usually take place through universities and public research institutes. A government can also provide monopoly rights over the patents a company registered so that the firms that invested in R&D can benefit from protection in market competition (Ghosh, 1995; Roin, 2014).

Other supports from the government include procurement and collective purchasing to reduce the uncertainty of product sales after the innovation (Hassink, 2001, p. 1392). These reduce the whole risk and encourage firms and individuals to produce technology that society requires. Thus, government make policies in a way that reduces uncertainty and risks in large scale investment in R&D (Hillman *et al.*, 1999; Bloom and van Reenen, 2002). Further direct supports include grants, subsidised or guaranteed loans are important and at the same time indirect support like tax credits or relief are also increasing (Hassink, 2001; Carnes, 2009).

Firms receiving public support, however, can encounter some problems including rent seeking behaviour of economic agents and sometimes the supports do not improve the ultimate outcome of the work (David *et al.*, 2000; Boldrin and Levine, 2003). Catozzella and Vivarelli (2011, p. 40), therefore, argue that even if firms increase expenditure on research and development with the support of government, the innovations can decrease. Moreover, in terms of tax credit or relief, small firms that perform innovation activities may have too little income to be taxed and special arrangements may be needed for such firms (OECD, 2007).

H4 The interaction between the public and private sector is important in systems of innovation and, therefore, policies for R&D supports including funding, tax relief, procurement, and collective purchasing are expected to have a positive impact on innovation.

Cooperation

Domestic rivalry and competition has been treated as an important key determinant, in other words a driving force for innovation and global competitive advantage by Porter (1990, p. 73). Cooperation among firms, however, is important since the foundation of competitive advantage of firms is on continuous innovation and this process is seen as interactive learning processes that are embedded within territory (Maskell and Malmberg, 1999; Asheim and Isaksen, 2000; Sternberg, 2000; Frisch and Franke, 2004; Cowan and Jonard, 2004; Crevoisier, 2004; Hoekman *et al.*, 2010). As Freitas *et al.* (2011) emphasise, personal connections between individuals related to institutional collaborations are important in stimulating cooperation.

Using a game theoretic framework, Oughton and Whittam (1997) analysed cooperation and innovation and recognised that collective external economies may be realised by cooperation over input activities. Firms, especially small and medium firms that collaborate with other firms and organisations, can have access to specialised and diverse expertise and they can share costs and also risks (Keeble, 1997, p. 284). Thus, cooperation can take place because of strictly rational profit maximising behaviour and because of institutional and cultural environments that encourage cooperation and trust (Oughton and Whittam, 1997, p. 3).

In the same vein, empirical studies, for example, Smith (1995) and Park (2001) confirm firms involved in high levels of inter firm relations are more innovative than firms that do not cooperate. Smith (1995) and Park (2001) argue that one reason underlying this result is that cooperation makes economic performance better and it reduces costs in obtaining knowledge.

The level of innovation by firms increases when firms co-operate and collaborate with other firms and bodies such as universities and also when firms network with their suppliers, customers or even competitors (Park and Nahm, 2000; Frenz *et al.*, 2004). A cooperative culture, associative disposition, learning orientation, and quest for consensus are typical of a region displaying systemic interactive innovation at both the institutional and organisational levels.

Chesbrough (2003, p. xxiv) identified the role of firms in carrying out basic research activities by arguing traditionally the basic research took place within firms but there has been a shift to an open innovation model. In this model, firms complement and supplement their own technological resources with other firms. Not only small firms but also large firms are increasingly outsourcing their basic research activities. In order for a firm to be part of the open innovation model, two conditions have to be satisfied. First of all, it has to be a part of technological innovation and secondly, there should be an external relationship either outside-in or inside-out (Chesbrough, 2003).

Firms benefit from research and development activities of specialised and dedicated institutions like universities, public research institutes and commercial research labs. This is because firms that cooperate with different partners have easier access to more varied technological capabilities that they do not have internally in timely manner (Clark and Rhoads, 2009; Wang *et al.*, 2012). Through this activity firms have better innovation capabilities. Due to this trend laboratories in the large firms function more as coordinator and integrator of internal and external knowledge (Clark and Rhoads, 2009).

Firms need to collect information both internally and externally in order to generate innovation and with the increasingly shorter life cycle of products firms, especially small and medium sized firms, are more dependent on information from outside. The innovation process includes collaboration with other organisations and, in terms of institutional contexts, every nation, region and locality have different interactive learning processes (Hassink, 2001, p. 1373).

Although there are positive views on outsourcing research and development there are also negative views. Grimpe and Kaiser (2010) argue that difficulties lie in intellectual property rights about outsourced research and development. It is hard to assimilate and leverage the acquired knowledge since competitors perhaps equally take advantage from the contractor's expertise. This is because the knowledge generated from outsourced research and development is tacit and can be difficult to transfer to their own company (Inkpen, 1998, p. 74).

Embeddedness enables emergence of a milieu *"within which the associational networks so crucial to interactive innovation can become institutionalized"* (Cooke *et al.*, 1997, p. 489). Regions display significantly different structures of systems of innovation components and therefore it is at the level of the internal dynamics of the interaction of firms and organisations, and their links back to the wider institutional structure within the regional system of innovation, that is so important and make regions valuable for study in their own right (Howells, 1999).

Interfirm interaction in local areas and local networks are important in exchanging tacit knowledge and also in creating new knowledge that can serve as a foundation for innovation (Park, 2001, p. 32). Furthermore, the innovation capacity and propensity of firms can be enhanced in many ways when firms and universities cooperate. The relationships enable firms to have access to the research skills and techniques acquired in university research and therefore, firms may gain access to relatively new scientific knowledge located within universities. The more general interaction can encourage the firms to develop new products and processes (Frenz *et al.*, 2004).

H5 Cooperative activity with other institutes or firms in innovation activity has a positive influence on innovation.

Access to Finance and Innovation Funding

Innovation is a costly and risky process since significant resources have to be poured into R&D in order to start the innovation process and the outcome of R&D is uncertain (Schumpeter, 1942; Freeman, 1987; Sutton, 1991; Sirilli and Evangelista, 1998). Finance, however, is very important and access to it is a key driver of the process of creation, survival and growth for firms (King and Levine, 1993; Brown *et al.*, 2009).

In his earlier writing on the microeconomics of innovation, Schumpeter (1939, p. 223-224) emphasised the process of credit creation but then changed his view in his later publication '*Capitalism, Socialism and Democracy*' published in 1942 where he reduced the role of credit creation for innovation production and consequent economic development (O'Sullivan, 2005, p. 242).

Schumpeter (1942, p. 106) argued that large firms are the engine of economic progress and defined them as perfectly bureaucratised giant industrial units that made rationalising and routinising the innovation process possible. This is the reason why he reduced the role of external finance and the banking system but changed his view in favour of internal finance in making innovative investment.

In terms of small sized firms, Casson *et al.* (2008) argue that firms' tendencies to have their own financing modes are based on the company size, the maturity of the firm, and how much finance they need. Small firms compared to larger ones usually have weaker access to formal external finance sources. Private funds from family and friends play a more important role when firms are in the early stages of their life cycle and if the amount they need is not large.

Although Berger and Udell (1998, p. 625) argue that internal finance never outweighs the finance provided from outsiders regardless of whether the firm is young or not, Carpenter and Petersen (2002) emphasise firms that are R&D intensive have to be more dependent on internal funds to finance their investment since the financing constraints caused by capital markets' imperfections impact more heavily on R&D than other investments.

Schumpeter placed the role of innovation as the main stimulus for the economic development process and is considered to be a founding father of the economic analysis of innovation since the allocation of resources, particularly financial resources, was at the centre of his studies (O'Sullivan, 2005, p. 240). Systemic analysis is crucial to a comprehensive economic theory of innovation because allocation of resources to innovation and its complex relationship to that process are important (O'Sullivan, 2005, p. 240).

Access to innovation funds is, therefore, fundamental for firms' activities in order to create economic growth and for investing in tangible (such as, purchasing new equipment or expansion of facilities), and intangible assets such as research and development activities providing a positive influence on innovation (Wang, 2014; Lee *et al.*, 2015; Kim *et al.*, 2016).

Sources of financing can be categorised into private, debt, equity and others. Private funding includes firms' self finance, personal savings of the founder of the firm, family or friends. Debt includes loans from banks or public institutions and risk sharing finance facilities while equity is like venture capital stock market. Others include subsidies and grants from governments and international organisations (Cincera and Santos, 2016, p. 6).

Another source of finance, venture capital, has previously received little attention from financial economists. Silicon Valley's venture capitalists, however, made heavy investments in their ventures and this provides a good example of how they helped in producing innovation and the consequent growth of the firms (Dean and Gigilerano, 1990; Hellmann and Puri, 2002). The US government provided a number of legislative initiatives such as reducing capital gains tax in the late 1970s to allow venture capital to become a more attractive option for investment since then (Saxenian, 1994; O'Sullivan, 2005).

Legal and financial institutions assist all firms that deserve to have access to innovation funds and the greatest effect comes from smaller firms. The most effective way of reducing the growth constraints of SMEs and to encourage them to contribute to economic growth, therefore, is the improvement of institutions and the business environment in general (Beck and Demirguc-Kunt, 2006, p. 2933).

H6 Having access to finance for innovation activities is important in production of innovation.

Geographical Proximity

With a growing globalised economy, where communication and transportation become more rapid every day, we may consider that the importance of locality will be reduced. On the contrary, regions are becoming more important. According to Smith (2000) this is apparent from the fact that increased importance of and attention to clusters, systems of innovation, global production networks and value chains for a firm's knowledge creation and innovation processes, demonstrating that the relevant knowledge base for many industries is not internal to the industry but is distributed across a range of technologies, actors and industries.

Creating knowledge and innovation processes have become more complex, diverse and interdependent. Nonaka and Takeuch (1995) and Lundvall and Borras (1998) have pointed out that there is a dynamic interplay between the transformation of tacit and codified forms of knowledge in knowledge exploration and exploitation. What is also required is a strong interaction of people within and between organisations (Asheim, 2007, p. 224).

According to Asheim (2007, p. 229) the distinction between knowledge bases takes account of the rationale of knowledge creation, the way knowledge is developed and used, the criteria for successful outcomes, and the interplay between actors in the processes of creating, transmitting and absorbing knowledge. This helps to explain their different sensitivities to geographical distance and accordingly the importance of spatial proximity for localised learning (Rodriguez-pose and Cresccenze, 2008, p. 11).

When interrelated and interdependent producers concentrate and operate in a localised area *"good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the businesses have their merits promptly discussed; if one person starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas"* (Marshall, 1890/1930, p. 156).

The importance of location makes it more important to consider science-based (analytical) knowledge for innovation and competitiveness of firms and regions rather than engineering-based (synthetic) knowledge or arts-based (symbolic) knowledge (Laestadius, 2000). An analytical knowledge base refers to economic activities where scientific knowledge based on formal models and codification is highly important and, therefore, knowledge inputs and outs are often codified in this type of knowledge base.

Furthermore, a synthetic knowledge base refers to economic activities where innovation usually takes place by application or novel combinations of knowledge that already exist thus knowledge of this type is more tacit, usually resulting from experience obtained at the workplace and through using and interacting (Lundvall and Nielsen, 1999; Lorenz and Valeyre, 2006).

Symbolic knowledge, on the other hand, is related to the creation of meaning and desire and this type of knowledge is related to aesthetic attributes of products, producing designs, images and symbols, and the economic use of such forms of cultural artifacts

(Scott, 1997, 2007). A distinctive tacit component characterises this type of knowledge due to the cultural embeddedness of interpretations (Granovetter, 1985, p. 482).

According to Moodysson *et al.* (2008, p. 1052), while creation of analytical knowledge tends to be less sensitive to distance and facilitate global knowledge networks together with dense local collaboration, synthetic knowledge creation is more likely to be sensitive to proximity effects between the actors involved and therefore favour local collaboration. A good example can be found from Ormerod *et al.* (2011) who carried out studies on four industries located in Manchester City and identified that a well connected network is important through measuring the locally available knowledge networks and how willing the actors are in exchanging innovation.

Regional development is likely to occur when knowledge spills over among actors who are technologically related (Asheim *et al.*, 2011, p. 883). Related variety affects the knowledge spillovers[34] happen in regions and may also affect the opportunities of regions to diversify into new industries over time (Frenken *et al.*, 2007; Asheim *et al.*, 2011: Boschma and Frenken, 2011). It is also expected that technological breakthrough is enhanced since related technologies to be recombined in a new technology is easy and this can produce technological breakthrough, radical innovation (Castaldi *et al.*, 2015; Hausmann and Klinger, 2007).

There is a strong need to account for such a variety of regional innovation potentials and one should acknowledge that industries based on different knowledge bases innovate in different ways or what is called different modes of innovation (Jensen *et al.*, 2007, p. 682).

The geographical dimension of knowledge transfer has been identified as a key variable in shaping regional innovation performance (Asheim and Gertler, 2005, p. 300). Interactive and real innovations may be hampered if there is too much cognitive proximity, although some degree is needed to ensure effective communication and interactive learning (Nooteboom, 2000). This is because not much learning will happen if actors have the same competences which may even result in cognitive lock-in. Knowledge transfer is shown not to depend only on geographic proximity but on firms'

[34] So called Jacob's externalities (Frenken *et al.*, 2007)

capabilities, absorptive capacity and their ability to renew capabilities over time as well (Asheim *et al.*, 2011, p. 885).

Furthermore, another important factor of the geographical proximity influencing innovation, according to Cooke (2005), is cultural factors. He refers to these as the super-structural issues which are the mentalities among regional actors or the 'culture' of the region. 'Culture' appears at institutional and organisational level, for firms and governance, and it helps to define the embeddedness of the region, its institutions, and organisations or the extent to which a social community operates in terms of shared norms of co-operation, trustful interaction, and 'untraded interdependencies' (Gertler, 1995; Cooke, 2005; Knoben and Oerlemans, 2006).

H7. Regional factors including local knowledge creation, diffusion, application and cultural embeddedness influence innovation.

Firm Size

The issue of firm size, market structure and innovation were raised by Schumpeter (1942) and empirical studies on the relationship between innovation and firm size usually relate innovation indicators to firm size using cross-sectional data (Syrneonidis, 1996, p. 36).

While authors like Scherer (1965) and Kamien and Schwartz (1982) concluded that the Schumpeterian's hypothesis of a more than proportionate effect of firm size on R&D and output of innovation is not fully supported, authors like Soete (1979), Rothwell and Zegveld (1982) and Freeman (1982) concluded that the hypothesis is supported. The findings by Pavitt *et al.* (1987) show a similar phenomenon in the UK where large firms with more than 10,000 employees had higher innovation intensity than small firms with between 100 and 2000 employees thus supporting the Schumpeterian view.

Thus, although Gibrat's law states that the proportionate rate of growth of the firm is unrelated to firm size, the size of a firm is treated as an important determining factor in many literatures on innovation (Teece, 1992; Klepper, 1996; Henderson and Cockburn, 1996; Cohen and Klepper, 1996; Chandy and Tellis, 1998).

According to Chun *et al.* (2015) firms' competitive advantage is from a productive research and development and they argue that in order to examine the relationship between performance of firms and R&D activities, therefore, taking the size of firms and industry type into consideration is the usual practice.

Large firms can benefit from economies of scale, obtaining advantages in the market in comparison to small and medium firms, and therefore having easier access to financial resources permit larger firms to have easier access to sources of funding (Almeida and Fernandes, 2008, p. 13).

H8. Firm size influences innovation: larger firms find it easier to innovate, while smaller firms find it more difficult to innovate.

5.2 SUMMARY

This chapter has reviewed theories of innovation from the influential linear model of innovation to evolutionary theories and the national and regional systems of innovation literature. The linear model begins with basic research followed by added applied research and development and ends with production and diffusion. While under this theory technical progress was endogenous being determined by R&D expenditure, mainstream economics assumed technical progress was exogenous and these two theories developed in parallel with little discussion between them.

Using the Cobb-Douglas type of production function, Solow, a key contributor to neoclassical growth theory, explains output requires capital and labour input as well as a total factor productivity. Furthermore, if a country grows with capital accumulation as the Solow model suggests, all countries will converge on the same living standards. In reality, this is not the case and there has not been full convergence.

The basic factors of the neoclassical explanation include a competitive industry and the sector is presumed to have equilibrium in terms of supply and demand, maximisation and aggregation. While the high degree of diversity is hidden in neoclassical theory, evolutionary economic theory emphasises diversity and selection.

Thus, the inability of neoclassical theories to explain patterns in innovation and growth (Maurseth, 2001, p. 3) together with Freeman's early work led Freeman and others to develop a new approach to innovation – national systems of innovation.

While national systems of innovation is used in explaining national differences between economies, with the view that innovation is localised and locally embedded and innovation emerges from socio institutional environments (Storper, 1997), regional systems of innovation was developed by Cooke in 1992.

In regional systems of innovation, cooperation for innovation activity, knowledge creation and diffusion among organisations such as universities, R&D institutes and technology transfer agencies as well as the innovation supportive culture from which firms and systems evolve as time passes are important.

The research hypotheses for this thesis, therefore, have been drawn from core elements that are identified as important from national and regional systems of innovation approaches. They are R&D, human capital, public policy, cooperation, access to finance and innovation funding, geographical proximity, and firm size.

The hypotheses developed in this chapter will be tested using the data from the Korea Innovation Surveys that have been informed by the Oslo Manual produced based on the systems of innovation approaches in the next chapter.

Chapter 6
REGIONAL ANALYSIS

In order to identify variation in innovation performance across the sixteen different regions in Korea, raw data from the 2008, 2010 and 2012 Korean Innovation Surveys (KIS) has been analysed by region. This analysis focuses on the four main types of innovation identified in the Green Paper on innovation by the European Commission (1995, p. 7) discussed in Section 4.2.1.1.

Product Innovation is a composite variable that combines *New Product Innovation* and *Significantly Improved Product Innovation*. *Process Innovation* is another composite variable that includes the following types of innovation: *New or Significantly Improved Methods of Manufacturing Goods*; *New or Significantly Improved Logistics Delivery or Distribution Methods*; and *New or Significantly Improved Supporting Activities. Organisational Innovation* combines the following types of organisational innovation: *New business practices for organising procedures*; *New methods of organising work responsibility*; and *New methods of organising external relations with other organisations*. Finally, *Marketing Innovation* includes at least one of the following: *Significant changes to the aesthetic design or packaging of a good*; *New media or techniques for product promotion*; *New sales strategies such as new methods for product placement or sales channels*; and *New methods of pricing goods*.

The following sections analyse innovation activities by region.

6.1 Measurement of Innovation by Region, 2005-2007 (KIS 2008)

Table 6.1 reports the proportion of firms that introduced different types of innovation and the coefficient of variation across the regions based on an analysis of 3,081 manufacturing firms for twenty two industries operating in Korea between 2005 and 2007 (KIS 2008).

Table 6.1 Proportion of Innovators for All Types (Product, Process, Organisational and Marketing) by Region, 2005-2007

%	Product Innovation	Process Innovation	Organisational Innovation	Marketing Innovation	New to the Market Product Innovation	New to the Firm Product Innovation
Seoul	38.5	29.4	33.0	28.5	18.4	35.2
Busan	34.1	30.5	23.2	15.9	15.0	31.8
Daegu	23.5	24.8	24.2	10.1	8.1	22.1
Incheon	28.3	24.7	19.1	13.1	12.4	24.7
Gwangju	20.3	12.5	10.9	4.7	9.4	18.8
Daejeon	50.8	37.7	41.0	21.3	21.3	42.6
Ulsan	27.1	27.1	21.4	5.7	4.3	25.7
Kyunggi	33.7	25.4	24.7	16.6	12.6	31.5
Gangwon	18.9	13.5	13.5	10.8	2.7	16.2
ChoongBook	35.9	37.9	33.0	16.5	14.6	32.0
ChoongNam	35.4	29.1	28.3	15.7	15.7	33.9
Jeonbook	29.0	26.1	24.6	15.9	14.5	23.2
Jeonnam	26.5	26.5	14.7	11.8	11.8	22.1
KyungBook	25.2	22.3	19.3	8.4	6.9	22.3
KyungNam	26.0	24.3	19.6	7.1	10.8	23.3
Jeju	25.0	25	12.5	25.0	12.5	25.0
Average	29.89	26.05	22.69	14.32	11.94	26.90
Standard Deviation	7.95	6.74	8.23	6.57	4.89	6.93
Coefficient of Variation	26.59	25.86	36.28	45.90	40.99	25.75

Source: KIS 2008 own calculations

Using Table 6.1, Figures 6.1 and 6.2 have been produced:

Figure 6.1 Proportion of Innovators for Product, Process, Organisational and Marketing Innovation by Region, 2005-2007

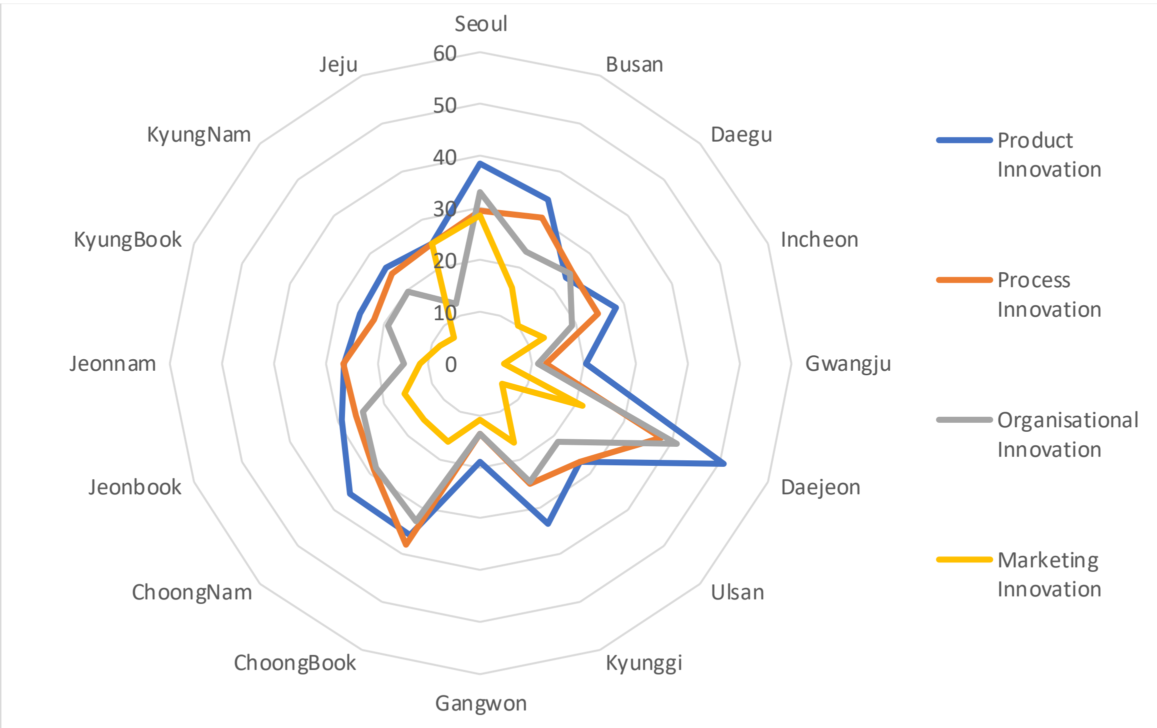
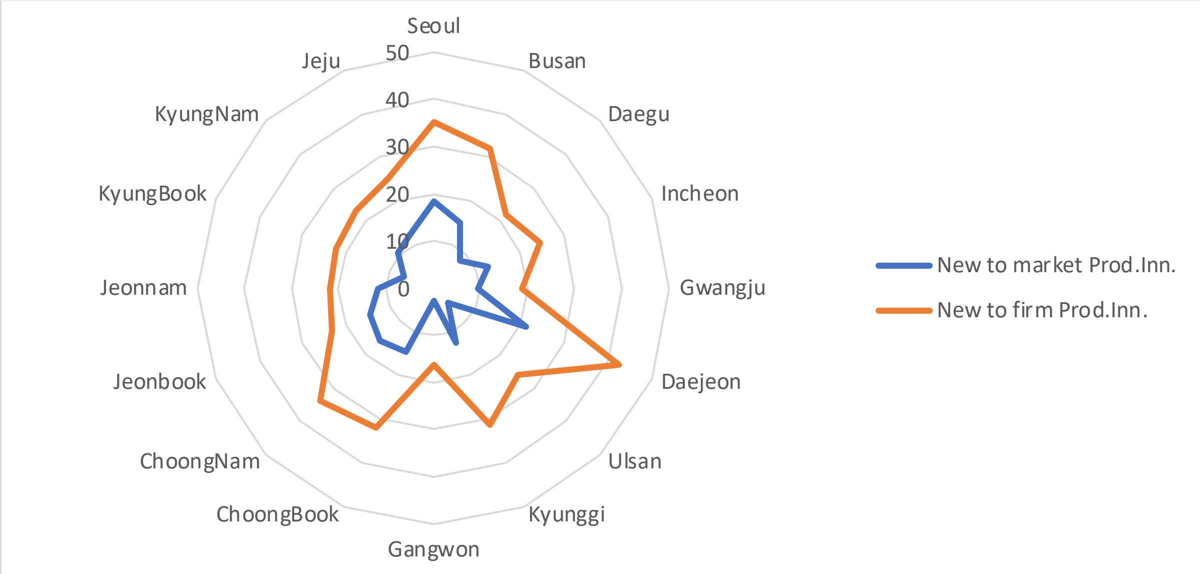


Figure 6.2 Proportion of Product Innovators (New to market and New to company) by Region, 2005-2007



As Table 6.1 and Figures 6.1 and 6.2 illustrate, the most common type of innovation across all regions was product innovation followed by process, organisational and marketing innovation between 2005 and 2007. The highest proportion of firms that produced product innovations can be found from Daejeon (50.8%) followed by Seoul (38.5%). Gangwon (18.9) and Gwangju (20.3%) had the lowest proportion of firms that introduced product innovations. The value of the coefficient of variation is 26.59%.

As far as *Process Innovation* is concerned, Choongbook (37.9%) and Daejeon (37.7%) had the highest proportion of firms that produced at least one process innovation while Gwangju (12.5%) followed by Gangwon (13.5%) had the lowest proportion of firms that introduced process innovation. Dejeon (41%), Seoul (33%) and Choongbook (33%) had the highest proportion of Organisational innovation producing firms while the lowest proportion of firms producing this category of innovation were in Gwangju (10.9%) followed by Jeju (12.5%). As for Marketing innovation, the highest proportion of firms that produced this innovation were in Seoul (28.5%) and Daejeon (21.3%) and the lowest proportion of firms were in Gwangju (4.7%) followed by Ulsan (5.7%).

The value of coefficient of variation of process innovation is 25.86% and this is similar to that of product innovation. The values of the coefficient of variation for organisational and marketing innovation are 36.28% and 45.90% respectively.

As far as New to market product innovation is concerned, the highest proportion of firms in Daejeon followed by Seoul produced the new to market product innovation while the lowest proportion of firms in Gangwon followed by Ulsan produced this category of innovation.

The highest proportion of firms in Daejeon followed by Seoul produced the new to firm product innovation while the lowest proportion of firms in Gangwon followed by Gwangju produced this category of innovation. The value of coefficient of variation for new to market product innovation is 40.99% while the value for new to firm product innovation is 25.75% across the regions.

6.2 Measurement of innovation by region, 2007-2009 (KIS 2010)

Table 6.2 shows the proportion of firms that introduced different types of innovation and the coefficient of variation across the regions based on an analysis of 4,086 manufacturing firms spread over twenty two different industries operating in Korea for 2007-2009 (KIS 2010).

Table 6.2 Proportion of Innovators for All Types (Product, Process, Organisational and Marketing) by Region, 2007-2009

%	Product Innovation	Process Innovation	Organisational Innovation	Marketing Innovation	New to the Market Product Innovation	New to the Firm Product Innovation
Seoul	50.2	38.4	42.4	35.5	21.5	46.7
Busan	38.6	29.7	26.8	16.7	11.4	35.8
Daegu	39.0	32.7	27.7	18.9	13.8	36.5
Incheon	38.3	31.7	27.5	19.5	13.9	34.1
Gwangju	45.6	33.3	38.6	17.5	12.3	43.9
Daejeon	70.3	54.7	51.6	50.0	39.1	57.8
Ulsan	34.5	41.6	31.9	12.4	11.5	32.7
Kyunggi	47.0	36.3	33.3	23.4	18.0	42.6
Gangwon	46.9	42.9	34.7	32.7	20.4	40.8
ChoongBook	53.0	47	38.9	29.5	22.8	45.0
ChoongNam	43.6	41.2	37.7	23.5	16.7	40.2
Jeonbook	36.6	26.9	24.7	20.4	16.1	30.1
Jeonnam	25.9	30.6	20.0	14.1	7.1	24.7
KyungBook	40.9	35	33.1	15.6	14.0	35.8
KyungNam	37.8	36	31.4	16.8	15.6	33.1
Jeju	26.7	13.3	20.0	20.0	6.7	20.0
Average	42.18	35.71	32.10	24.06	18.09	36.70
Standard Deviation	10.60	9.26	8.20	10.56	10.40	9.33
Coefficient of Variation	25.13	25.93	25.5	43.89	57.49	25.42

Source: KIS 2010 own calculations

Using the figures in Table 6.2, Figures 6.3 and 6.4 have been produced:

Figure 6.3 Proportion of Innovators for Product, Process, Organisational and Marketing Innovation by Region, 2007-2009

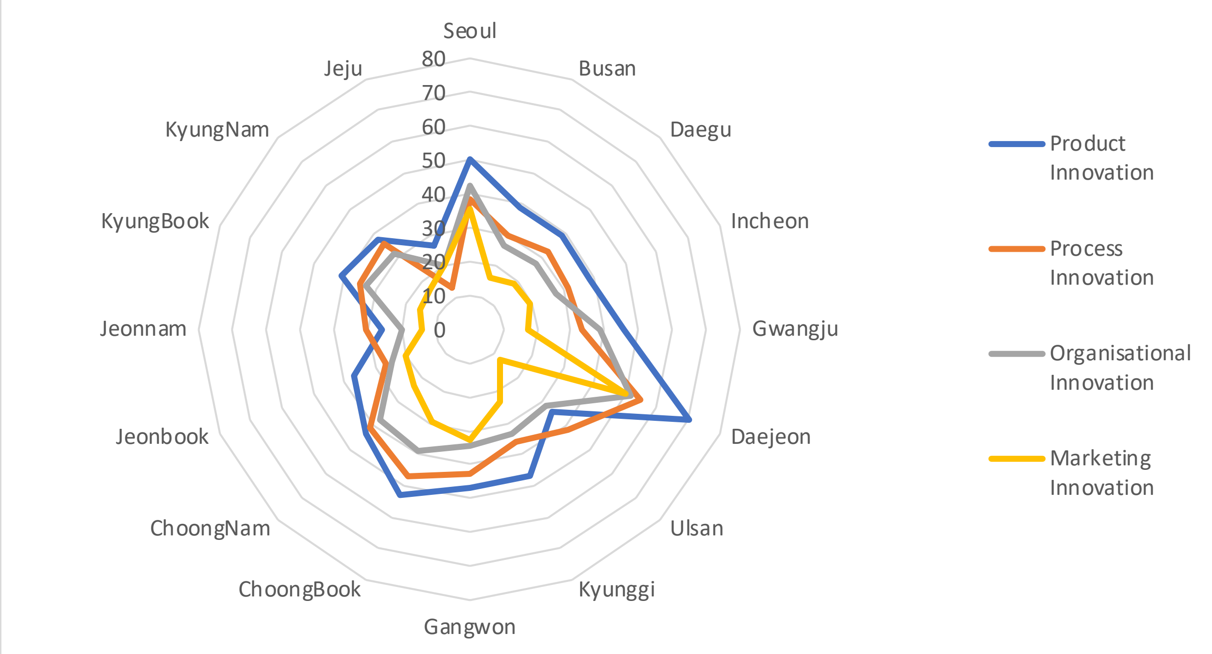
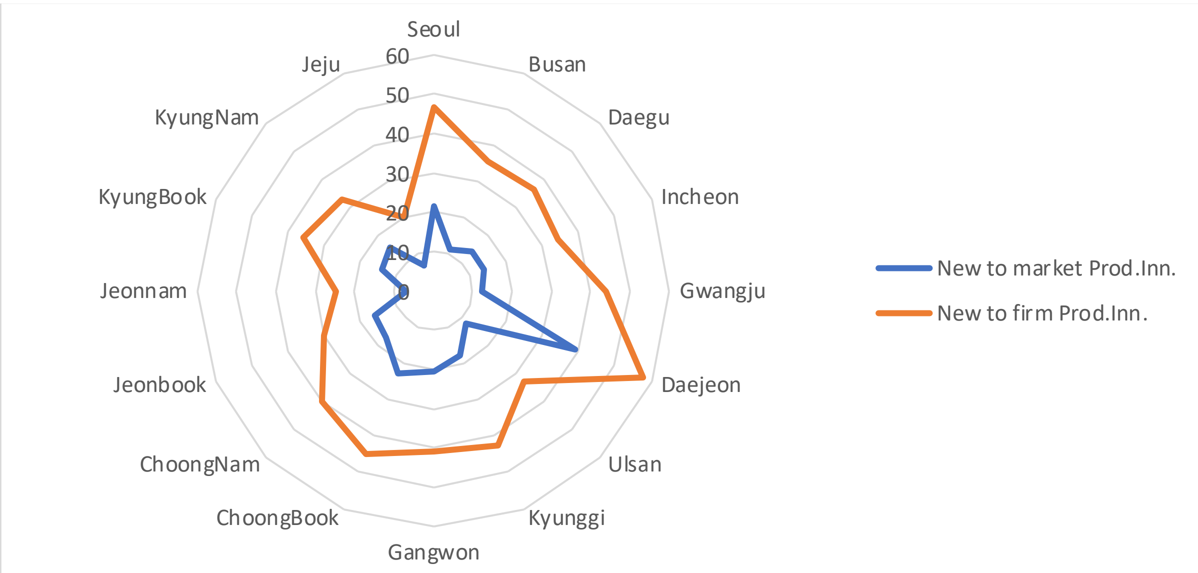


Figure 6.4 Proportion of Product Innovators (New to market and New to company) by Region, 2007-2009



The innovation types that had the highest proportion of firms were *product innovation* followed by *process, organisational and marketing innovation* as a whole between 2007 and 2009. Daejeon had the highest proportion of firms (70.3%) that carried out *product innovation* during this period, followed by Choongbook (53%). Jeonnam had the lowest proportion of firms (25.9%) that performed *Product Innovation* followed by Jeju (26.7%). The value of the estimated coefficient of variation is 25.13%.

For *Process innovation*, Daejeon had the highest proportion of firms, 54.7%, that carried out Process innovation followed by Gangwon (42.9%) whilst Jeju (13.3%) had the lowest proportion followed by Jeonbook (26.9%). The same region, Daejeon, had the highest proportion of firms (51.6%) that produced *Organisational innovation* followed by Seoul (42.4%). Jeju and Jeonnam both had the lowest proportion firms, 20.0%, that produced *organisational innovation*. *Marketing Innovation* was the least active innovation produced over the period. Again, Daejeon was the most active region in producing *marketing innovation* with 50% of innovative firms followed by Seoul (35.5%) whilst Ulsan (12.4%) had the least proportion of innovative firms followed by Jeonnam (14.1%).

As far as *New to market product innovation* is concerned, the highest proportion, 39.1% firms in Daejeon followed by Choongbook (22.8%) which produced at least one *new to market product innovation* while the lowest proportion of firms in Jeju (6.7%) followed by Jeonnam (7.1%) firms produced this category of innovation. The coefficient of variation for this category is 57.49%. For *New to firm product innovation*, the highest proportion of 57.8% of firms in Daejeon followed by Seoul (46.7%) produced at least one *new to firm product innovation* while the lowest proportion of firms in Jeju (20%) followed by Jeonnam (24.7) produced this category of innovation. The value of coefficient of variation for new to *market product innovation* is 57.49% while it is 25.42% for *new to firm product innovation*.

6.3 Measurement of Innovation by Region, 2009-2011 (KIS 2012)

Table 6.3 reports the proportion of firms that introduced different types of innovation and the coefficient of variation across the regions based on an analysis of 3,925 manufacturing firms spread over twenty two different industries operating in Korea for 2009-2011 (KIS 2012).

Table 6.3 Proportion of Innovators for All Types (Product, Process, Organisational and Marketing) by Region, 2009-2011

%	Product Innovation	Process Innovation	Organisational Innovation	Marketing Innovation	New to Market Product Innovation	New to Firm Product Innovation
Seoul	15.3	7.1	14.6	14.4	6.4	9.9
Busan	5.3	13.7	5.3	13.7	3.1	7.1
Daegu	14.7	12.5	9.7	16.5	3.6	9.7
Incheon	18.3	8.3	10.5	14.3	5	13.5
Gwangju	15.8	14.5	6.6	21.1	5.3	10.5
Daejeon	19.4	9.7	9.7	22.2	8.3	11.1
Ulsan	3.2	2.2	3.2	15.1	0	2.2
Kyunggi	17.6	10.1	10.8	15.6	6.9	11.5
Gangwon	13.7	5.9	7.8	11.8	9.8	5.9
ChoongBook	18.9	12.2	14	24.4	7.9	8.5
ChoongNam	17.1	10.2	7.8	18	5.4	8.8
Jeonbook	17.4	9.6	11.3	24.3	6.1	9.6
Jeonnam	13.3	4	10.7	21.3	5.3	12
KyungBook	9.4	7.3	6.3	13.2	2.8	6.6
KyungNam	9.3	10	7.5	16.5	4.5	5.5
Jeju	6.7	0	6.7	6.7	6.7	0
Average	13.46	8.58	8.91	16.82	5.44	8.28
Standard Deviation	5.14	4.04	3.07	4.83	2.38	3.60
Coefficient of Variation	38.17	47.13	34.51	28.70	43.69	43.48

Source: KIS 2012 own calculations

Using the figures in Table 6.3, Figures 6.5 and 6.6 have been produced:

Figure 6.5 Proportion of Innovators for Product, Process, Organisational and Marketing Innovation by Region, 2009-2011

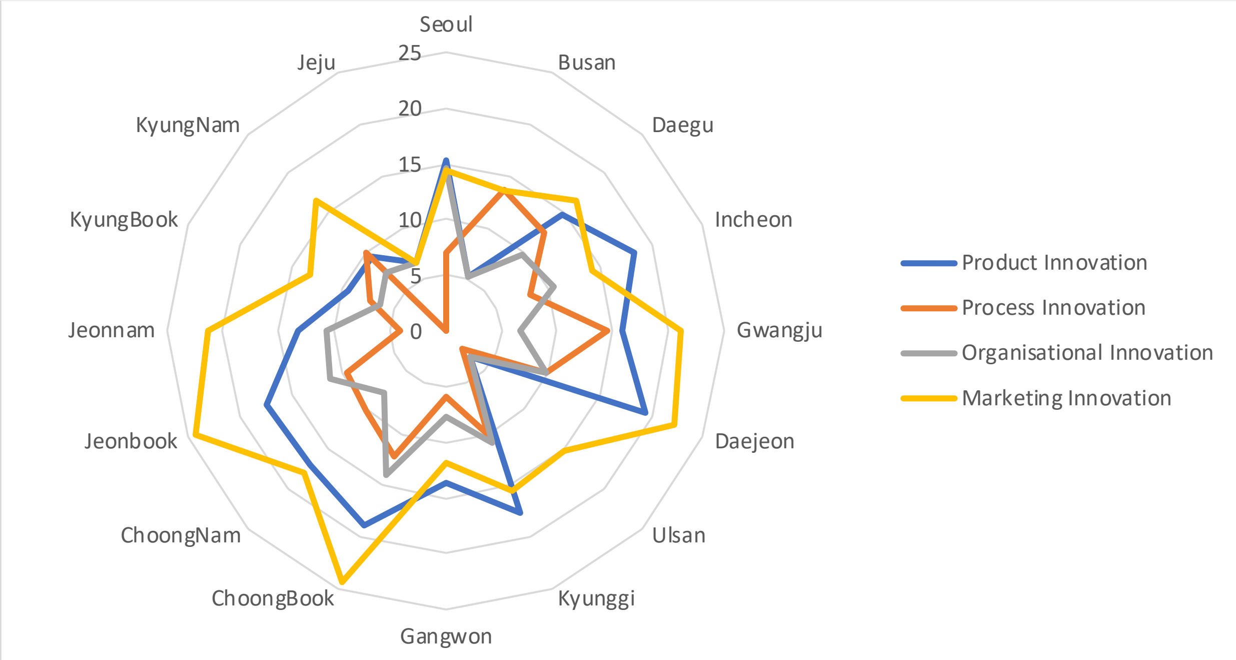


Figure 6.6 Proportion of Product Innovators (New to market and New to company) by Region, 2009-2011

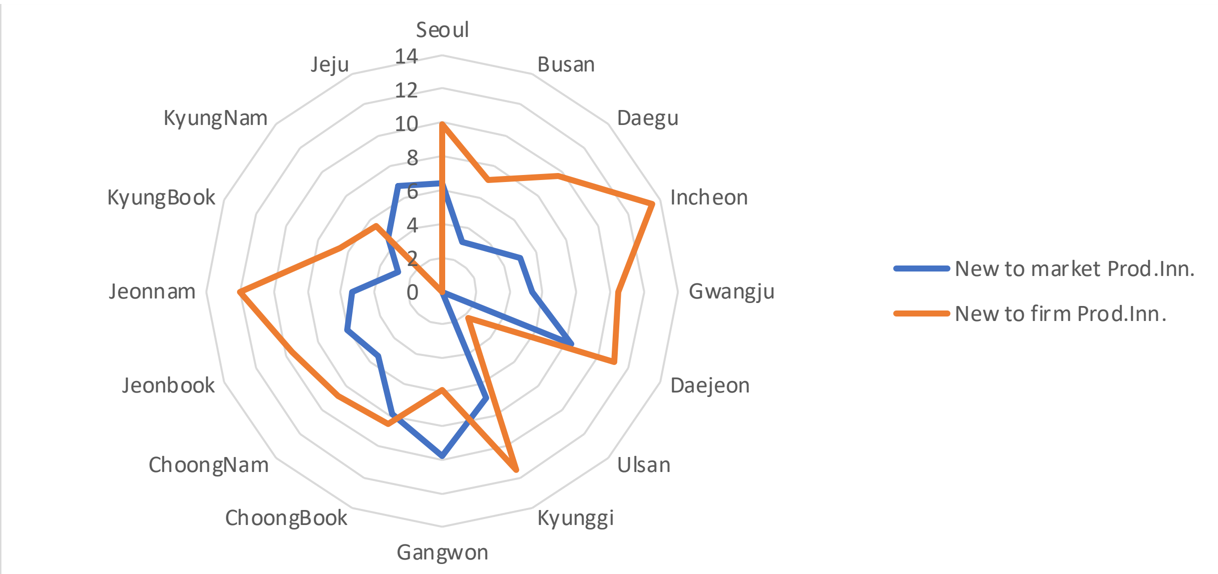


Table 6.3 and Figures 6.5 and 6.6, show that the most common types of innovation were *marketing innovation* and *product innovation*. *Process* and *organisational innovation* were produced at a similar level between 2009 and 2011. The highest proportion of firms (19.4%) in Daejeon followed by Choongbook (18.9%) introduced *product innovation*

while the lowest proportion of firms (3.2%) in Ulsan produced *product innovation* followed by Busan (5.3%). The value of the estimated coefficient of variation is 38.17%.

As far as *process innovation* is concerned, the highest proportion of firms (14.5%) in Gwangju followed by Busan (13.7%) produced at least one type of *process innovation* while Jeju (0%) followed by Ulsan (2.2%) had the lowest proportion of firms introducing the innovation. Seoul had the highest proportion of firms, 14.6%, followed by Jeonbook (11.3%) that carried out *Organisational innovation* while the lowest proportion of firms producing this type of innovation were in Ulsan (3.2%) followed by Busan (5.3%). As for *Marketing innovation*, the highest proportion of firms (24.4%) producing this innovation were in Choongbook (24.4%) followed very closely by Jeonbook (24.3%) while the lowest proportion were in Jeju (6.7%) and Gangwon (11.8%).

The value of the coefficient of variation of *process innovation* is 47.13%. The value of the coefficient of variation of *organisational innovation* is 34.51%. *Marketing innovation* shows a coefficient of variation value of 28.70%.

As far as *New to market product innovation* is concerned, the highest proportion of firms, 9.8%, in Gangwon followed by Daejeon (8.3%) produced at least one *new to market product innovation* when the lowest proportion in Ulsan (0%) followed by Kyungbook (2.8%) produced this category of innovation. For *New to firm product innovation*, the highest proportion of firms, 13.5%, in Incheon (13.5%) followed by Kyunggi (11.5%) produced at least one *new to firm product innovation* when the lowest proportion in Jeju (0%) followed by Ulsan (2.2%) produced this category of innovation. The values of coefficient of variation for new to market and *new to firm product innovation* are 43.69% and 43.48% respectively across the regions.

Table 6.4 lists the regions that had the highest proportion of firms producing innovations and it is noticeable that for the periods 2005-2007 and 2007-2009 the regions with the highest innovation are either Daejeon, Seoul or Choongbook while during 2009-2011 more various regions were innovative.

Table 6.4 The Regions with the Highest Proportion of Firms Producing Each Innovation, 2005-2011

	The regions with the highest proportion of firms producing innovations		
	2005-2007	2007-2009	2009-2011
Product Innovation	Daejeon, Seoul	Daejeon, Choongbook	Daejeon, Choongbook
Process Innovation	Choongbook, Daejoen	Daejeon, Choongbook	Gwangju, Busan
Organisational Innovation	Daejeon, Seoul, Choongbook	Daejeon, Seoul	Seoul, Jeonbook
Marketing Innovation	Seoul, Daejeon	Daejeon, Seoul	Choongbook, Jeonbook
New to market product innovation	Daejeon, Seoul	Daejeon, Choongbook	Gangwon, Daejeon
New to firm product innovation	Daejeon, Seoul	Daejeon, Seoul	Incheon, Kyunggi

Source: KIS 2008, 2010 and 2012 based on own calculations

In contrast, Table 6.5 lists the regions with the lowest proportion of firms for innovation production. Gangwon and Gwangju are the two least innovative regions for the period 2005-2007 and Jeju and Jeonnam for 2007-2009. In the case of the period 2009-2011, like the most innovative regions listed above, the least innovative regions are similarly quite diverse.

Table 6.5 The Regions with the Lowest Proportion of Firms Producing Each Innovation, 2005-2011

	The regions with the lowest proportion of firms producing innovations		
	2005-2007	2007-2009	2009-2011
Product Innovation	Gangwon, Gwangju	Jeonnam, Jeju	Ulsan, Busan
Process Innovation	Gwangju, Gangwon	Jeju, Jeonbook	Jeju, Ulsan
Organisational Innovation	Gwangju, Jeju	Jeju, Jeonnam	Ulsan, Busan
Marketing Innovation	Gwangju, Ulsan	Ulsan, Jeonnam	Jeju, Gangwon
New to market product innovation	Gangwon, Ulsan	Jeju, Jeonnam	Ulsan, Kyungbook
New to firm product innovation	Gangwon, Gwangju	Jeju, Jeonnam	Jeju, Ulsan

Source: KIS 2008, 2010 and 2012 based on own calculations

6.4 Innovation Activities by Region

In such a competitive economic environment like today, innovations are critically important for growth of the firm and there are various aspects of innovation activities that contribute to the production of innovation. As discussed in Section 5.1.3, *R&D*, *Human capital, public support, having access to innovation finance/funds,* and *cooperative activities* with other institutions and organisations are identified as important innovation activities influencing the production of innovation.

R&D is a composite variable that combines *Internal* and *External R&D*. *Public Support* is another composite variable that includes the following types of *public support*: *tax relief for technology development; support for technology development and funding; participation in government R&D projects; technical support from the government; technology information; technicians and educational research; procurement by government or collective purchasing; and marketing*. *Access to innovation funds* combines the following type of funds: *Internal Fund; Loans; Government Funding; and Stock Issue.* Finally, *Cooperation* includes either or both of cooperation in product/process. The composite variable values imply a firm carried out at least one of the sub activities.

This section is concerned with analysing and examining innovation activities by firms, and its variations across regions. Included in this analysis are over 11,000 firms that participated in the KIS 2008, 2010, and 2012.

6.4.1 KIS 2008 (2005-2007)

Daejeon was the most innovative region according to KIS 2008, followed by Seoul and Choongbook. Tables 6.6 and 6.7 show that these three regions have high proportions of firms that carried out at least one or both of *internal* and *external R&D* activities, *public supports*, *human capital* that include the presence of *MSc holders* and the presence of *research staff* among permanent employees, and *Cooperation* with other institutions and organisations for at least one of the four innovations: *product, process, organisational* and *marketing innovation.*

Looking at the *public support* the firms received, Daegu, the region with the lowest economic development level approximated by GRDP per capita income, had the highest proportion of firms, 26.8%, receiving tax relief support. Apart from the tax relief, Daejeon was the region with the highest proportion of firms that received seven other types of *public supports*.

In all regions the higher proportion of firms engaged in *internal R&D* more than *external* ones except Ulsan where only 14.3% of firms carried out internal R&D but 44.3% of firms carried out *external R&D*.

In terms of access to innovation finance/funds, *Internal Fund* that includes company's own funds and funds from affiliated and subsidiary firms were the most common funding source across the regions. Deajeon had the highest proportion of firms, 65.6%, 36.1%, and 21.3%, that used *Internal Finance*, *Government Funding*, and *loans* that include bank loans and company bonds respectively.

Looking at the coefficient of variation across various innovation activities, the lowest values for the coefficient of variation for *Access to innovation finance/funds* and *R&D* activities (firms carried out either or both *internal* and *external R&D*), 17.38% and 18.25%, can serve as evidence of high priority given to innovation activities. These are followed by *cooperation* with a value of the coefficient of variation of 32.15%.

On the contrary, the presence of *MSc or higher degree holders* among permanent employees has the highest value of the coefficient of variation, 71.29%, providing evidence of low priority in innovation activities.

As far as *access to innovation finance/funds* is concerned, the lowest value of coefficient of variation among four different types of innovation finance/funds, 17.51%, suggests that *Internal Finance* is the most commonly used source of funds for innovation across regions followed by loans which is 35.82%. Finally, the value of 98.97% for *Stocks* option may suggest that this is not a very common source of innovation finance/funds that firms adopt.

Table 6.6 Proportion of Firms that Carried out Innovation Activities (R&D and Public Support) by Region, 2005-2007

	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
Seoul	54.2	22.7	54.4	10.2	13.2	14.3	11.7	12.8	13.4	11.9	15.3	25.5
Busan	46.4	20.9	46.8	10.5	18.6	13.2	13.6	13.2	12.7	11.4	16.8	26.4
Daegu	40.9	18.1	40.9	26.8	26.8	16.1	11.4	14.1	12.8	10.7	18.8	30.2
Incheon	44.6	16.3	45	8	10.4	4.8	5.2	6.8	4	2	7.2	17.9
Gwangju	29.7	9.4	29.7	10.9	12.5	7.8	6.3	7.8	7.8	7.8	6.3	15.6
Daejeon	67.2	67.2	67.3	19.7	36.1	29.5	19.7	24.6	19.7	14.8	29.5	45.9
Ulsan	14.3	44.3	44.3	10	17.1	15.7	15.7	14.3	14.3	11.4	12.9	27.1
Kyunggi	48.7	19.4	49.3	9.8	14.9	11.8	10.9	11.1	11.1	8.7	12.1	22.8
Gangwon	40.5	18.9	40.5	2.7	13.5	8.1	5.4	8.1	5.4	5.4	8.1	16.2
Choongbook	59.2	26.2	60.2	11.7	11.7	11.7	7.8	7.8	11.7	7.8	11.7	23.3
Choongnam	49.6	20.5	49.6	12.6	18.1	14.2	11.8	15	8.7	7.9	12.6	29.9
Jeonbook	49.3	23.2	49.3	10.1	11.6	15.9	13	14.5	11.6	14.5	13	26.1
Jeonnam	47.1	10.3	47.1	7.4	13.2	8.8	10.3	10.3	10.3	7.4	11.8	22.1
Kyungbook	43.6	16.3	43.6	10.4	12.9	11.4	10.9	13.4	12.9	8.9	9.9	19.8
Kyungnam	39.2	17.9	39.5	8.8	15.2	12.8	11.1	10.1	9.1	7.8	10.5	22
Jeju	50	25	50	25	37.5	25	37.5	25	25	25	25	50
Average	45.28	23.54	47.3	12.16	17.7	13.82	12.64	13.06	11.91	10.21	13.8	26.30
Standard Deviation	11.87	14.01	8.64	6.34	8.42	6.19	7.60	5.32	5.07	5.09	6.22	9.53
Coefficient of Variation	26.20	59.52	18.2	52.13	47.5	44.83	60.12	40.71	42.59	49.89	44.9	36.23

(Source: KIS 2008 own calculations)

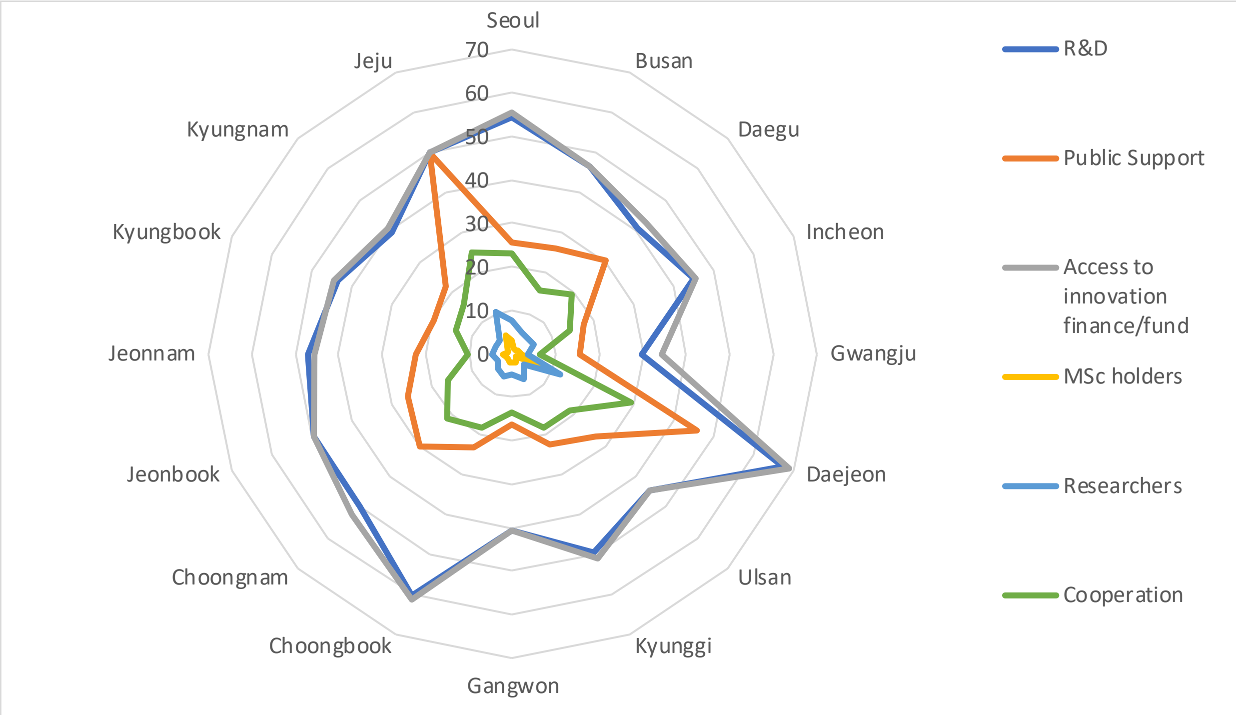
Table 6.7 Proportion of Firms that Carried out Innovation Activities (Access to Innovation Finance/Funds, Human capital and Cooperation) by Region, 2005-2007

	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
Seoul	53.4	13.8	13.6	1.7	55.5	3.12	7.43	23.1
Busan	44.1	12.7	18.2	0.9	46.8	1.13	5.39	15.9
Daegu	40.3	10.1	26.2	2	43	1.26	5.13	19.5
Incheon	43.4	13.1	11.2	2.4	45.4	1.41	5.06	14.3
Gwangju	34.4	14.1	12.5	0	34.4	2.33	3.54	6.3
Daejeon	65.6	21.3	36.1	1.6	68.9	7.08	11.9	29.5
Ulsan	42.9	12.9	17.1	1.4	44.3	0.97	3.48	18.6
Kyunggi	48.8	12.5	15.8	0.7	50.9	1.96	6.32	18.4
Gangwon	40.5	5.4	10.8	0	40.5	1.95	4.90	13.5
Choongbook	57.3	18.4	10.7	0	61.2	1.95	5.6	18.4
Choongnam	50.4	11.8	18.1	1.6	52	1.45	4.56	21.3
Jeonbook	46.4	14.5	10.1	2.9	49.3	1.68	3.91	15.9
Jeonnam	44.1	7.4	13.2	0	45.6	2.23	4.71	10.3
Kyungbook	42.6	10.9	13.4	0.5	44.6	1.12	4.17	13.9
Kyungnam	38.2	11.5	14.9	0	40.5	1.26	4.15	16.2
Jeju	37.5	25	37.5	0	50	4.55	10.4	25.0
Average	45.62	13.46	17.46	0.98	48.31	2.22	5.67	17.51
Standard Deviation	7.99	4.82	8.54	0.97	8.40	1.58	2.38	5.63
Coefficient of Variation	17.51	35.82	48.89	98.97	17.38	71.29	42.06	32.15

(Source: KIS 2008 own calculations)

Using Tables 6.6 and 6.7, Figure 6.7 has been produced:

Figure 6.7 Proportion of Firms that Carried out Innovation Activities (R&D and Public Support, Human capital, Cooperation and Access to Finance/Fund) by Region, 2005-2007



In general, in the case of the 2008 survey, the value of coefficient of variation of all innovation activities is less than 37%, except in the presence of *MSc or higher degree holders* which is 71.29%.

6.4.2 KIS 2010 (2007-2009)

As in the case of KIS 2008 Daejeon was the most innovative region according to KIS 2010 as well followed by Choongbook and Seoul. Tables 6.8 and 6.9 show that these three regions, Daejeon, Choongbook and Seoul, rank as the top three regions for having the highest proportion of firms that carried out at least one or both of *internal* and *external R&D* activities (79.7%, 71.8%, 68.2%), public supports (57.8%, 44.3%, 40.5%) and having access to innovation finance/funds (78.1%, 73.2%, 69.3%). Daejeon had the highest proportion of firms with the *presence of MSc holders*, 5.55%, *the presence of research staff*, 13.02%, *Cooperation* with other institutions and organisations for at least one of the four innovations, 35.9%.

Looking at *public support* measures, firms in Daejeon region had the highest proportion of firms that received all eight public policy supports, with the most frequently used support (42.2%) in the region being *technology development and funding*.

Comparing *internal* and *external R&D* across regions, all regions had a much higher proportion of firms engaged in *internal R&D* than *external* ones.

In terms of access to innovation finance/funds, *Internal Finance* that includes company's own fund and funding from affiliated and subsidiary firms were the most common funding source across the regions. Deajeon had the highest proportion of firms, 73.4%, 42.2%, and 28.1% using *Internal Finance*, *loans* that include *bank loans* and *company bonds* and *Government Funding* respectively.

Looking at the coefficient of variation across regions for various innovation activities, the lowest values, 13.61% and 14.02%, for *access to innovation finance/funds* and *R&D* activities (firms carried out either or both *internal* and *external R&D*), respectively can serve as evidence that these are the most commonly used innovation activities. This is followed by *public support* with a value of the coefficient of variation of 21.75%.

On the contrary, the *presence of MSc or higher degree holders* among permanent employees, has the highest value of the coefficient of variation, 46.23%. *Stock* options, as in the case of 2008, have an exceptionally high value of coefficient of variation, 135.96%.

As far as *access to innovation finance/funds* is concerned, the value of coefficient of variation, 17.51%, suggests that *Internal Finance* is the most commonly used source of funding for innovation across regions followed by *loans* which is 35.82%. The value of the coefficient of variation of *Government Funding* is 48.89% and 98.97 for *Stocks*.

Table 6.8 Proportion of Firms that Carried out Innovation Activities (R&D and Public Support) by Region, 2007-2009

	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
Seoul	67.5	29.6	68.2	24.4	22.4	27.3	20.7	21.5	25.3	19.1	23.5	40.5
Busan	54.9	16.7	56.5	18.3	22.4	19.9	16.3	16.7	18.3	13.4	19.1	32.5
Daegu	59.1	22.6	60.4	17	29.6	24.5	19.5	19.5	20.8	17.6	23.9	39.6
Incheon	56.8	17.4	57.1	11.5	16.4	16.4	14.6	13.2	12.9	11.1	15	27.5
Gwangju	61.4	24.6	63.2	31.6	26.3	26.3	26.3	26.3	28.1	22.8	26.3	40.4
Daejeon	78.1	35.9	79.7	35.9	42.2	32.8	23.4	26.6	28.1	25	32.8	57.8
Ulsan	53.1	23	55.8	17.7	20.4	16.8	15	16.8	17.7	11.5	16.8	31
Kyunggi	61.7	19.8	62.4	17.5	21.5	18	13.3	14.4	15.3	12.4	17.4	33.1
Gangwon	55.1	28.6	59.2	16.3	34.70	32.7	22.4	24.5	22.4	18.4	28.6	40.8
Choongbook	70.5	28.2	71.8	16.8	29.5	22.1	17.4	15.4	14.1	10.7	17.4	44.3
Choongnam	64.7	23	65.7	20.6	26	22.5	16.7	17.6	17.2	13.2	18.6	39.2
Jeonbook	59.1	10.8	59.1	15.1	22.6	18.3	19.4	18.3	18.3	15.1	16.1	28
Jeonnam	43.5	21.2	44.7	8.2	15.3	11.8	10.6	11.8	12.9	14.1	16.5	29.4
Kyungbook	59.5	24.1	60.3	17.5	25.3	25.7	21.8	21.8	19.1	19.8	23	38.9
Kyungnam	59.5	21.5	60.2	17	23.2	23.5	19.8	20.5	18.3	15.3	20.5	34.8
Jeju	46.7	13.3	46.7	6.7	26.7	13.3	20	13.3	6.7	13.3	6.7	26.7
Average	59.45	22.52	60.69	18.26	25.28	21.99	18.58	18.64	18.47	15.80	20.14	36.53
Standard Deviation	8.47	6.32	8.51	7.45	6.63	6.18	4.06	4.62	5.69	4.25	6.16	7.95
Coefficient of Variation	14.24	28.05	14.02	40.83	26.23	28.09	21.87	24.80	30.80	26.91	30.61	21.75

(Source: KIS 2010 own calculations)

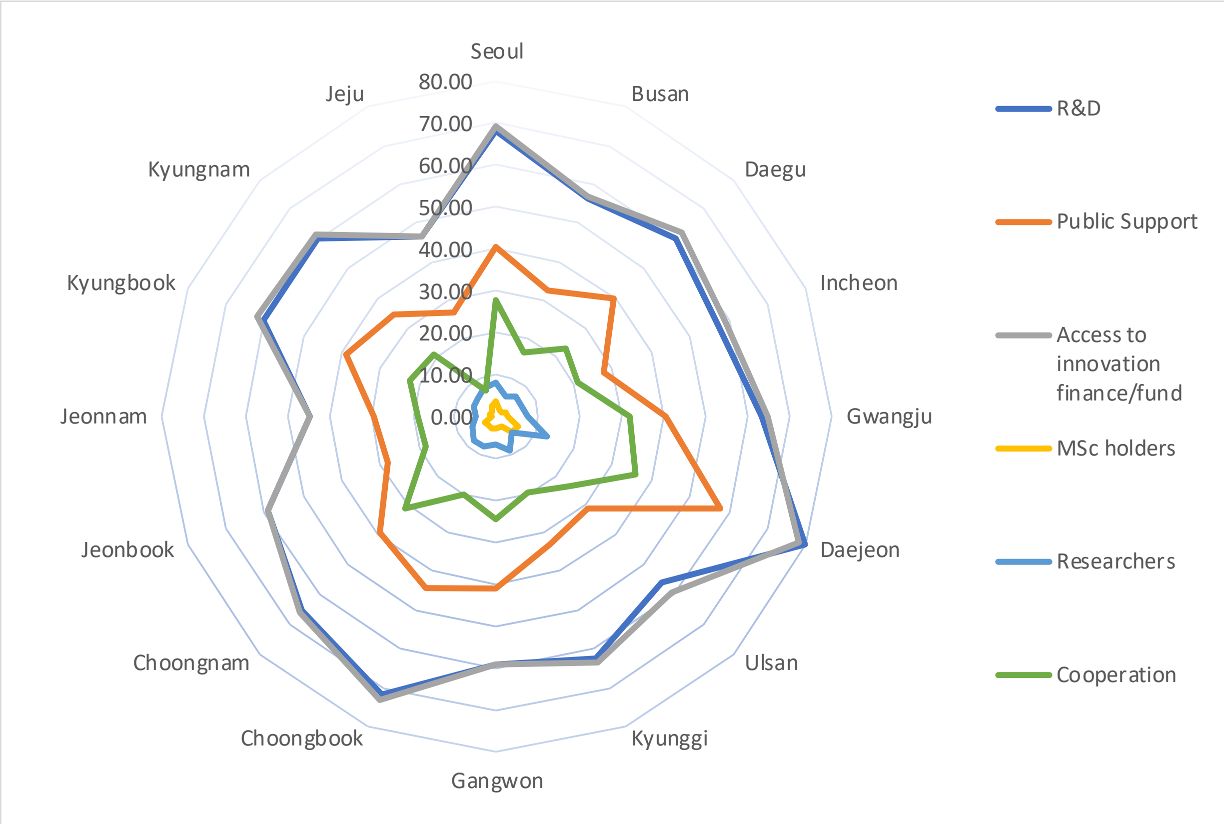
Table 6.9 Proportion of Firms that Carried out Innovation Activities (Access to Innovation Finance/Funds, Human capital and Cooperation) by Region, 2007-2009

	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
Seoul	65.8	22.4	18.7	1.8	69.3	3.65	8.11	27.8
Busan	53.3	22.8	16.7	0.4	56.9	1.38	5.38	16.7
Daegu	53.5	29.6	19.5	0	62.3	1.42	6.45	23.3
Incheon	55.1	16.4	18.1	0	59.2	2.14	6.5	20.9
Gwangju	59.6	31.6	17.5	0	64.9	2.89	7.43	31.6
Daejeon	73.4	42.2	28.1	4.7	78.1	5.55	13.02	35.9
Ulsan	58.4	20.4	13.3	0	59.3	5.22	5.41	23.9
Kyunggi	56.6	21.5	23.8	1	63.4	2.6	8.79	19.7
Gangwon	57.1	34.7	26.5	0	59.2	3.03	6.84	24.5
Choongbook	65.1	29.5	21.5	2	73.2	3.32	7.84	20.1
Choongnam	61.8	26	21.1	0.5	66.2	2.79	7.76	30.9
Jeonbook	55.9	22.6	11.8	1.1	59.1	3.06	6.26	18.3
Jeonnam	36.5	15.3	16.5	1.2	44.7	1.22	4.96	18.8
Kyungbook	55.6	25.3	21	0.8	61.9	1.52	6.09	22.6
Kyungnam	54.3	23.2	18	0.7	61.2	1.72	6.06	21.2
Jeju	26.7	26.7	6.7	0	46.7	2.49	7.46	6.7
Average	55.54	25.64	18.68	0.89	61.60	2.75	7.15	22.68
Standard Deviation	10.92	6.80	5.33	1.21	8.39	1.27	1.90	6.83
Coefficient of Variation	19.66	26.54	28.56	135.96	13.61	46.23	26.59	30.11

(Source: KIS 2010 own calculations)

Using Tables 6.8 and 6.9, Figure 6.8 has been produced:

Figure 6.8 Proportion of Firms that Carried out Innovation Activities (R&D and Public Support, Human capital, Cooperation and Access to Finance/Fund) by Region, 2007-2009



In the case of 2007-2009, generally the value of coefficient of variation of all innovation activities is less than 31%, except in the presence of *MSc or higher degree holders* which is 46.23%.

6.4.3 KIS 2012 (2009-2011)

Table 6.4 shows, unlike the previous two analyses for KIS 2008 and KIS 2010, various regions were the most innovative in each innovation and no two innovations had the same region as the most innovative one in KIS 2012 that includes the period from 2009 and 2011. According to Table 6.4, Daejeon, like the previous two analyses, was the most innovative for *Product innovation*, while it was Gwangju for *Process*, Seoul for *Organisational*, Choongbook for *Marketing*, Gangwon for *New to market product*, and Incheon was the most innovative for *New to firm product innovation*.

Table 6.10 shows that Daejeon had the highest proportion of firms, 37.5%, that carried out either or both *internal* or *external R&D* followed by Kyunggi and Choongbook that had 31.2% and 31.1% of firms respectively that carried out at least one of the *R&D* activities. Furthermore, Daejeon followed by Jeonbook and Choongnam firms had the highest proportion of firms, 34.7%, 31.3% and 24.4% respectively that had access to at least one of the eight *public support*s available to them.

The presence of rich *human capital* is strongest in Daejeon with a high proportion of firms with the presence of *MSc or higher degree holders* and *research staff* among permanent employees, 8.68% and 14.83% respectively. As far as *cooperation* is concerned, Jeonbook had the highest proportion of firms, 15.7% having *cooperated* in at least at one of the innovations.

In terms of *access to innovation finance/funds, Internal Finance* that includes company's own fund and funds from affiliated and subsidiary firms were the most common funding source across the regions. Deajeon had the highest proportion of firms, 33.3%, 5.6%, and 21.3%, that used *Internal Finance*, *Government Funding*, and *loans* that include bank loans and company bonds respectively.

Looking at the coefficient of variation across various innovation activities, the lowest values for the coefficient of variation among the *public supports*, 23.06% while the value of *access to innovation finance/funds* across regions according to the value of the coefficient of variation is 37.17%.

Table 6.10 Proportion of Firms that Carried out Innovation Activities (R&D and Public Support) by Region, 2009-2011

	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res Sppt	Procu Colltv Purch	Mktg	**Public Support**
Seoul	22.6	6.6	23.5	7.8	9.9	7.3	2.4	3.8	4.9	2.4	4	18.6
Busan	16.8	4	17.4	5.3	14.9	6.2	3.1	2.8	4	1.9	2.5	18
Daegu	21.5	4.3	22.9	6.1	15.8	5.4	2.9	3.9	3.6	1.1	2.5	21.5
Incheon	25.3	3.8	26	8	15.8	4.5	3.8	2.8	4	1.8	5.8	24
Gwangju	19.7	2.6	22.4	2.6	13.2	10.5	7.9	5.3	6.6	1.3	5.3	21.1
Daejeon	34.7	2.8	37.5	13.9	20.8	16.7	12.5	6.9	5.6	0	5.6	34.7
Ulsan	9.7	2.2	9.7	5.4	15.1	6.5	5.4	5.4	3.2	2.2	6.5	19.4
Kyunggi	30.7	4.2	31.2	7.1	13.5	7.4	4.8	4.7	2.4	2.1	4.2	21.8
Gangwon	1.6	5.9	17.6	5.9	15.7	9.8	3.90	2	3.9	0	7.8	19.6
Choongbook	31.1	4.9	31.1	6.7	14.6	3.7	5.5	4.9	1.8	1.8	4.3	23.2
Choongnam	26.8	5.9	26.8	4.4	13.7	6.8	2.9	2.4	5.4	2.9	3.9	24.4
Jeonbook	30.4	13	33	7	17.4	13	10.4	8.7	4.3	6.1	9.6	31.3
Jeonnam	13.3	4	13.3	1.3	9.3	5.3	2.7	5.3	5.3	2.7	5.3	20
Kyungbook	15.3	2.8	15.3	4.5	20.1	4.5	3.1	2.4	2.4	0.7	1.7	24.7
Kyungnam	14	3.8	14.8	4.3	13.3	7.8	4.3	2.8	2.5	1.8	4.5	19.5
Jeju	6.7	6.7	6.7	6.7	13.3	0	0	0	6.7	6.7	6.7	13.3
Average	20.01	4.84	21.83	6.06	14.7	7.21	4.73	4.01	4.16	2.22	5.01	22.19
Standard Deviation	9.59	2.58	8.83	2.77	3.03	3.91	3.15	2.11	1.50	1.84	2.04	5.12
Coefficient of Variation	47.93	53.50	40.45	45.67	20.53	54.19	66.77	52.61	36.04	82.91	40.66	23.06

(Source: KIS 2012 own calculations)

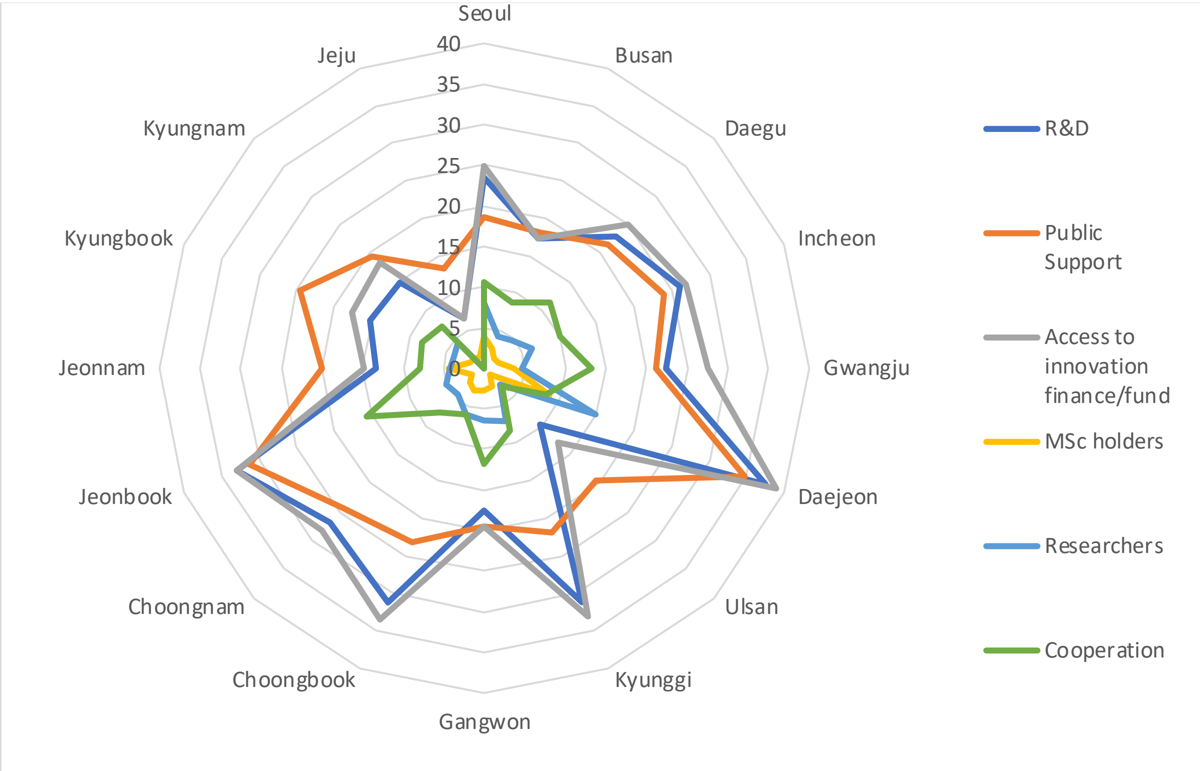
Table 6.11 Proportion of Firms that Carried out Innovation Activities (Access to Innovation Finance/Funds, Human capital and Cooperation) by Region, 2009-2011

	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
Seoul	22.1	1.4	1.4	0	24.9	3.9	8.05	10.6
Busan	13.7	0.9	2.8	0	17.4	2.49	4.17	8.7
Daegu	18.6	3.6	2.9	0	25.1	1.79	4.66	11.5
Incheon	23.3	1.8	2.0	0	27	1.92	6.23	10.0
Gwangju	25	1.3	1.3	0	27.6	3.76	4.74	13.2
Daejeon	33.3	0	5.6	0	38.9	8.68	14.83	8.3
Ulsan	9.7	1.1	2.2	0	12.9	0.97	2.83	3.2
Kyunggi	29.5	1.7	1.9	0	33.1	2.53	7.07	8.2
Gangwon	15.7	2	2	0	19.6	2.64	6.4	11.8
Choongbook	28	3.0	2.4	0	33.5	3.08	6.17	6.1
Choongnam	25.9	1.0	1.5	0	28.3	2.35	4.48	7.8
Jeonbook	24.3	2.6	6.1	0	33	1.75	5.09	15.7
Jeonnam	12	1.3	1.3	0	14.7	4.4	4.29	8.0
Kyungbook	13.2	3.1	1.4	0	17.7	2.01	3.97	8.3
Kyungnam	16.5	1.3	0.5	0	18.3	1.54	4.55	7.3
Jeju	6.7	0	0	0	6.7	1.62	0	0
Average	19.84	2.21	1.63	0	23.67	2.84	5.47	8.67
Standard Deviation	7.70	1.61	1.03	0	8.80	1.82	3.10	3.73
Coefficient of Variation	38.82	73.04	63.18	0	37.17	64.02	56.66	43.02

(Source: KIS 2012 own calculations)

Using the figures in Tables 6.10 and 6.11, Figure 6.9 has been produced:

Figure 6.9 Proportion of Firms that Carried out Innovation Activities (R&D and Public Support, Human capital, Cooperation and Access to Finance/Fund) by Region, 2009-2011



The values of the variation for innovation activities across regions are 40.45% for *R&D* activities, 43.02% for *cooperation*, 64.02% and 56.66% for *presence of MSc or higher degree holders* and *presence of researchers*, respectively. The values of the coefficient of variation for *public support* and the *access to innovation finance/funds*, are 23.06% and 37.17% respectively.

6.4.4 The Comparisons of Regional Variations for 2008, 2010 and 2012

Figures 6.10, 6.11 and 6.12 have been produced using Tables 6.12 and 6.13. As we can see from Figures 6.10, 6.11 and 6.12, the regional variations of different innovation activities is the smallest in 2010 followed by 2008 and regional variation is highest in 2012. *R&D* is the activity that has been most commonly practised in 2010 and 2008 while it is *public supports* in 2012.

Table 6.12 Comparisons of the average, standard deviation, coefficient of variation of innovation activities (R&D, Public support) of firms in the period 2005-2007, 2007-2009 and 2009-2011

	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
2005-2007												
Average	45.28	23.54	47.34	12.16	17.71	13.82	12.64	13.06	11.91	10.21	13.84	26.30
Standard Deviation	11.87	14.01	8.64	6.34	8.42	6.19	7.60	5.32	5.07	5.09	6.22	9.53
Coefficient of Variation	26.20	59.52	18.25	52.13	47.56	44.83	60.12	40.71	42.59	49.89	44.95	36.23
2007-2009												
Average	59.45	22.52	60.69	18.26	25.28	21.99	18.58	18.64	18.47	15.80	20.14	36.53
Standard Deviation	8.47	6.32	8.51	7.45	6.63	6.18	4.06	4.62	5.69	4.25	6.16	7.95
Coefficient of Variation	14.24	28.05	14.02	40.83	26.23	28.09	21.87	24.80	30.80	26.91	30.61	21.75
2009-2011												
Average	20.01	4.84	21.83	6.06	14.78	7.21	4.73	4.01	4.16	2.22	5.01	22.19
Standard Deviation	9.59	2.58	8.83	2.77	3.03	3.91	3.15	2.11	1.50	1.84	2.04	5.12
Coefficient of Variation	47.93	53.50	40.45	45.67	20.53	54.19	66.77	52.61	36.04	82.91	40.66	23.06

(Source: KIS 2008, 2010 and 2012 own calculations)

Table 6.13 Comparisons of the average, standard deviation, coefficient of variation of innovation activities (Access to innovation finance/funds, Human capital, and Cooperation) of firms in the periods 2005-2007, 2007-2009 and 2009-2011

	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
2005-2007								
Average (%)	45.62	13.46	17.46	0.98	48.31	2.22	5.67	17.51
Standard Deviation	7.99	4.82	8.54	0.97	8.40	1.58	2.38	5.63
Coefficient of Variation	17.51	35.82	48.89	98.97	17.38	71.29	42.06	32.15
2007-2009								
Average (%)	55.54	25.64	18.68	0.89	61.60	2.75	7.15	22.68
Standard Deviation	10.92	6.80	5.33	1.21	8.39	1.27	1.90	6.83
Coefficient of Variation	19.66	26.54	28.56	135.96	13.61	46.23	26.59	30.11
2009-2011								
Average (%)	19.84	2.21	1.63	0	23.67	2.84	5.47	8.67
Standard Deviation	7.70	1.61	1.03	0	8.80	1.82	3.10	3.73
Coefficient of Variation	38.82	73.04	63.18	0	37.17	64.02	56.66	43.02

Source: KIS 2008, 2010 and 2012 own calculations

Figure 6.10 Average, standard deviation and coefficient of variation of the innovation activities, 2005-2007

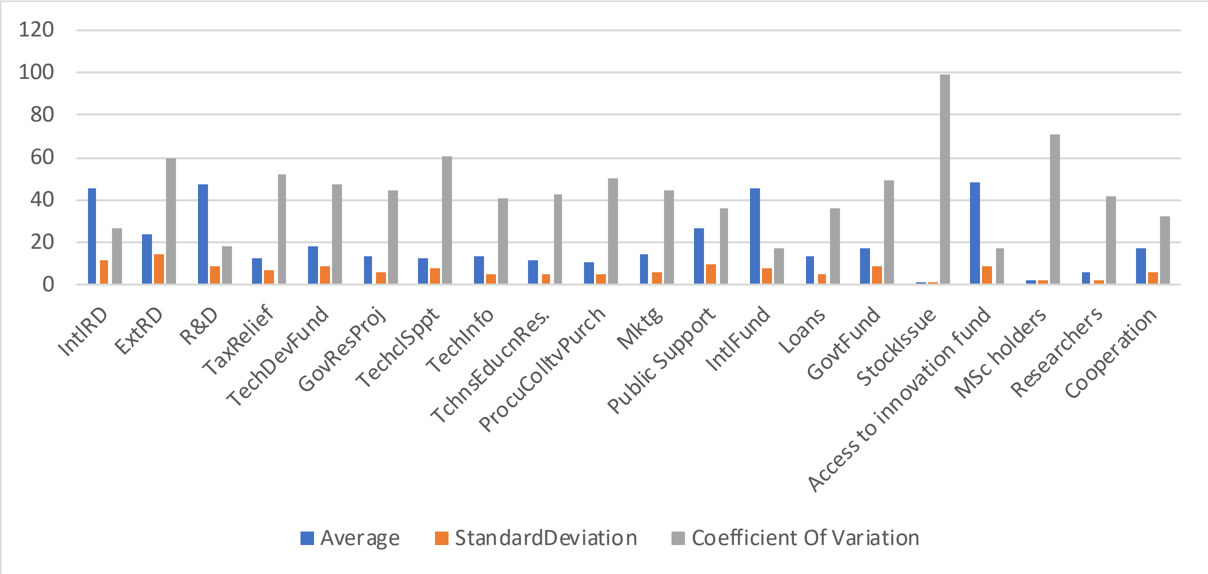


Figure 6.11 Average, standard deviation and coefficient of variation of the innovation activities, 2007-2009

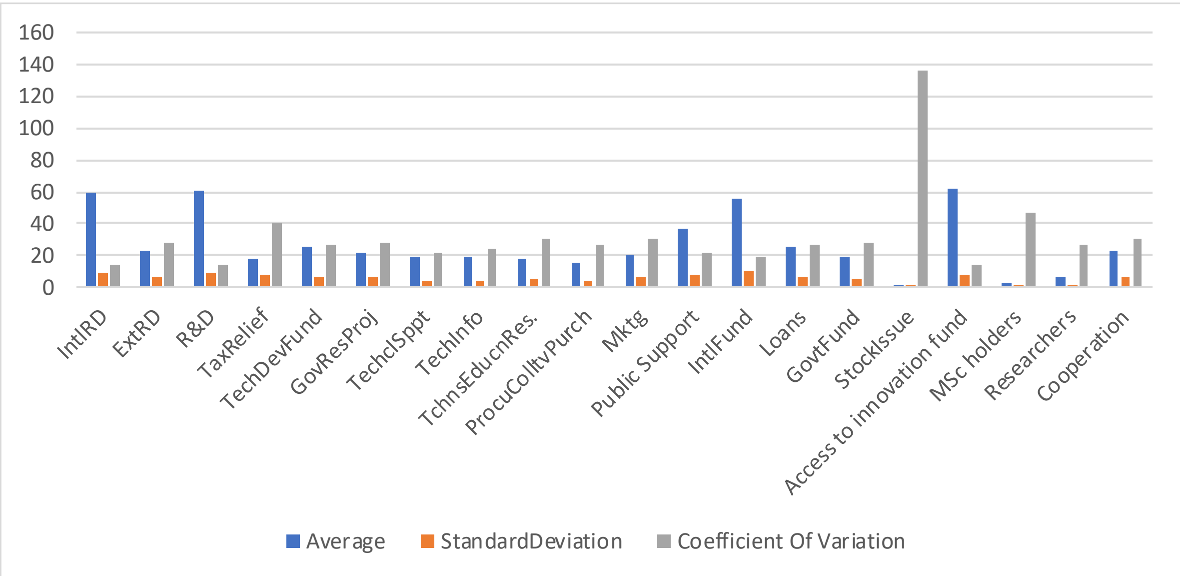
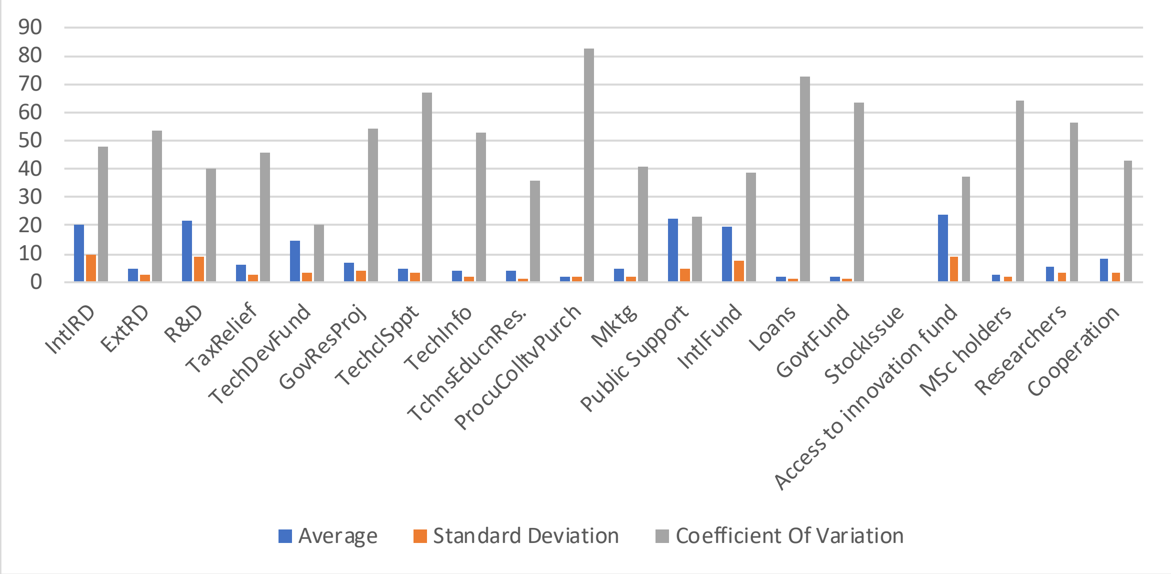


Figure 6.12 Average, standard deviation and coefficient of variation of the innovation activities, 2009-2011



6.5 INNOVATION ACTIVITIES BY REGION FOR INNOVATORS

In section 6.4, the innovation activities across regions in Korea have been discussed. This section will examine and observe regional variation through innovation activities that innovative firms carried out by region.

6.5.1 KIS 2008 (2005-2007)

Tables 6.14 and 6.15 contain the proportion of firms that carried out each innovation activity among the firms that produced at least one of the innovations: *product, process, organisational and marketing innovation*. Out of all the innovation activities, the highest proportion of firms, all over 95%, had *research staff* and the value for coefficient of variation is 1.64%. This is small compared to the coefficient of 42.06% for the whole firms. The second highest proportion can be found in *internal R&D*, all over 90% except Gwangju where 83% of the innovative firms carried out *internal R&D*. The value of coefficient of variation is 4.36%, and this serves as evidence that the presence of *researchers* and *internal R&D* are highly commonly carried out innovation activities throughout the regions. Almost all the innovative firms over 96%, except a few, had access to at least one type of innovation fund.

On average, 44.26% of the innovative firms claimed that they cooperated with other institutions or organisations and the value of coefficient of variation is 23.97%. The proportion of firms that had the presence of *MSc or higher degree holders* were on average 60% throughout the country and the coefficient of variation is 16.29%.

Although less than 50% of the firms took advantage of each *public support*, more than 40% of the firms across all the regions took advantage of at least one of the eight *public supports*. The highest proportion of innovative firms in Jeju, Daejeon, and Ulsan, 100%, 73.3% and 72%, used *public supports*. The value for the coefficient of variation of *public support* as a whole is 32.15%.

Daejeon, the most innovative region of all, had 97.4% of firms that carried out at least one of the R&D activities, 73.3% of the firms received at least one of the *public supports*, 100% of the firms had some type of *access to innovation finance/funds*, 78.9%, 97.4% and 47.4% of the firms had the presence of employees with *MSc and higher degree holders*, *research staff*, and carried out *cooperation* respectively. These proportions are not the highest of all the regions however, except in the case *of public support* and the presence of *MSc or higher degree holders*.

Table 6.14 Proportion of Firms carried out Innovation Activities among Innovators only (R&D and Public Support) by Region, 2005-2007

Region (No. of innovative firms)	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
Seoul (257)	97.3	44	97.7	19.8	25.3	27.2	22.2	24.5	24.1	21.4	28.8	47.1
Busan (88)	100	48.9	100	23.9	43.2	30.7	30.7	29.5	29.5	26.1	38.6	58
Daegu (52)	92.9	46.4	92.9	25	60.7	39.3	28.6	32.1	32.1	26.8	42.9	64.3
Incheon (91)	97.8	41.8	98.9	20.9	25.3	13.2	13.2	18.7	9.9	4.4	17.6	41.8
Gwangju (18)	83.3	27.8	83.3	33.3	38.9	22.2	16.7	22.2	22.2	22.2	16.7	50
Daejeon (38)	97.4	52.6	97.4	31.6	57.9	47.4	31.6	39.5	31.6	23.7	44.7	73.7
Ulsan (25)	100	40	100	24	48	44	44	40	40	32	36	72
Kyunggi (344)	95.9	43	96.8	22.4	32	26.2	23.5	24.4	23.3	18	25.3	48
Gangwon (9)	100	66.7	100	11.1	44.4	33.3	22.2	33.3	22.2	22.2	33.3	55.6
Choongbook (51)	98	43.1	98	23.5	19.6	21.6	15.7	15.7	21.6	15.7	21.6	39.2
Choongnam (59)	96.6	40.7	96.6	27.1	37.3	30.5	23.7	32.2	18.6	16.9	27.1	61
Jeonbook (25)	100	60	100	28	32	44	32	36	32	32	32	64
Jeonnam (26)	100	26.9	100	19.2	30.8	19.2	23.1	23.1	23.1	15.4	26.9	50
Kyungbook (71)	94.4	40.8	94.4	25.4	31	26.8	26.8	31	28.2	21.1	23.9	45.1
Kyungnam (101)	97	50.5	97	23.8	43.6	35.6	31.7	27.7	26.7	19.8	29.7	57.4
Jeju (3)	100	66.7	100	66.7	100	66.7	66.7	66.7	66.7	66.7	66.7	100
Average	96.91	46.24	97.06	26.61	41.88	32.99	28.28	31.04	28.24	24.03	31.99	57.95
Standard Deviation	4.23	11.4	4.25	11.85	19.23	13.14	12.73	11.79	12.32	13.21	12.3	15.11
Coefficient of Variation	4.36	24.65	4.38	44.53	45.92	39.83	45.01	37.98	43.63	54.97	38.45	26.07

(Source: KIS 2008 own calculations)

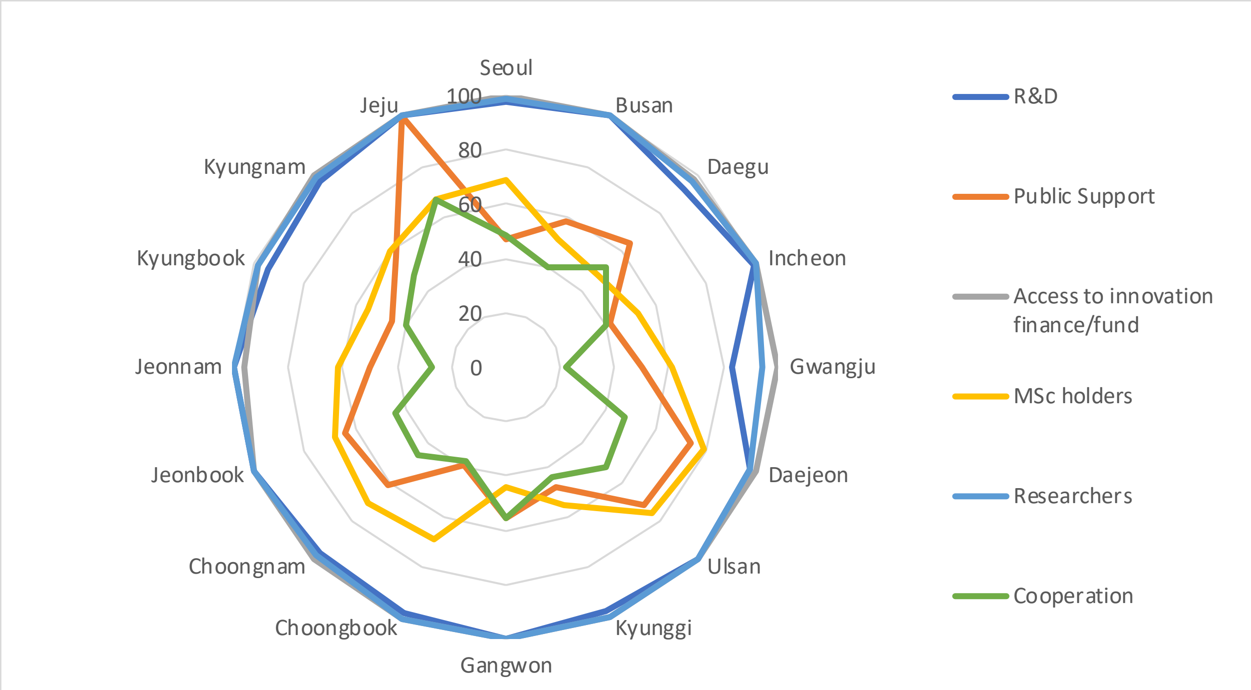
Table 6.15 Proportion of Firms carried out Innovation Activities (Access to innovation finance/funds, Human capital, and Cooperation) for Innovators only by Region, 2005-2007

Region (No. of innovative firms)	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
Seoul (257)	95.7	27.2	26.1	3.1	100	68.9	98.8	48.2
Busan (88)	93.2	28.4	43.2	2.3	100	51.1	100	39.8
Daegu (52)	94.6	25	60.7	3.6	98.2	48.2	96.4	51.8
Incheon (91)	95.6	33	27.5	6.6	100	52.7	100	39.6
Gwangju (18)	100	44.4	38.9	0	100	61.1	94.4	22.2
Daejeon (38)	94.7	31.6	57.9	2.6	100	78.9	97.4	47.4
Ulsan (25)	96	24	48	4	100	76	100	52
Kyunggi (344)	95.6	26.2	33.7	1.7	99.7	55.2	99.7	43.9
Gangwon (9)	100	22.2	33.3	0	100	44.4	100	55.6
Choongbook (51)	92.2	33.3	17.6	0	100	68.6	100	37.3
Choongnam (59)	96.6	22	37.3	3.4	100	71.2	98.3	45.8
Jeonbook (25)	92	40	28	8	100	68	100	44
Jeonnam (26)	92.3	19.2	30.8	0	96.2	61.5	100	26.9
Kyungbook (71)	93	26.8	32.4	0	98.6	54.9	98.6	39.4
Kyungnam (101)	94.1	31.7	42.6	0	100	60.4	99	47.5
Jeju (3)	66.7	66.7	100	0	100	66.7	100	66.7
Average	93.27	31.36	41.13	2.21	99.54	61.74	98.91	44.26
Standard Deviation	7.48	11.51	19.39	2.51	1.05	10.06	1.62	10.61
Coefficient of Variation	8.02	36.70	47.14	113.57	1.05	16.29	1.64	23.97

(Source: KIS 2008 own calculations)

Using Table 6.14 and 6.15, Figure 6.13 has been produced:

Figure 6.13 Innovation Activities for Innovators only, 2005-2007



6.5.2 KIS 2010 (2007-2009)

Tables 6.16 and 6.17 show the proportion of firms that carried out each innovation activity among the firms that produced at least one of the innovations. Out of all the innovation activities, the activity that the highest proportion of firms applied, all over 90%, was *internal R&D*. The value of coefficient of variation is 2.41%, and this serves as evidence that *internal R&D* had the highest priority in innovation activities. The second highest proportion can be found in the presence of *research staff* all over 94% except Ulsan, 89.4%, and Choongbook, 68% respectively. Considering that Choongbook was the second most innovative region according to the 2010 survey, this is quite an interesting result.

As far as *public support* is concerned, on average over 60% of the firms used at least one of the *public supports*. The value of coefficient of variation of *public support* is 11.54% which means that there is very little regional variation.

Almost all the innovative firms, mostly 100%, except a few that were over 95%, had access to at least one type of *innovation fund*. The coefficient of variation value is 1.22.

Furthermore, the proportion of firms that have the presence of employees with *MSc or higher degree holders* were on average 59.55% and the value of coefficient of variation is 15.45%.

On average, 41.08% of the innovative firms *cooperated* with other institutions or organisations although regional variation is low, 22.96%.

As the higher proportion of firms that carried out each activity compared to the whole firms and even lower values of the coefficient of variation for all the innovation activities compared to the 2008 survey suggest that these activities significantly contribute to the *production of innovation*.

Daejeon, the most innovative region of all, had 100% of the firms that carried out at least one of the *R&D*, 73.5% of the firms used *public support*, 95.9% of the firms had *access to innovation finance/funds*, 79.6%, 98% and 44.9% of the firms had employees with *MSc and higher degree holders*, had the presence of *researchers*, and carried out *cooperation* respectively. These proportions are not the highest of all the regions however, except in the case of *public support* and the presence of *MSc or higher degree holders*. As in the case of 2008, this implies that these activities are not the only ones that contribute to the production of innovation.

Table 6.16 Proportion of Firms carried out Innovation Activities among Innovators only (R&D and Public Support) by Region, 2007-2009

Region (No. of innovative firms)	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
Seoul (339)	96.5	47.5	97.6	37.5	35.7	42.5	32.7	33	39.5	29.8	36.6	61.7
Busan (118)	96.6	32.2	99.2	33.9	41.5	36.4	31.4	33.1	34.7	25.4	36.4	58.5
Daegu (80)	96.3	43.8	98.8	30	52.5	45	36.3	36.3	38.8	30	41.3	66.3
Incheon (143)	95.1	33.6	95.8	20.3	28.7	30.1	27.3	24.5	24.5	20.3	26.6	47.6
Gwangju (32)	93.8	43.8	96.9	34.4	56.3	43.8	43.8	43.8	46.9	40.6	43.8	68.8
Daejeon (49)	100	44.9	100	44.9	55.1	42.9	30.6	34.7	36.7	32.7	42.9	73.5
Ulsan (57)	91.2	43.9	94.7	35.1	40.4	31.6	28.1	31.6	31.6	21.1	28.1	56.1
Kyunggi (679)	96.9	33.6	97.9	29.5	35.1	29.3	22.1	23.9	25.2	19.7	27.8	52.6
Gangwon (28)	96.4	46.4	100	28.6	57.1	57.1	39.3	42.9	39.3	32.1	50	67.9
Choongbook (100)	96	40	97	23	43	31	24	22	21	15	24	60
Choongnam (116)	97.4	40.5	99.1	34.5	41.4	36.2	28.4	30.2	29.3	19.8	31	61.2
Jeonbook (45)	100	22.2	100	31.1	46.7	37.8	40	37.8	37.8	31.1	33.3	57.8
Jeonnam (36)	94.4	47.2	97.2	19.4	36.1	27.8	25	27.8	30.6	27.8	30.6	58.3
Kyungbook (137)	95.6	44.5	97.1	31.4	42.3	43.8	37.2	38	32.1	32.8	38.7	64.2
Kyungnam (214)	96.3	38.3	97.7	29.4	39.3	41.1	35	36	32.2	26.6	36	57.9
Jeju (6)	100	33.3	100	16.7	50	16.7	33.3	16.7	16.7	16.7	16.7	50
Average	96.41	39.73	98.06	29.98	43.83	37.07	32.16	32.02	32.31	26.34	33.99	60.15
Standard Deviation	2.32	7.04	1.61	7.29	8.4	9.35	6.2	7.52	7.77	7.03	8.45	6.94
Coefficient Of Variation	2.41	17.72	1.64	24.32	19.16	25.22	19.28	23.49	24.05	26.69	24.86	11.54

Source: KIS 2010 own calculations

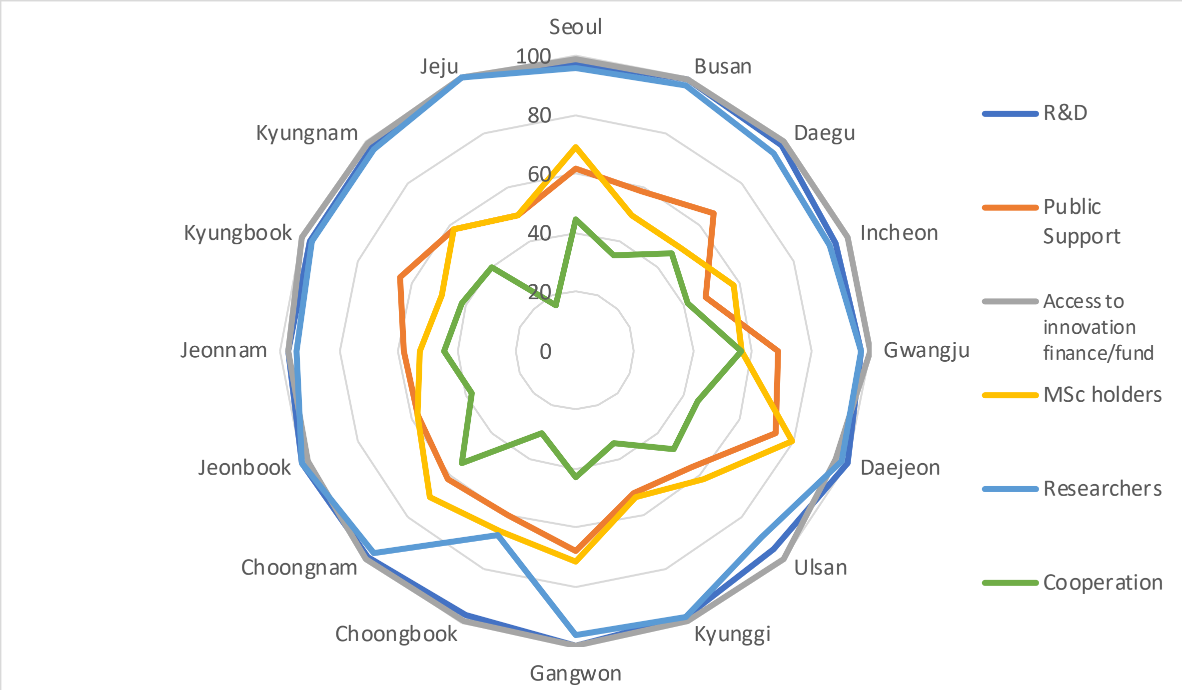
Table 6.17 Proportion of Firms carried out Innovation Activities (Access to innovation finance/funds, Human capital, and Cooperation) for Innovators only by Region, 2007-2009

Region (No. of innovative firms)	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
Seoul (339)	93.5	26.3	35.7	2.9	98.8	69	95.8	44.5
Busan (118)	92.4	29.7	42.4	0.8	99.2	50	97.5	34.7
Daegu (80)	87.5	31.3	52.5	0	100	50	94.9	46.3
Incheon (143)	94.4	28	28.7	0	100	58	93.7	41.3
Gwangju (32)	93.8	25	56.3	0	100	56.3	96.9	56.3
Daejeon (49)	89.8	36.7	55.1	6.1	95.9	79.6	98	44.9
Ulsan (57)	100	21.1	40.4	0	100	61.4	89.4	47.4
Kyunggi (679)	88.8	37.6	35.1	1.8	99.3	53.8	97.4	34
Gangwon (28)	96.4	46.4	57.1	0	100	71.5	96.4	42.9
Choongbook (100)	87	31	43	3	99	66	68	30
Choongnam (116)	92.2	31.9	41.4	0.9	100	69.8	96.6	54.3
Jeonbook (45)	91.1	22.2	46.7	2.2	97.8	57.8	100	37.8
Jeonnam (36)	80.6	36.1	36.1	2.8	97.2	52.8	94.4	44.4
Kyungbook (137)	88.3	35	42.3	1.5	100	48.9	96.4	41.6
Kyungnam (214)	87.4	31.8	39.3	1.4	99.5	57.9	96.2	40.2
Jeju (6)	66.7	16.7	50	0	100	50	100	16.7
Average	89.37	30.43	43.88	1.46	99.17	59.55	94.48	41.08
Standard Deviation	7.53	7.3	8.38	1.67	1.21	9.2	7.49	9.43
Coefficient of Variation	8.43	23.99	19.10	114.38	1.22	15.45	7.93	22.96

Source: KIS 2010 own calculations

Tables 6.16 and 6.17 have been used to produce Figure 6.14:

Figure 6.14 Innovation Activities for Innovators only, 2007-2009



6.5.3 KIS 2012 (2009-2011)

Tables 6.18 and 6.19 show the proportion of firms that carried out each innovation activity among the firms that produced at least one of the innovations. Jeju has been removed from the analysis since only one firm in Jeju was innovative and this may contribute to the substantial difference in the conclusion reached.

As was the case in 2008, out of all the innovation activities, the activity that the highest proportion of firms, all over 56% except Jeonnam which is 48%, had the presence of *research staff*. The value of the coefficient of variation is 12.80%.

The second highest proportion of firms carried out *internal R&D*, all over 56% of the firms in the region carried out the activity except Ulsan, 25%, Jeonnam, 36%, and Kyungnam, 47.3%.

As far as *public support* is concerned, on average over 31% of the firms used at least one of the public supports. The value of the coefficient of variation of *public support* is 16.58%.

Almost all the innovative firms, mostly 63% and except Ulsan, 31.1%, Jeonnam, 40%, Kyungnam 59.1%, had access to at least one type of *innovation fund*. The coefficient of variation value is 19.40%. Furthermore, the proportion of firms that have the presence of employees with *MSc or higher degree holders* were on average 49.33% throughout the country and the coefficient of variation is 19.95%. On average, 25.98% of the innovative firms *cooperated* with other firms or institutions and its value of coefficient of variation is 38.76%.

Daejeon, one of the most innovative regions of all, had 63.3% of the firms that carried out at least one of the *R&D*, 43.3% of the firms used *public support*, 70% of the firms had *access* to *innovation finance/funds*, 73.3%, 73.3% and 13.3% of the firms had employees with *MSc and higher degree holders*, dedicated *researchers*, and carried out *cooperation* respectively. These proportions are not the highest of all the regions however, except in the case of the presence of *MSc or higher degree holders*.

Table 6.18 Proportion of Firms carried out Innovation Activities among Innovators only (R&D and Public Support) by Region, 2009-2011

	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
Seoul	65.3	22	68.6	18.6	22.9	19.5	6.8	10.2	13.6	5.9	12.7	44.1
Busan	57.7	14.1	60.6	15.5	39.4	19.7	11.3	8.5	12.7	4.2	5.6	46.5
Daegu	56.3	12.6	59.8	13.8	28.7	13.8	5.7	8	5.7	3.4	6.9	40.2
Incheon	69.8	11.1	71.4	15.9	23.8	8.7	7.1	4.8	8.7	4	14.3	38.1
Gwangju	45.8	8.3	54.2	4.2	20.8	12.5	16.7	12.5	8.3	0	8.3	37.5
Daejeon	63.3	3.3	66.7	16.7	33.3	20	20	10	10	0	10	43.3
Ulsan	25	12.5	25	6.3	25	25	18.8	18.8	12.5	6.3	18.8	37.5
Kyunggi	67.2	9.8	68.2	15	24.8	12.7	10.3	9	4.7	4.9	9.8	37.7
Gangwon	60	20	60	13.3	20	26.7	13.3	6.7	13.3	0	6.7	33.3
Choongbook	60.3	11	60.3	12.3	26	2.7	8.2	9.6	4.1	2.7	6.8	31.5
Choongnam	68.1	14.5	68.1	10.1	23.2	10.1	4.3	1.4	11.6	4.3	8.7	40.6
Jeonbook	61.4	29.5	65.9	13.6	31.8	25	22.7	20.5	11.4	13.6	22.7	56.8
Jeonnam	36	12	36	4	20	12	4	8	4	4	12	36
Kyungbook	61.7	13.3	61.7	15.0	36.7	11.7	13.3	10	10	1.7	8.3	46.7
Kyungnam	45.5	13.6	47.3	9.1	20.9	16.4	8.2	6.4	3.6	3.6	9.1	31.8
Average	56.23	13.84	58.25	12.23	26.49	15.77	11.38	9.63	8.95	3.91	10.71	40.11
Standard Deviation	12.75	6.16	13.01	4.53	6.18	6.79	5.92	4.84	3.67	3.35	4.78	6.65
Coefficient of Variation	22.67	44.51	22.33	37.04	23.33	43.06	52.02	50.26	41.01	85.68	44.63	16.58

(Source: KIS 2012 own calculations)

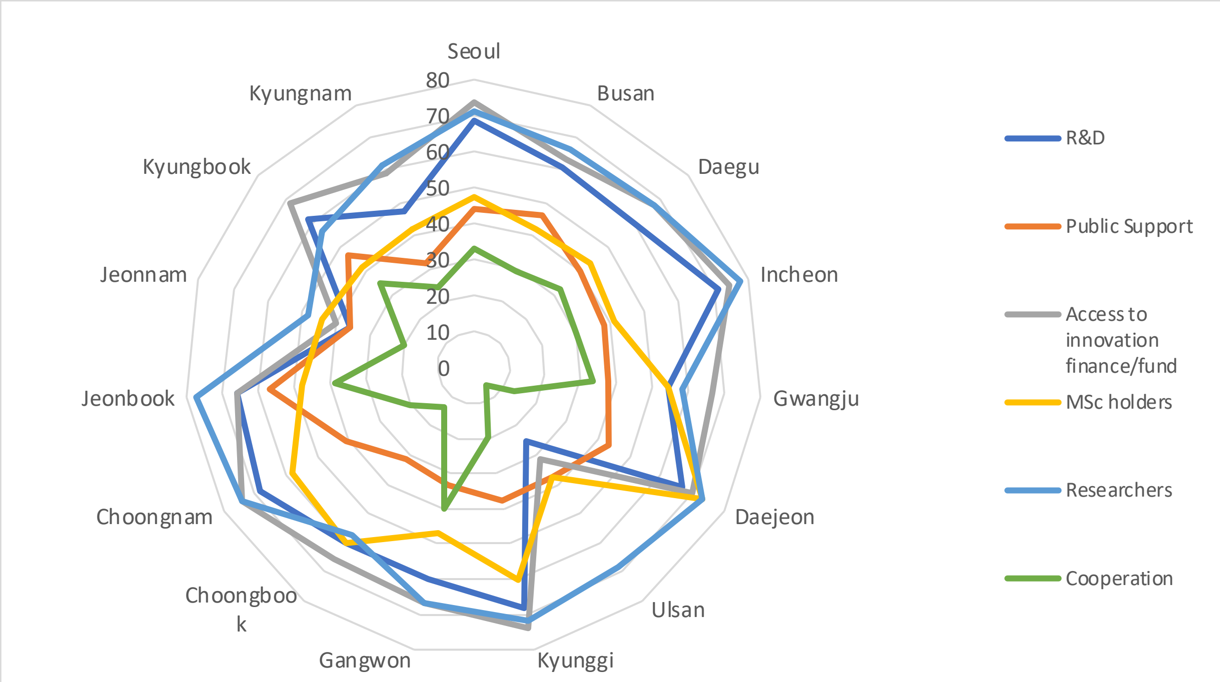
Table 6.19 Proportion of Firms carried out Innovation Activities (Access to innovation finance/funds, Human capital, and Cooperation) for Innovators only by Region, 2009-2011

	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
Seoul	65.3	5.1	3.4	0	73.7	47.4	71.2	33.1
Busan	49.3	2.8	11.3	0	63.4	42.3	66.2	29.6
Daegu	48.3	11.5	8	0	67.8	43.7	67.8	32.2
Incheon	64.3	4.8	5.6	0	74.6	41.3	77.8	30.2
Gwangju	62.5	4.2	0	0	66.7	54.2	58.3	33.3
Daejeon	63.3	0	6.7	0	70	73.3	73.3	13.3
Ulsan	18.8	6.3	6.3	0	31.3	37.5	68.7	6.3
Kyunggi	65.6	3.6	4.7	0	73.9	60.2	71.8	19.6
Gangwon	53.3	6.7	6.7	0	66.7	46.7	66.7	40
Choong book	53.4	6.8	5.5	0	65.8	60.3	57.5	13.7
Choong nam	66.7	2.9	4.3	0	73.9	58	73.9	20.3
Jeon book	50	6.8	9.1	0	65.9	47.7	77.3	38.6
Jeon nam	32	4	4	0	40	44	48	20
Kyung book	51.7	11.7	5	0	68.3	41.6	56.6	35
Kyung nam	52.7	4.5	1.8	0	59.1	41.8	61.8	24.5
Average	53.15	5.45	5.49	0	64.07	49.33	66.46	25.98
Standard Deviation	13.31	3.09	2.79	0	12.43	9.84	8.51	10.07
Coefficient of Variation	25.04	56.70	50.82	0.00	19.40	19.95	12.80	38.76

(Source: KIS 2012 own calculations)

Using the figures in Tables 6.18 and 6.19, Figure 6.15 has been produced:

Figure 6.15 Innovation Activities for Innovators only, 2009-2011



6.5.4 The Comparisons of the Regional Variations for Innovators

Tables 6.20 and 6.21 present the average proportion of innovative firms that carried out each innovation activity, standard deviation, and the value of coefficient of variation across the sixteen regions in Korea.

The proportion of firms that carried out one or both of *R&D* increased from 97.06% to 98.06% in 2010 then dropped to 58.25% in 2012. The use of at least one of the eight public supports also increased from 57.95% in 2008 to 60.15% in 2010 but dropped to 40.11% in 2012. Out of eight public supports *procurement and collective purchasing* was used by the lowest proportion of firms while *technology development and funding* was used by the highest proportion followed by *participation in government research project* in all three surveys.

In contrast, *access to innovation finance/funds*, presence of *MSc or higher degree holders*, presence of *research staff*, and *cooperation* were decreasing as time progressed. The regional variation for access to *innovation finance/funds* continued to increase as time progressed while presence of *MSc or higher degree holders* and *cooperation* decreased until 2010 then increased in 2012. The value for the variation of the presence of *research* *staff* continued to increase meaning the regional variation was widening as time progressed.

The value for coefficient of variation of sub-innovation activities are high in 2008 and 2012 while they were lower in 2010. The values of coefficient of *tax relief* and *technology development funding* were high in 2008, 44.53% and 45.92% respectively and these decreased to 24.32% and 19.16% in 2010 but slightly increased again to 37.04% and 23.33% in 2012 but smaller compared to 2008.

Table 6.20 Comparisons of the Average, Standard Deviation, and Coefficient of Variation of Innovation Activities (R&D, Public support) for Innovators 2008, 2010 and 2012

	IntlRD	ExtRD	**R&D**	Tax Relief	Tech Dev Fund	GovRes Proj	Techcl Sppt ByGov	Tech Info	Tchcns Educn Res. Sppt	Procu Colltv Purch	Mktg	**Public Support**
2008												
Average	96.91	46.24	97.06	26.61	41.88	32.99	28.28	31.04	28.24	24.03	31.99	57.95
Standard Deviation	4.23	11.4	4.25	11.85	19.23	13.14	12.73	11.79	12.32	13.21	12.3	15.11
Coefficient Of Variation	4.36	24.65	4.38	44.53	45.92	39.83	45.01	37.98	43.63	54.97	38.45	26.07
2010												
Average	96.41	39.73	98.06	29.98	43.83	37.07	32.16	32.02	32.31	26.34	33.99	60.15
Standard Deviation	2.32	7.04	1.61	7.29	8.4	9.35	6.2	7.52	7.77	7.03	8.45	6.94
Coefficient Of Variation	2.41	17.72	1.64	24.32	19.16	25.22	19.28	23.49	24.05	26.69	24.86	11.54
2012												
Average	56.23	13.84	58.25	12.23	26.49	15.77	11.38	9.63	8.95	3.91	10.71	40.11
Standard Deviation	12.75	6.16	13.01	4.53	6.18	6.79	5.92	4.84	3.67	3.35	4.78	6.65
Coefficient of Variation	22.67	44.51	22.33	37.04	23.33	43.06	52.02	50.26	41.01	85.68	44.63	16.58

(Source: KIS 2008, 2010 and 2012 own calculations)

Table 6.21 Comparisons of the Average, Standard Deviation and Coefficient of Variation of Innovation Activities (Access to Innovation Finance/Funds, Human Capital, and Cooperation) for Innovators only in 2008, 2010 and 2012

	IntlFund	Loans	GovtFund	StockIssue	**Access to innovation finance/fund**	**MSc holders**	**Researchers**	**Cooperation**
2008								
Average (%)	93.27	31.36	41.13	2.21	99.54	61.74	98.91	44.26
Standard Deviation	7.48	11.51	19.39	2.51	1.05	10.06	1.62	10.61
Coefficient Of Variation	8.02	36.70	47.14	113.57	1.05	16.29	1.64	23.97
2010								
Average (%)	89.37	30.43	43.88	1.46	99.17	59.55	94.48	41.08
Standard Deviation	7.53	7.3	8.38	1.67	1.21	9.2	7.49	9.43
Coefficient Of Variation	8.43	23.99	19.10	114.38	1.22	15.45	7.93	22.96
2012								
Average (%)	53.15	5.45	5.49	0	64.07	49.33	66.46	25.98
Standard Deviation	13.31	3.09	2.79	0	12.43	9.84	8.51	10.07
Coefficient of Variation	25.04	56.70	50.82	0.00	19.40	19.95	12.80	38.76

(Source: KIS 2008, 2010 and 2012 own calculations)

Using Tables 6.20 and 6.21, Figures 6.16, 6.17 and 6.18 have been produced for easy comparison of the average proportion of firms that carried out each innovation activity and their coefficient of variation.

Figure 6.16 Average, Standard Deviation and Coefficient of Variation of the Innovation Activities for Innovators only, 2005-2007

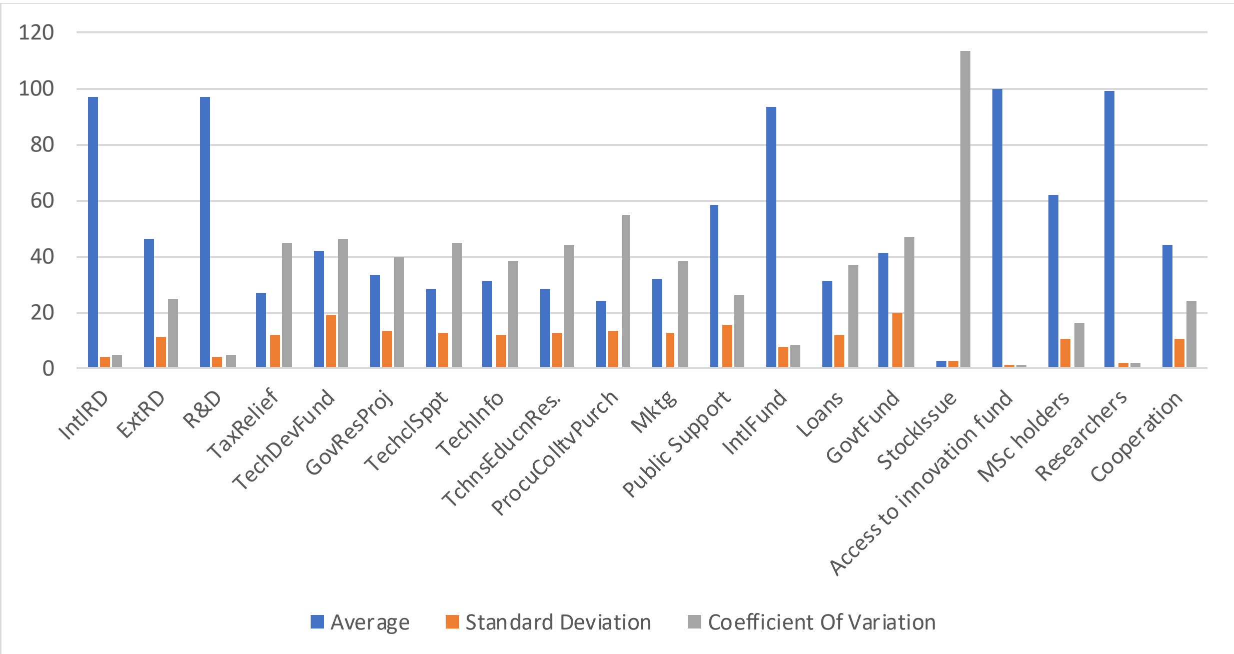


Figure 6.17 Average, Standard Deviation and Coefficient of Variation of the Innovation Activities for Innovators only, 2007-2009

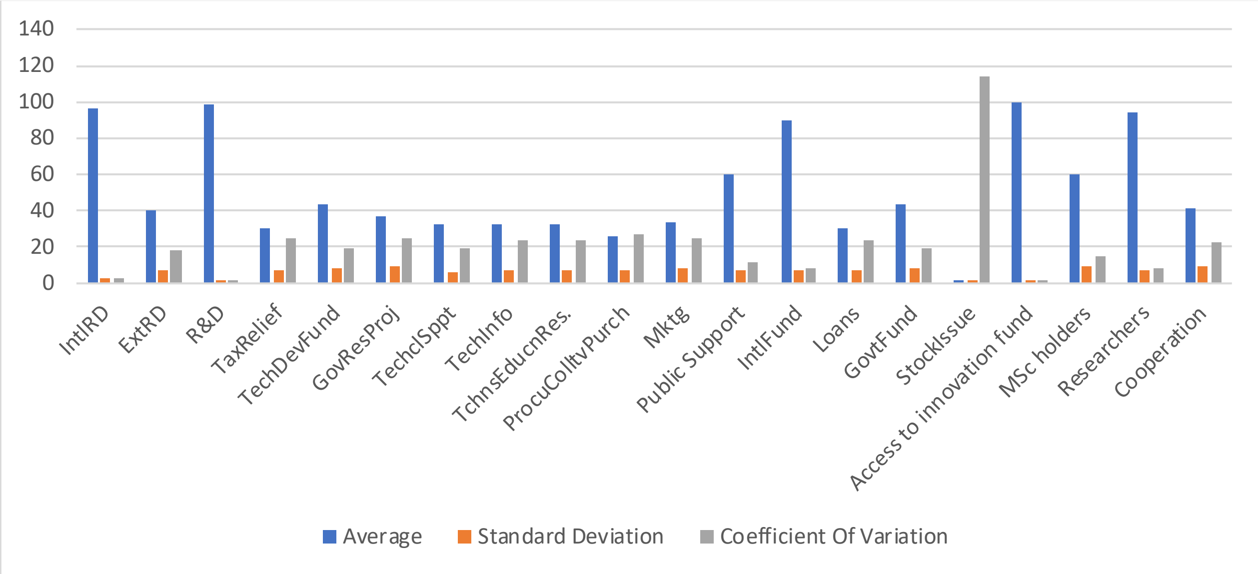
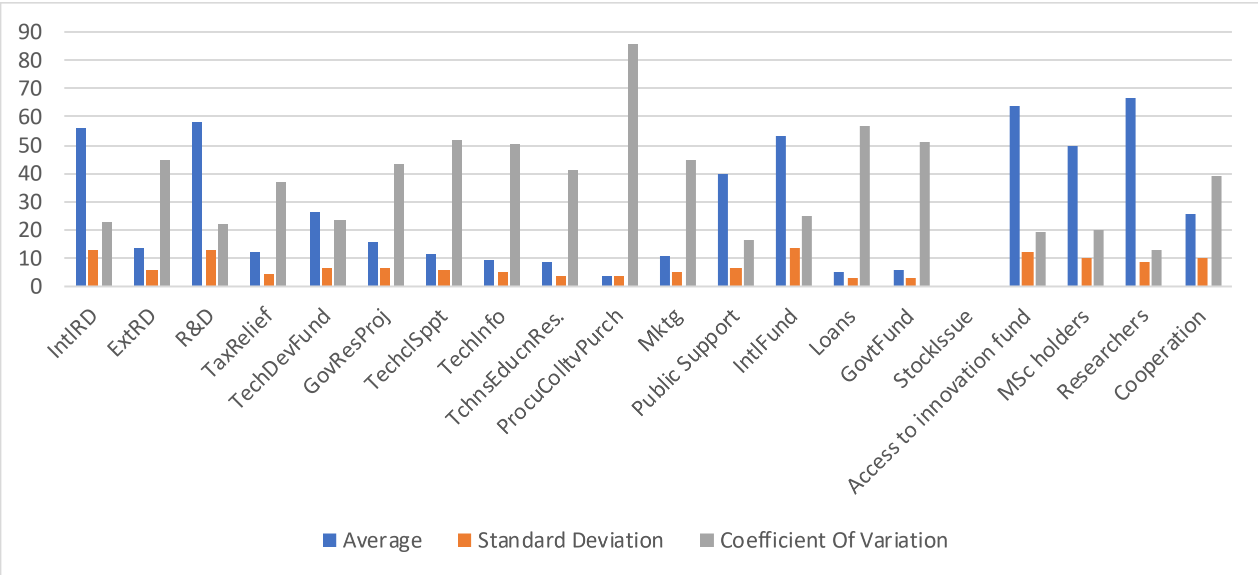


Figure 6.18 Average, Standard Deviation and Coefficient of Variation of the Innovation Activities for Innovators only, 2009-2011



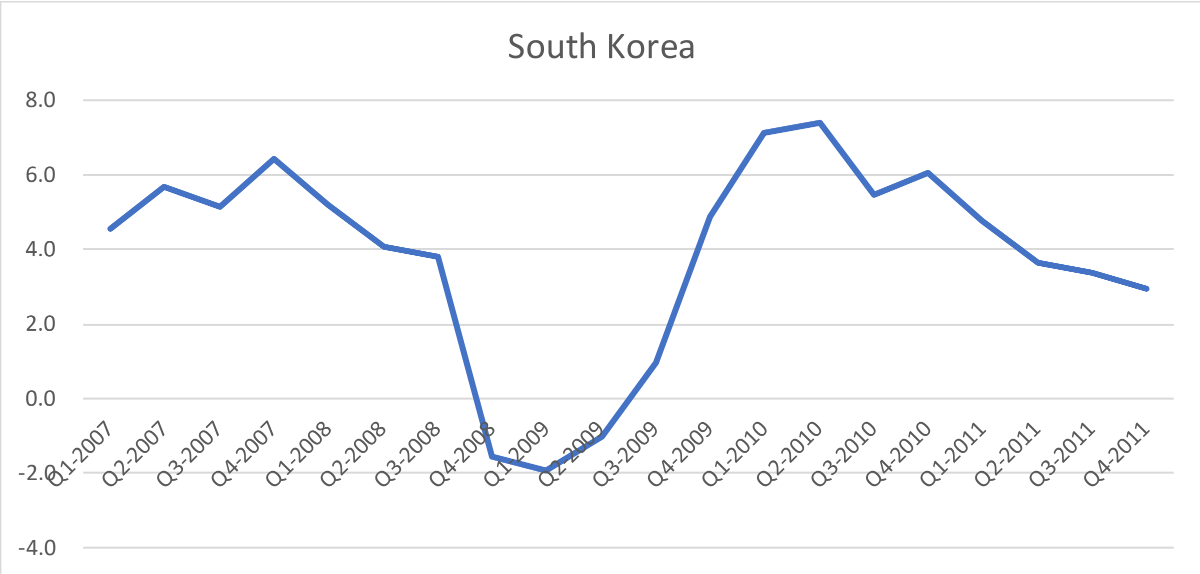
By looking at the values of the coefficient of variations, the general trend shows that the regional variation of innovation activities became narrower from 2008 to 2010 then widened in 2012.

6.5.5 The fall in the Proportion of Innovators in 2009-2011

ECONOMIC CRISIS

Comparing the results of the 2012 survey with 2008 and 2010, overall innovation activity and the introduction of innovations decreased. In an effort to find the reasons behind this decline, the quarterly growth of the real GDP per capita from 2007 and 2011 has been captured as follows:

Figure 6.19 Quarterly Real GDP Growth Rate in Korea between 2007 and 2011



(OECD.stat)

There was a deep plunge in the real GDP growth rate at the end of 2008 due to the financial crisis in Korea followed by a sharp increase from the third quarter of 2009 until the second quarter of 2010. From the second quarter of 2010 until the end of 2011 there was a gradual decrease in the real GDP growth. Considering the 2010 survey covers the period between 2007 and 2009 the plunge at the end of 2008 might not have affected the survey result. Since the recession in 2009 could have had a knock on effect to the later years the results of 2012 may have demonstrated this effect.

SAMPLE SIZE

Another possible reason behind this phenomenon could be the size of the samples taken from large firms. Table 6.22 displays firms divided into five different size categories for the population and the sample. The proportion of the sample firms with 10 to 49, 50-99, and 100-299 employees selected from the population are similar in 2008, 2010 and 2012.

Table 6.22 Number and Proportion of Firms by Firm size based on the Number of Employees

KIS		Firm Size	**10-49**	**50-99**	**100-299**	**300-499**	**500+**
2008	Population (47,267)	No of firms	39,598	4,510	2,432	317	410
		Proportion	83.8	9.5	5.1	0.7	0.9
	Sample (3,081)	No of firms	1,855	317	478	168	263
		Proportion	60.2	10.3	15.5	5.5	8.5
2010	Population (41,485)	No of firms	33,678	4,409	2,668	352	378
		Proportion	81.2	10.6	6.4	0.8	0.9
	Sample (3,925)	No of firms	2,086	505	824	225	283
		Proportion	53.1	12.9	21.0	5.7	7.2
2012	Population (43,810)	No of firms	37,042	4,199	2,198	205	166
		Proportion	84.6	9.6	5.0	0.5	0.4
	Sample (4,086)	No of firms	2,509	441	797	103	166
		Proportion	62.5	11.0	19.8	2.6	4.1

(Source: KIS 2008, 2010 and 2012 own calculations)

The number of firms with less than 300 employees in the sample is similar for all three surveys, 2008, 2010 and 2012, however, the proportion of the sample firms with more than 300 employees drops to half in the survey 2012. Due to the dramatically smaller percentage of large firm size category made the percentage of smaller firm size category much larger compared to 2008 and 2010 survey. Based on the discussion that larger firms are more likely to innovate than smaller firms, this could be the reason for the fall in the number of innovators in 2009-2011.

Table 6.23 shows how much the proportion of innovators decreased in 2012 compared to 2008 and 2010. This is especially the case as the size of firms get larger. It seems clear from the table that larger firms are more innovative in each survey year. Innovation has been discussed at various analytic levels and these have been expanded to the discussion of firm size and the output of innovation. The relationship between firm size and innovation has been studied in a large volume of literature and the most important hypothesis appears to be that firm size has a positive correlation with innovation (Symeonidis, 1996; Alsharkas, 2014).

Table 6.23 Proportion of Innovators by Firm Size in 2008, 2010 and 2012

Innovation	Firm size	10-49	50-99	100-299	300-499	500+
		Proportion of Innovators				
2008	Product Innovation	19.1	31.9	46.0	63.7	76.4
	Process Innovation	13.5	28.7	39.7	59.5	71.1
	Organisational Innovation	10.5	27.1	67.2	61.3	71.5
	Marketing Innovation	8.5	14.2	25.3	32.7	45.6
	New to market Product Innovation	7.3	12.9	16.1	26.8	39.2
	New to Company Product Innovation	17.1	28.1	42.7	60.1	70.7
2010	Product Innovation	30.2	46.9	58.7	71.1	74.9
	Process Innovation	21.5	41.4	51.3	61.8	72.4
	Organisational Innovation	18.3	21.6	49.8	61.3	77.7
	Marketing Innovation	15.2	33.1	31.3	37.8	48.4
	New to market Product Innovation	11.0	14.5	23.3	29.8	37.1
	New to Company Product Innovation	26.5	43.6	53.5	64.4	69.6
2012	Product Innovation	12.5	15.8	21.6	34.2	35.8
	Process Innovation	7.4	9.8	14.0	22.4	23.5
	Organisational Innovation	12.8	17.7	24.5	32.9	51.9
	Marketing Innovation	9.0	8.9	10.5	15.8	30.9
	New to market Product Innovation	4.2	6.2	8.9	11.8	19.8
	New to Company Product Innovation	8.0	9.8	14.2	21.1	24.7

(Source: KIS 2008, 2010 and 2012 own calculations)

Like Schumpeter (1934) who at first favoured new, small entrepreneurs for innovation, small firms were said to be more innovative since it is easier for them to make the structure of the firm flexible and, also easier for them to be reactive to decision making, accepting and implementing changes (Antonelli and Scellato, 2015).

When producing technological knowledge, small firms depend primarily on tacit knowledge that has been accumulated through repeated learning that are quite unique in terms of the limited range of techniques that individual firms have managed to practise in the past (Polanyi, 1948). They acquire new technological knowledge through informal activities, although this depends on performing various functional activities ranging from production to procurement including marketing, implemented within the firm by expert practitioners (Antonelli and Scellato, 2015; Stoneman, 2010).

Small firms can be more sensitive to external conditions and pecuniary externalities that can influence technological change. Although financial factors are important in determining innovation strategies and therefore influence technological change at firm level, small firms mainly depend on cash flow to fund innovation since they have very limited access to equity markets (Hall and Lerner, 2009).

On the other hand, as Schumpeter (1942) later changed his views and argued larger firms that operate in concentrated markets are the central drivers of technological advancement that lead to economic growth, creating disproportionate innovation outcomes between large and small firms. Larger firms have easier access to equity markets and they can also depend on the extra profits gained from previous innovations to fund new innovations (Antonelli and Scellato, 2015).

This enables large firms to spread the risks of R&D and since their sales volumes are large they are more able to have access to external finance and can set aside stable funding for R&D activities (Alsharkas, 2014). Large firms can, therefore, build scientific facilities, employ highly skilled staff and market the outcome innovation (Nord and Tucker, 1987; Chancy and Tellis, 2000). The technological knowledge that large firms introduce can be applied widely and can result in the introduction of a variety of innovations that leads to firm diversification and also new industries can be created (Vaona and Pianta, 2008).

Damanpour (2009) favours a positive relationship between firm size and innovation and to back up his argument he has taken the results of his own meta-analytical review of 36 correlations where the mean correlation of 0.32 with $p<0.05$ between firm size and innovation from 20 empirical studies carried out in 1992. Another meta-analytical review that favoured a positive relationship was carried out by Camison-Zornoza *et al.* in 2004 using 87 correlations where the mean correlation of 0.15 with $p<0.05$ from 53 empirical studies. Both results demonstrate that the correlation between firm size and innovation are statistically significant.

On the other hand, through case studies, Shefer and Frenkel (2005), a negative and significant correlation has been found in a large number of small firms investing in R&D activities between firm size and R&D investment. Tether *et al.* (1997) also found a non-linear relationship between size and innovation by case study.

Thus, Schumpeter's theory provides straight forward predictions, there are a variety of results that came out of the empirical analysis that supports the two main theories above. Tables 6.22 and 6.23 support the positive relationship between firm size and innovation.

Chapter 7
DATA ANALYSIS AND ECONOMETRICS

In this chapter, descriptive data analysis will be provided on innovation measures, dependent variables, and innovation activities, independent variables. Brief analysis of firm behaviour for each Korean Innovation Survey (KIS) 2008, 2010 and 2012 will be carried out.

Four different models will be estimated to test hypotheses using econometrics and the results will be presented together with a discussion.

7.1 DATA ANALYSIS AND HYPOTHESIS TESTING

Following the review of the literature and the development of hypotheses in Chapter 5.1.3 four measures of innovation will be used: product innovation; process innovation; organisational innovation; and marketing innovation. Analysis will be carried out at the national level and regional level.

7.1.1 Innovation Measures and Activities of Innovation in Korea

Measures of innovation

Product innovation is categorised into *new* product introduction and *significantly improved* product introduction. The former can be further categorised into *new to market* and *new to firm* product innovation that can be used as proxy variables for radical and incremental innovation. If a firm introduced a new product to the market before its competitors it will be *new to market* product innovation while if a firm introduced a new or significantly improved product that is already available in the market it will be *new to firm* product innovation.

Process innovation will be separated into: *new or significantly improved manufacturing method(s); new or significantly improved logistics;* and *new or significantly improved support activities*. Organisational innovation includes all activities related to introducing changes to business practices for organising procedures, knowledge management, methods of organising work responsibility, or methods of organising external relations with other organisations.

Marketing innovation includes changes to the aesthetic design or packaging of a good, introduction of new media or techniques for product promotion, employment of new sales strategies such as new methods for product placement or sales channels, and new methods of pricing goods. These are based on data from the Korea Innovation Surveys that were informed by the Oslo Manual that utilises the national systems of innovation framework.

The theoretical analysis in Chapter 5.1.3 has identified a number of variables that shape innovation. These include: R&D, human capital, cooperation, public policy to support innovation and access to innovation finance/funds. *R&D* includes *internal* and *external* research and development. Measures of human capital available from KIS include the *proportion of MSc or higher degree holders among permanent employees* together with the *proportion of research staff among permanent employees*. Public policy and support measures include: *tax relief for technology development*; *support for technology development and funding*; *participation in government R&D projects*; *technical support from the government*; *technology information*; *government provided technicians and support for educational research*; *procurement by government or collective purchasing*; and *marketing*. Access to innovation finance/funds/finance includes: *internal finance* that combines a firm's own funds with funds from a subsidiary or affiliated company; *government funding*; *loans* that include bank loans and company bonds; and *stock issues*.

Because innovation activity is known to vary with size and across regions data will be analysed by firm size and region. Firm sizes[35] and sixteen regions in Korea will be used. Table 7.1 shows the variables that are going to be used in the analysis and how they are measured.

[35] Five size categories will be used for firm level analysis while three size categories will be used for regional analysis.

Table 7.1 Dependent Variables

Dependent variables - Measurement of innovation	
New product Innovation	Product innovation. The company introduced at least one new product to the company during the last three years; coded '1', otherwise, coded '0'. Included in both firm and regional level analysis.
Significantly improved product Innovation	Product innovation. The company introduced at least one significantly improved product from the present one during the last three years; coded '1', otherwise, coded '0'. Included in both firm and regional level analysis.
New to market product Innovation	Proxy for radical innovation. The company introduced a new or significantly improved product to the market before competitors during the last three years; coded '1', or coded '0' if not relevant. Included only in firm level analysis.
New to firm product Innovation	Proxy for incremental innovation. The company introduced a new or significantly improved product that was already available from its competitors in the market during the last three years; coded '1', or '0' if not relevant. Included only in firm level analysis.
New or significantly Improved production method	Process innovation. The company introduced at least one new or significantly improved manufacturing method during the last three years; coded '1', otherwise, coded '0'. Included in both firm and regional level analysis.
New or significantly improved logistics	Process innovation. The company introduced at least one new or significantly improved logistics, delivery or distribution methods during the last three years; coded '1', otherwise, coded '0'. Included in both firm and regional level analysis.
New or significantly improved supporting activities	Process innovation. The company introduced at least one new or significantly improved supporting activity for the processes such as maintenance systems or operations for purchasing, accounting, or computing during the last three years; coded '1', otherwise, coded '0'. Included in both firm and regional level analysis.
Organisational Innovation SUM	Organisational innovation. The company introduced changes to business practices for organising procedure, knowledge management, methods of organising work responsibility, or methods of organising external relations with other organisations during the last three years; coded '1', otherwise, coded '0'. Included only in regional level analysis.
Marketing Innovation SUM	Marketing innovation. The company introduced significant changes to the aesthetic design or packaging or a good, new media or techniques for product promotion, new sales strategies such as new methods for product placement or sales channels, new methods of pricing goods during the last three years; coded '1', otherwise, coded '0'. Included only in regional level analysis.

Table 7.2 Independent Variables

Independent Variables - Innovation activities	
Internal R&D	The company carried out creative work undertaken on a systematic basis in order to increase level of knowledge and its use to improve or create products and processes; coded ‘1’, otherwise, coded ‘0’
External R&D	The company purchased the created work undertaken on a systematic basis in order to increase level of knowledge and its use to improve or create products and processes; coded ‘1’, otherwise, coded ‘0’
Proportion of MSc holders	Proxy for human capital. Proportion of MSc or higher degree holders among permanent employees.
Proportion of research staff	Proportion of research staff among permanent employees.
Cooperation	The company cooperated on the innovation activities with other enterprises or institutions; coded ‘1’, or coded ‘0’ if not relevant.
Tax relief for technology development	The company used tax relief for technology development during the last three years; coded ‘1’, otherwise, coded ‘0’.
Support for technology development and funding	The company used support for technology development and funding during the last three years; coded ‘1’, otherwise, coded ‘0’.
Participation in government R&D project	The company participated in government R&D project during the last three years; coded ‘1’, otherwise, coded ‘0’.
Technical support from the government	The company used technical support from the government during the last three years; coded ‘1’, otherwise, coded ‘0’.
Technology information	The company used technology information from the government during the last three years; coded ‘1’, otherwise, coded ‘0’.
Technicians and educational research	The company used technicians and educational research supported by the government during the last three years; coded ‘1’, otherwise, coded ‘0’.
Procurement by government or collective purchasing	The company used procurement by government or collective purchasing during the last three years; coded ‘1’, otherwise, coded ‘0’.
Marketing	The company used marketing supported by government during the last three years: coded ‘1’, otherwise, coded ‘0’
Internal Finance	Company sourced the fund for innovation activities by themselves or from subsidiary or affiliated company; coded ‘1’, or coded ‘0’ if not relevant.
Government Funding	Company used Government Funding for innovation activities. Coded ‘1’ or coded ‘0’ if not relevant.
Loans	Company used bank loans or bonds for innovation activities. Coded ‘1’ or coded ‘0’ if not relevant
Stock Issue	Company used stocks for innovation activities. Coded ‘1’ or coded ‘0’ if not relevant

Table 7.3 Control Variables

Control Variables	
Firm sizes	Firms with up to 49, 99, 299, 499, and with over 500 employees
Regions	Sixteen regions in Korea

7.1.2 General Analysis of Behaviour of the Firms

Korea has conducted innovation surveys based on the Oslo Manual since 1996. The analysis in this chapter will be based on the surveys conducted in 2008, 2010 and 2012 that cover the period 2005-2011. The sample sizes for the 3 surveys were presented in Table 4.2 in Chapter 4.2.1.4 and are re-presented here.

Table 4.2 Sample Breakdown of 2008/2010/2012 Surveys

REGION	Number of Total manufacturing firms in the region			Number of Firms in the sample			% of sample firms in the region		
	2008	2010	2012	2008	2010	2012	2008	2010	2012
Seoul	6,472	3,481	3,763	537	550	425	8.3	15.08	11.29
Busan	3,560	2,561	3,589	220	246	322	6.2	9.61	8.97
Daegu	2,799	2,297	2,828	149	159	279	5.3	6.92	9.87
Incheon	4,253	3,218	3,599	251	287	400	5.9	8.92	11.11
Gwangju	1,248	716	845	64	57	76	5.1	7.96	8.99
Daejeon	773	487	693	61	64	72	7.9	13.14	10.39
Ulsan	1,096	1,043	982	70	113	93	6.4	10.83	9.47
Kyunggi	13,531	15,077	13,503	819	1,192	1,106	6.1	7.91	8.19
Gangwon	598	382	529	37	49	51	6.2	12.83	9.64
Choongbook	1,416	1,481	1,710	103	149	164	7.3	10.06	9.59
Choongnam	1,614	1,877	1,955	127	204	205	7.9	10.87	10.49
Jeonbook	1,025	912	1,119	69	93	115	6.7	10.20	10.28
Jeonnam	985	730	817	68	85	75	6.9	11.64	9.18
Kyungbook	3,231	2,596	3,308	202	257	288	6.3	9.90	8.71
Kyungnam	4,504	4,431	4,406	296	405	400	6.6	9.14	9.08
Jeju	162	196	163	8	15	15	4.9	7.65	9.20
Whole of Korea	47,267	41,485	43,810	3,081	3,925	4,086	6.5	9.46	9.33

The weights were calculated based on the type of industry and size of the firm and the proportion of firms that carried out each innovation activity have been worked out. Although the proportions of weighted and unweighted firms turned out to be similar, unweighted data is used since there are questions that some firms fail to answer.

Korea Innovation Survey 2008 (2005-2007)

R&D by firm size

In the case of the 2008 Korea Innovation survey, 11.2% out of 3,081 firms, that is 246 firms, were large firms, 28.8% or 886 firms were medium sized and 59.9% or 1,848 firms were small. The proportion of product innovation that includes new or significantly improved product innovation was higher for large firms.

Table 7.4 presents the number of firms which introduced each innovation and their percentage out of the total number of firms by firm size. It can be seen that the larger the firm size, the higher the percentage of firms who introduced innovations in Korea.

Table 7.4 The Number/Percentage of Firms that Introduced Innovations by Firm Type - 2008

2008 SURVEY (3,081 firms)	Large Firm (total 347 firms)		Medium Firm (total 886 firms)		Small Firm (total 1,848 firms)	
	Number	Percentage	Number	Percentage	Number	Percentage
Product Innovation	246	*70.9*	383	*43.2*	112	*6.1*
Process Innovation	231	*66.6*	339	*38.3*	248	*13.4*
Organisation Innovation	236	*68.0*	332	*37.5*	193	*10.4*
Marketing Innovation	145	*41.8*	196	*22.1*	157	*8.5*

(own creation using KIS 2008 dataset)

The importance of R&D can be seen from Table 7.5 that shows how many firms by size produced innovation by carrying out research and development. More than 99% of firms in each company type that produced product innovation conducted R&D. The R&D activities include: internal; external; and collective (carrying out R&D with other firms or institutions). It is interesting to see among all three types of firms that produced innovation, around 95% of the firms conducted at least one type of research and development.

Table 7.5 The Number/Percentage of Firms that Introduced Each Innovation that Carried out R&D by Firm Type - 2008

2008 SURVEY (3,081 firms)		Large Firm produced innovation carried out R&D	Medium Firm produced innovation carried out R&D	Small Firm produced innovation carried out R&D
Product Innovation	Number	246	380	112
	Percentage	*100*	*99.2*	*100*
Process Innovation	Number	230	334	239
	Percentage	*99.6*	*98.5*	*96.4*
Organisation Innovation	Number	235	323	183
	Percentage	*99.6*	*97.3*	*94.8*
Marketing Innovation	Number	145	192	152
	Percentage	*100*	*98.0*	*96.8*

Korea Innovation Survey 2010 (2007-2009)

R&D by firm size

In the case of the 2010 Korea Innovation Survey, 3.2% out of 3,926 firms, that is 125 firms, were large firms, 8.6% that is 336 firms, were medium sized and 88.2% that is 3,464 firms, were small sized. Product innovation was the most introduced innovation for large and small firms but organisation innovation was introduced by medium firms the most. Table 7.6 presents the number of firms which introduced each innovation and their percentage out of the total number of firms by three different sizes.

Table 7.6 The Number/Percentage of Firms that Introduced Each Innovation by Firm Type - 2010

2010 SURVEY (3,926 firms)	Large Firm (total 125 firms)		Medium Firm (total 336 firms)		Small Firm (total 3,464 firms)	
	Number	Percentage	Number	Percentage	Number	Percentage
Product Innovation	83	*66.4*	222	*66.1*	1,417	*40.9*
Process Innovation	72	*57.6*	210	*62.5*	1,143	*32.9*
Organisation Innovation	69	*55.2*	223	*66.4*	1025	*29.6*
Marketing Innovation	36	*28.8*	140	*41.7*	731	*21.1*

The importance of R&D can be seen from Table 7.7 that shows how many firms by size produced innovation by carrying out research and development. The R&D activities here include internal, external and collective R&D.

More than 97% of firms in each size class that were product innovators conducted R&D activity. Large firms produced the highest percentage of each innovation except in process innovation where it had the lowest proportion of innovative firms that performed research and development.

Table 7.7 The Number/Percentage of Firms that Introduced Each Innovation that Carried out R&D by Firm Type – 2010

2010 SURVEY (3,926 firms)		Large Firm produced innovation carried out R&D	Medium Firm produced innovation carried out R&D	Small Firm produced innovation carried out R&D
Product Innovation	Number	83	221	1410
	Percentage	*100*	*99.5*	*99.5*
Process Innovation	Number	70	207	1121
	Percentage	*97.2*	*98.6*	*98.1*
Organisation Innovation	Number	69	221	1013
	Percentage	*100*	*99.1*	*98.8*
Marketing Innovation	Number	36	139	720
	Percentage	*100*	*99.3*	*98.5*

<u>Korea Innovation Survey 2012 (2009-2011)</u>

R&D by firm size

In the 2012 Korea Innovation survey, 3.4% out of 4,086 firms[36] that is 139 firms were large firms, 28.9% or 1,179 firms were medium sized and 67.4% or 2,754 firms were small sized. As in the 2010 survey, the proportion of product innovation that includes New product innovation and New or significantly improved product innovations was highest among large firms in the 2012 survey.

Table 7.8 presents the number of firms that introduced each innovation and their percentage out of the total number of firms by size class. For all 4 types of innovation the larger the firm size, the higher the percentage of firms who introduced the innovations in Korea. The fall in proportion of innovators in 2012 is noticed in Table 7.8. This will be discussed further in Chapter 9.

Table 7.8 The Number/Percentage of Firms Introduced Each Innovation by Firm Type – 2012

<u>2012 SURVEY</u> (4,072 firms)	Large Firm (total 139 firms)		Medium Firm (total 1,179 firms)		Small Firm (total 2,754 firms)	
	Number	Percentage	Number	Percentage	Number	Percentage
Product Innovation	52	*37.4*	243	*20.6*	305	*11.1*
Process Innovation	39	*28.1*	141	*12.0*	186	*6.8*
Organisation Innovation	56	*40.3*	249	*21.1*	347	*12.6*
Marketing Innovation	33	*23.7*	127	*10.8*	232	*8.4*

The importance of R&D can be seen from Table 7.9 below that presents how many firms by size produced innovation by carrying out R&D. R&D is especially important for product innovation. More than 95% of firms in each company type that produced product innovation carried out R&D activity.

The R&D activities here include internal, external and collective R&D. It is interesting to see that only 45.5% of small firms who conducted R&D produced organisation innovation and 55.6% of small firms who conducted R&D produced marketing innovation. Product and process innovations were invariably associated with R&D activity.

[36] 14 firms out of 4,086 firms are system missing

Table 7.9 The Number/Percentage of Firms that Introduced Each Innovation that Carried out R&D by Firm Type – 2012

2012 SURVEY (4,072 firms)		Large Firm produced innovation carried out R&D	Medium Firm produced innovation carried out R&D	Small Firm produced innovation carried out R&D
Product Innovation	Number	51	237	291
	Percentage	*98.1*	*97.5*	*95.4*
Process Innovation	Number	36	126	130
	Percentage	*92.3*	*89.4*	*69.9*
Organisation Innovation	Number	45	156	158
	Percentage	*80.4*	*65.7*	*45.5*
Marketing Innovation	Number	28	89	129
	Percentage	*84.8*	*70.1*	*55.6*

In general, the proportion of innovative large firms are predominantly large between 2005 and 2007 but the proportion of innovative medium size firms increased to a similar level as large firms in 2007 and 2009. The proportion of large, medium and small size innovative firms decrease to more than half in 2009 and 2011.

Although the proportion of firms that introduced each innovation that carried out R&D activity remains high between 2005 and 2007, and 2007 and 2009 they are reduced in 2009 and 2011.

Financial Independence by Region

Table 7.10 illustrates, the financial independence[37] of regions in Korea is relatively low other than four regions out of sixteen, Seoul, Ulsan, Kyunggi and Incheon, where their independence rate is over 60 per cent. The financial independence rate of Busan, Daegu and Dajeon was more than sixty per cent until 2007 but fell from 2008 in Busan and Daegu while Dajeon fell from 2009. Apart from those four regions whose financial independence rate is over sixty per cent, the remaining twelve regions show a high dependency rate on the central government.

[37] Percentage of financial independence of region has been worked out using the following equation: [(regional income tax + external income of the region) / total budget of the region] * 100
Source: $KOSTAT_c$, 2017)

Table 7.10 Financial independence by region between 2005 and 2011

%	2005	2006	2007	2008	2009	2010	2011
KOREA	56.2	54.4	53.6	53.9	53.6	52.2	51.9
Seoul	95.0	93.3	88.7	85.7	90.4	83.4	88.8
Busan	70.6	68.7	60.8	59.2	55.5	54.1	52.1
Daegu	72.6	70.6	61.9	56.7	50.7	52.7	48.6
Incheon	66.3	68.3	67.7	71.2	75.7	70.0	65.8
Gwangju	54.6	54.1	50.1	47.8	42.9	43.2	42.0
Daejeon	71.0	68.9	67.4	61.2	54.5	52.1	51.9
Ulsan	63.7	60.0	63.0	63.3	59.3	60.2	62.5
Kyunggi	70.3	68.8	66.5	66.1	64.1	59.3	60.1
Gangwon	22.4	21.8	24.2	23.3	21.4	20.8	21.4
Choongbook	25.2	25.6	27.1	27.0	25.4	25.1	24.1
Choongnam	29.0	29.4	30.4	29.7	28.1	24.0	28.3
Jeonbook	17.9	18.0	18.4	15.3	17.5	17.3	18.6
Jeonnam	11.9	13.6	10.6	11.0	10.4	11.5	13.5
Kyoungbook	22.4	19.6	21.9	20.7	19.1	21.7	21.4
Kyoungnam	29.8	31.4	30.5	32.1	32.5	34.2	35.2
Jeju	30.3	29.9	26.3	25.9	24.9	25.7	24.9

(Source: KOSTAT$_{c}$, 2017)

7.2 HYPOTHESIS TESTING

Chapter 5 provided a review of theories of innovation and outlined specific hypotheses to be analysed for Korea. The hypotheses that are going to be tested in this chapter are:

H1. R&D activities, internal and external, provide a positive influence on producing innovations.

H2. MSc or higher degree holders have a positive influence on innovation.

H3. Having staff especially devoted to research is necessary to drive innovation and therefore the proportion of research staff among permanent employees is expected to have a positive impact on innovation.

H4. The interaction between the public and private sector is important in systems of innovation and therefore, public support provides a positive impact on innovation.

H5. Cooperative activity with other institutes or firms in innovation activity has a positive influence on innovation.

H6. Having access to innovation finance/funds for innovation activities is important in the production of innovation.

H7. Regional factors including local knowledge creation, diffusion, application and cultural embeddedness influence innovation.

H8. Firm size influences innovation: larger firms find it easier to innovate, while smaller firms find it more difficult to innovate.

7.3 THE MODELS

Building on the earlier discussion in Chapter 5 and the discussion of methodology in Chapter 4, the following models will be estimated using logistic regression for different types of innovation. As noted in Chapter 4, Polhmann and Leitner (2003) have argued that OLS, Logistic or Probit regression analysis can be used if a dependent variable has a binary outcome and OLS and Logistic are the most commonly used models. If, however, the probability estimation of the outcome event is the purpose of the research then logistic regression is the better model. The results of logistic regression are comparable with OLS ones in many ways, however, it provides more precise probabilities and predictions of the dependent variable. Therefore, only logistic regression results are presented here since OLS regressions produced similar results.

Model A: Without control variables

$$\text{Innovation} = a + \beta_1(\text{Internal R\&D}) + \beta_2(\text{External R\&D}) - \beta_3(\text{Prop of MScHolders}) + \beta_4(\text{Prop of Research staffs}) + \beta_5(\text{Tax Relief}) + \beta_6(\text{Support for technical development and fund}) + \beta_7(\text{Participation in Government research project}) + \beta_8(\text{Technical support by government}) + \beta_9(\text{Technology information provided by government}) + \beta_{10}(\text{Technicians and educational research support}) + \beta_{11}(\text{Procurement and collective purchasing}) + \beta_{12}(\text{Marketing supported by government}) + \beta_{13}(\text{Internal Finance}) + \beta_{14}(\text{Government Funding}) + \beta_{15}(\text{Loans}) + \beta_{16}(\text{Stocks}) + \beta_{17}(\text{Cooperation})$$

Model B: with control variable 'Region'

$$\text{Innovation} = a + \beta_1(\text{Internal R\&D}) + \beta_2(\text{External R\&D}) - \beta_3(\text{Prop of MScHolders}) + \beta_4(\text{Prop of Research staffs}) + \beta_5(\text{Tax Relief}) + \beta_6(\text{Support for technical development and fund}) + \beta_7(\text{Participation in Government research project}) + \beta_8(\text{Technical support by government}) + \beta_9(\text{Technology information provided by government}) + \beta_{10}(\text{Technicians and educational research support}) + \beta_{11}(\text{Procurement and collective purchasing}) + \beta_{12}(\text{Marketing supported by government}) + \beta_{13}(\text{Internal Finance}) + \beta_{14}(\text{Government Funding}) + \beta_{15}(\text{Loans}) + \beta_{16}(\text{Stocks}) + \beta_{17}(\text{Cooperation}) + \beta_{18}(\text{Region})$$

Model C: with control variable 'Firm Size'

$Innovation = a + \beta_1(\text{Internal R\&D}) + \beta_2(\text{External R\&D}) - \beta_3(\text{Prop of MScHolders}) + \beta_4(\text{Prop of Research staffs}) + \beta_5(\text{Tax Relief}) + \beta_6(\text{Support for technical development and fund}) + \beta_7(\text{Participation in Government research project}) + \beta_8(\text{Technical support by government}) + \beta_9(\text{Technology information provided by government}) + \beta_{10}(\text{Technicians and educational research support}) + \beta_{11}(\text{Procurement and collective purchasing}) + \beta_{12}(\text{Marketing supported by government}) + \beta_{13}(\text{Internal Finance}) + \beta_{14}(\text{Government Funding}) + \beta_{15}(\text{Loans}) + \beta_{16}(\text{Stocks}) + \beta_{17}(\text{Cooperation}) + \beta_{18}(\text{Firm Size})$

Model D: with both control variables 'Firm Size and Region'

$Innovation = a + \beta_1(\text{Internal R\&D}) + \beta_2(\text{External R\&D}) - \beta_3(\text{Prop of MScHolders}) + \beta_4(\text{Prop of Research staffs}) + \beta_5(\text{Tax Relief}) + \beta_6(\text{Support for technical development and fund}) + \beta_7(\text{Participation in Government research project}) + \beta_8(\text{Technical support by government}) + \beta_9(\text{Technology information provided by government}) + \beta_{10}(\text{Technicians and educational research support}) + \beta_{11}(\text{Procurement and collective purchasing}) + \beta_{12}(\text{Marketing supported by government}) + \beta_{13}(\text{Internal Finance}) + \beta_{14}(\text{Government Funding}) + \beta_{15}(\text{Loans}) + \beta_{16}(\text{Stocks}) + \beta_{17}(\text{Cooperation}) + \beta_{18}(\text{Firm Sizes}) + \beta_{19}(\text{Region})$

The null hypothesis for each variable is that the coefficients in the above models are equal to 0, while the alternative hypothesis is they are different from 0 as indicated in the predicted signs in Table 7.14.

STATISTICAL SOFTWARE

In order to carry out the data analysis, SPSS (IBM statistical analysis software) version 23 and STATA 14 have been used. Maximum likelihood estimation was used for the logistic regression model.

7.3.1 Complications to Consider in Statistical Analysis

There are various complications that we come across when performing cross sectional regression analysis. These include multicollinearity, heteroskedasticity, specification errors, and endogeneity:

Multicollinearity

There are cases when more than two explanatory variables in the regression model are highly correlated and this is called multicollinearity. Even with the assumption that there is no exact linear relation with one another among independent variables, some linear dependence, multicollinearity, can often be found among them. Multicollinearity can be problematic and makes it difficult to separate their individual effects on the dependent variables (Gujarati and Porter, 2013).

The VIF (variance inflation factor) is an indicator of multicollinearity and the higher value of VIF the higher level of multicollinearity. Acceptance level of VIF value varies but is usually between 1 to 10 and a treatment is needed if it is over 10 since it means that there is a serious multicollinearity. Although there is no perfect solution for multicollinearity, dropping the variable with high multicollinearity and the theoretically least significant one, or, it can be solved by expanding the data size. Since multicollinearity is the problem with the sample, not the population, this can be solved by using new data for the same variable.

When multicollinearity test was carried out for the analysis in this thesis, most of the time there was no multicollinearity but when serious multicollinearity occurs, this was treated by removing a variable that had higher multicollinearity.

Heteroscedasticity

In the classical regression model assumption, the variance of the disturbances in the relationship of the dependent variable with independent variables are the same across all the independent variables. This is called homoscedasticity and if this assumption is violated heteroscedasticity exists. By definition, Ordinary Least Square regression provides the same weight to all observations but the cases that have larger disturbances have more pull than others if heteroscedasticity is present. Moreover, the standard errors are biased with heteroscedasticity and it leads to incorrect conclusions about the significance of the regression coefficients (Statistics Solution, 2013).

There are a number of diagnostic tools such as the Park test, Glejser test, White's test, and Breusch-Pagan test, that can be used to check the presence of heteroskedasticity. If these tests produce a p-value that is less than a significance level of 0.05, we can say that heteroskedasticity is present. In this case, we can rectify the problem by the method of

Weighted Least Squares when we know the true error variance or carry out Box-Cox transformation (Gujarati and Porter, 2013).

Specification Errors

A model has to include key variables that are proposed by theory and there are a number of ways a model can be deficient, leading to model specification errors. Taking the criticism of Keynes who argued that no economic theory is testable, Hendry (1980, p. 396) explains that this can be literally interpreted as economic itself has lost the scientific value but he believes Keynes might have not intended to implicate this. From Keynes' objections, however, 'problems of the linear regression model' is listed up and these include omission of a relevant variable, inclusion of an unnecessary variable, adapting the wrong functional form and errors of measurement.

When one or more explanatory variables have been omitted and they are correlated with more than one independent variable in the model, other variables that have been included in the model can be correlated with the error term. Moreover, irrelevant variable bias happens when unnecessary variables are included in the model and when this happens we end up getting larger estimated variances of the coefficients and therefore our probability inferences about the true parameters are less precise due to the wider confidence interval. This will make us unable to identify significant relationships between the dependent and independent variables (Gujarati and Porter, 2013, 221-227).

Endogeneity

Endogeneity can be a problem when we use a single equation model to investigate the relationship between innovation and the innovation activities such as R&D, human capital, cooperation, public supports, and financial access. This is because their relationship might not be a simple one-way causal relationship since innovation can be affected by innovation activities while innovation activities can be affected by innovation as well. Machin and Van Reenen (1996) suggested that this problem can be solved if we use instrumental variables.

7.3.2 Variables and Their Types used for KIS 2008, 2010 and 2012

Innovations are measured through *New product innovation, Significantly improved product innovation, New to market innovation, New to firm innovation, New or significantly improved methods of manufacturing goods process innovation, New or significantly improved logistics process innovation, New or significantly improved delivery or distribution methods process innovation,* and *New or significantly improved supporting activities process innovation*.

Based on the theories of innovation discussed in Chapter 5, five sets of variables influence innovation:

R&D (internal and external),

Human capital (*Proportion of Master or higher degree holders among permanent employees* and *Proportion of research staff among permanent employees*),

Cooperation (Cooperative innovation activities with other firms or institutions for product and process innovation),

Public Policy (*Tax relief for technology development, Support for technology development and funding, Participation in government R&D projects, Technical support from the government, Technology information provided by the Government, Technicians and educational research, Procurement by the government or collective Purchasing, Marketing supported by the government*), and

Access to innovation finance/funds (*Internal Finance, Government Funding, Loans, Stocks*).

Tables 7.11, 7.12 and 7.13 show the variables used in the analysis and their measurement.

Table 7.11 Dependent Variables and Their Measurement in the Survey and Analyses

Dependent Variables	**Variable measure in the survey**
New product Introduction	Binary
Significantly improved product Introduction	Binary
New to market product Innovation	Binary
New to firm product Innovation	Binary
New or significantly improved methods of manufacturing goods	Binary
New or significantly improved logistics, delivery or distribution methods	Binary
New or significantly improved supporting activities for your processes	Binary

Table 7.12 Independent Variables and Their Measurement in the Survey and Analyses

Independent Variables	**Variable measure in the survey**
Internal R&D	Binary
External R&D	Binary
Proportion of employees with MSc or higher degree among permanent employees	Scale
Proportion of research staffs among permanent employees	Scale
Tax relief for technology development	Nominal
Support for technology development and funding	Nominal
Participation in government R&D project	Nominal
Technical support from the government	Nominal
Technology information	Nominal
Technicians and educational research	Nominal
Procurement by government or collective purchasing	Nominal
Marketing	Nominal
Internal Finance	Nominal
Government Funding	Nominal
Loans	Nominal
Stocks	Nominal
Cooperation in product innovation	Binary
Cooperation in process innovation	Binary

Table 7.13 Control Variables and Their Measurements in the Survey and Analyses

Control Variables	**Variable measure in the survey**
Regions	Nominal converted to Binary
Firm Sizes	Nominal converted to Binary

PREDICTED SIGNS

The hypotheses in section 7.1.3, developed in chapter 5.2.3 are based on the relevant theories and the predicted signs are presented in Table 7.14:

Table 7.14 Predicted Signs for Each Hypothesis

HYPOTHESES	PREDICTED SIGN
Internal R&D	+
External R&D	+
Proportion of MSc Holders	+
Proportion of Research staff	+
Cooperation	+
Tax relief for technology development	+
Support for technology development and funding	+
Participation in government R&D project	+
Technical support from the government	+
Technology information provided by the government	+
Technicians and educational research supported by the gov.	+
Procurement by government or collective purchasing	+
Marketing	+
Internal Finance/Funds	+
Government Funding	+
Loans	+
Stock issue	+
Region	+/-
Firm size	+/-

7.3.3 Results

This section examines test statistics and regression estimations for four models. In all models in this analysis the dependent variable, Y, is an innovation measure and in this analysis innovation has been measured by the production of product and process innovation. Following the Schumpeterian tradition that has been incorporated in the KIS, innovation also includes New or Significantly Improved products and processes (Cecere, 2013). The production of New to the market and New to firm/company product innovation has been used as well.

Innovation activities as discussed above have also been commonly entered as explanatory variables. These include:

Internal and *External R&D*, *Human capital* that has been proxied by the proportion of MSc or higher degree holders and the proportion of researchers among permanent employees to explain the importance of human capital, *Public support* that has been categorised into eight different support activities: participation in government R&D projects; technical support from the government; technology information; technicians and educational research; procurement by government or collective purchasing; and marketing, *Cooperation*, and *Access to innovation finance/funds* that has been divided into four composite variables including internal finance, Government Funding, loans and stock issue.

The results of the regression analysis [38] for models B and D which include 15 regional dummies (with one region as a reference) have not been presented in the Tables below when the regional dummies were insignificant, individually and jointly. The results of the regression analysis for model B and D, however, are presented in the case where the dummy variables for the 15 regions were jointly significant.

[38] The results can be provided upon request.

Regression Analysis for KIS 2008 (2005-2007)

Table 7.15 presents descriptive statistics for the dependent and independent variables:

DESCRIPTIVE STATISTICS (KIS 2008)

Table 7.1541 Descriptive Statistics for KIS 2008

	N	Mean	Stand. Dev.	Min.	Max.
1 New Product Innovation	1524	.33	.469	0	1
2 Significantly Improved Product Innovation	1524	.58	.493	0	1
3 New or significantly improved production process	1524	.45	.497	0	1
4 New or significantly improved logistics	1524	.19	.393	0	1
5 New or significantly improved support activity	1524	.26	.439	0	1
6 New to Market Product Innovation	3082	.130	.336	0	1
7 New to firm Product Innovation	3082	.291	.454	0	1
8 Inland R&D	3081	.48	.500	0	1
9 External R&D	3081	.20	.397	0	1
10 Proportion of MSc or higher degree holders among permanent employees	3081	69.55	1.974	0	69.55
11 Proportion of Research staff among permanent employees	3078	94.55	5.736	0	94.55
12Tax relief for technology development	3081	.10	.302	0	1
13 Support for technology development and funding	3081	.15	.361	0	1
14 Participation in government R&D project	3081	.13	.331	0	1
15 Technical support from the government	3081	.11	.312	0	1
16 Technology information provided by the government	3081	.12	.322	0	1
17 Technicians and educational research	3081	.11	.314	0	1
18 Procurement by the government or collective purchasing	3081	.09	.188	0	1
19 Marketing supported by the government	3081	.13	.335	0	1
20 Internal Finance	3082	.47	.499	0	1
21 Government Funding	3082	.15	.362	0	1
22 Loans	3082	.13	.333	0	1
23 Stock	3082	.01	.103	0	1
24 Cooperation in Product Innovation	3082	.12	.324	0	1
25 Cooperation in Process Innovation	3082	.08	.272	0	1
26 EmployeesUpTo49	3082	.06	.489	0	1
27 EmployeesUpTo99	3082	.10	.304	0	1
28 EmployeesUpTo299	3082	.16	.362	0	1
29 EmployeesUpTo499	3082	.05	.227	0	1
30 EmployeesOver500	3082	.09	.279	0	1
31 Regions	3081	7.15	4.675	1	16

CORRELATION MATRIX, 2005-2007

Table 7.16 provides the correlation matrix between dependent and independent variables for 2005-2007:

Table 7.16 Correlation Matrix between Measurements of Innovation and Aspects of Innovation Activities using the Data for the Whole of Korea, 2005-2007

	1	2	3	4	5	6	7	8
1 New Product Innovation	1							
2 Significantly Improved Product Innovation	.315**	1						
3 New or significantly improved production process	.140**	.281**	1					
4 New or significantly improved logistics	.154**	.178**	.351**	1				
5 New or significantly improved support activity	.158**	.206**	.350**	.433**	1			
6 New to Market Product innovation	.466**	.394**	.181**	.157**	.147**	1		
7 New to firm Product innovation	.433**	.818**	.257**	.162**	.197**	.419**	1	
8 Internal R&D	.089**	.136**	.089**	.058*	.067**	.399**	.651**	1
9 External R&D	.171**	.222**	.207**	.245**	.225**	.347**	.480**	.500**
10 Proportion of MSc Holders	.066**	.051*	.007	.012	.048	.164**	.191**	.265**
11 Proportion of Research staff among permanent employees	.091**	.096**	-.092**	-.075**	-.025**	.299**	.425**	.580**
12 Tax relief for technology development	.112**	.153**	.138**	.070**	.149**	.251**	.325**	.341**
13 Support for technology development and funding	.100**	.168**	.154**	.093**	.105**	.255**	.399**	.433**
14 Participation in government R&D project	.088**	.205**	.168**	.184**	.203**	.282**	.377**	.387**
15 Technical support from the government	.073**	.190**	.167**	.174**	.202**	.269**	.347**	.349**
16 Technology information provided by the Government	.079**	.192**	.171**	.185**	.183**	.284**	.351**	.371**
17 Technicians and educational research	.069**	.171**	.130**	.173**	.209**	.266**	.326**	.343**
18 Procurement by the government or collective Purchasing	.053**	.179**	.114**	.166**	.183**	.276**	.288**	.307**
19 Marketing supported by the government	.089**	.204**	.144**	.148**	.167**	.298**	.362**	.377**
20 Internal Finance	.004	.005	-.009	-.002	.014	.372**	.622**	.925**
21 Government Funding	.094**	.175**	.169**	.085**	.093**	.271**	.405**	.439**
22 Loans	.049	.057*	.116**	.008	-.001	.179**	.274**	.365**
23 Stocks	.070**	.062*	.011	.008	.014	.100**	.100**	.109**
24 Cooperation in Product Innovation	.249**	.378**	.219**	.210**	.227**	.331**	.515**	.380**
25 Cooperation in Process Innovation	.062*	.128**	.343**	.351**	.349**	.173**	.291**	.308**
26 Firms with 10-49 Employees	-.062*	-.124**	-.205**	-.260**	-.208**	-.210**	-.325**	-.392**
27 Firms with 50-99 Employees	-0.037	-.074**	-0.023	-0.038	-.065*	-0.001	-0.008	.049**
28 Firms with 100-299 Employees	-0.015	0.049	0.033	0.003	0.004	.039*	.128**	.153**
29 Firms with 300-499 Employees	.061*	0.021	.110**	.100**	.062*	.098**	.164**	.186**
30 Firms with over 500 Employees	.083**	.158**	.169**	.296**	.279**	.237**	.280**	.285**
31 Regions	-.085**	-0.034	0.016	0.001	-0.016	-.061**	-.059**	-.045*

	9	10	11	12	13	14	15	16
9 External R&D	1							
10 Proportion of MSc Holders	.217**	1						
11 Proportion of Research staffs among permanent employees	.318**	.391**	1					
12Tax relief for technology development	.323**	.194**	.267**	1				
13 Support for technology development and funding	.434**	.235**	.365**	466**	1			
14 Participation in government R&D project	.478**	.252**	.296**	.458**	.614**	1		
15 Technical support from the government	.426**	.206**	.247**	.416**	.548**	.789**	1	
16 Technology information provided by the Government	.426**	.209**	.258**	.458**	.554**	.762**	.816**	1
17 Technicians and educational research	.399**	.180**	.238**	.419**	.494**	.731**	.742**	.739**
18 Procurement by the government or collective Purchasing	.355**	.190**	.223**	.391**	.450**	.701**	.747**	.741**
19 Marketing supported by the government	.390**	.221**	.294**	.405**	.509**	.672**	.660**	.693**
20 Internal Finance	.472**	.258**	.557**	.314**	.399**	.361**	.319**	.336**
21 Government Funding	.432**	.231**	.359**	.482**	.953**	.609**	.534**	.538**
22 Loans	.234**	.081**	.224**	.169**	.197**	.176**	.168**	.175**
23 Stock	.147**	.117**	.119**	.143**	.113**	.103**	.064**	.099**
24 Cooperation in Product innovation	.555**	.145**	.261**	.274**	.368**	.402**	.373**	.353**
25 Cooperation in Process innovation	.362**	.112**	.143**	.205**	.238**	.299**	.282**	.273**
26 Firms with 10-49 Employees	-.279**	-.098**	-.036*	-.228**	-.218**	-.251**	-.220**	-.240**
27 Firms with 50-99 Employees	-0.019	0.028	0.010	.053**	.040*	-0.002	0.001	-0.001
28 100-299 Employees	.085**	0.030	0.000	.076**	.099**	.101**	.088**	.085**
29 Firms with 300-499 Employees	.137**	.042*	0.028	.076**	.084**	.099**	.090**	.098**
30 Firms with over 500 Employees	.288**	.069**	0.031	.182**	.144**	.232**	.198**	.231**
31 Regions	-0.028	-.070**	-.079**	-0.007	-0.010	-0.008	-0.001	-0.008

	17	18	19	20	21	22	23	24
17 Technicians and educational research	1							
18 Procurement by the government or collective Purchasing	.746**	1						
19 Marketing supported by the government	.689**	.707**	1					
20 Internal Finance	.318**	.280**	.350**	1				
21 Government Funding	.157**	.140**	.185**	.293**	1			
22 Loans	.481**	.437**	.488**	.404**	.202**	1		
23 Stocks	.084**	.066**	.092**	.079**	.140**	.095**	1	
24 Cooperation in Product innovation	.335**	.328**	.334**	.351**	.154**	.364**	.078**	1
25 Cooperation in Process innovation	.256**	.217**	.229**	.283**	.120**	.245**	.039*	.362**
26 Firms with 10-49 Employees	-.236**	-.194**	-.203**	-.384**	-.091**	-.216**	-.070**	-.224**
27 Firms with 50-99 Employees	0.003	-0.003	0.001	.050**	.047**	.038*	-0.014	-0.009
28 Firms with 100-299 Employees	.091**	.092**	.103**	.139**	.054**	.098**	.043*	.036*
29 Firms with 300-499 Employees	.088**	.058**	.062**	.195**	0.007	.078**	0.017	.145**
30 Firms with over 500 Employees	.221**	.178**	.171**	.280**	0.033	.148**	.070**	.239**
31 Regions	-0.017	-0.025	-.046**	-.047**	-0.018	-0.013	-.046**	-0.023

	25	26	27	28	29	30	31
25 Cooperation in Process innovation	1						
26 Firms with 10-49 Employees	-.247**	1					
27 Firms with 50-99 Employees	-0.018	-.416**	1				
28 Firms with 100-299 Employees	.048**	-.527**	-.145**	1			
29 Firms with 300-499 Employees	.102**	-.295**	-.081**	-.103**	1		
30 Firms with over 500 Employees	.307**	-.376**	-.103**	-.131**	-.073**	1	
31 Regions	-.038*	.052**	0.007	-0.012	-.023	-.064**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Looking at the correlations among dependent variables, 1 to 7, we can see generally weak to moderate correlations. The variables, *Significantly improved product innovation* and *New to firm product innovation*, however, show a strong correlation with r = 0.82.

The correlations between the independent variables, 8 to 25, are weak to strong with a very strong correlation between *Support for technology development and funding* and *Government funding* with r = 0.95. VIF tests were carried out for each of the models as follows:

<u>Model A: Without control variables</u>

Multicollinearity tests were carried out and no VIF value of the remaining variables exceeded the recommended cut off value of 10 (Hair *et al.*, 1998) with VIF ranging between 1.03 and 9.28.

<u>Model B: with control variable 'Region'</u>

Regions have been entered as a control variable in Model A to capture the influence of location of firms for the production of innovation. When multicollinearity tests were carried out no VIF value of the remaining variables exceeded the recommended cut off value of 10 with the VIF ranging between 1 and 8.82.

Model C: with control variable 'Firm Size'

Firm size has been entered as a control variable in Model A to capture the importance of firm sizes in the production of innovation.

The VIF of *Support for technology development and funding* is 11.38 and *Government funding* is 11.30 with the rest ranging between 1.07 and 5.51. The first two VIF statistics exceed the recommended cut off value of 10 and therefore the variable with the highest VIF, and theoretically less important, that is 'Support for technology development and funding' has been removed making the VIF of the rest of the variables range between 1.06 and 5.50. *Firms with 300-499 employees* has been removed from the regression due to collinearity.

Model D: with control variables: Firm Size and Region

Finally, both regions and firm size have been added to the model as control variables. No VIF value of the remaining variables exceeded the recommended cut off value of 10 with VIF ranging between 1 and 9.3. *Firms with 50-99 employees* has been removed from the regression due to collinearity.

REGRESSION RESULTS

The four models are estimated for a number of different types of innovation as the factors shaping the different innovations may be different. Tables 7.17 to 7.23 present the results of Logistic Regressions for each of the four models: Logit coefficients, Wald Chi square value in brackets, pseudo R squared values (Nagelkerke and Cox and Snell) and the Chi square statistic.

In order to estimate the coefficients of a non-linear equation, a statistical method, maximum likelihood estimation is used. In logistic regression, Chi square tests are used to see if there is a significant difference between the log likelihoods especially between -2 log likelihoods of the baseline model and the new model. We have a significantly reduced -2 Log likelihoods compared with the baseline model which means that the new model explains more of the variance in the outcome and is an improvement.

The Chi square value for our model A (without any control variable) is highly significant ($p<0.001$, d.f.=17) with a Chi-square value of 128.780 for the dependent variable *New product innovation*, and 315.616 for the dependent variable *Significantly improved product innovation*. For model B, where "region", the dummy variables for the 15 regions were jointly significant, the Chi square value is 151.829 turned out to be highly significant ($p<0.001$, d.f.=32) for New product innovation.

The Chi square value for *New product innovation* changes only slightly as control variable(s) are included and it was 139.266 (d.f.=20) for model C. The values for *Significantly improved product innovation* are 350.928 (d.f.=20) for models C. They are statistically highly significant with $p<0.001$.

Nagelkerke R squared values for model A in Table 7.17 of 0.113 and 0.252 in Table 7.18 show a weak relationship between innovation activities and output of *New product* innovation and *Significantly improved product innovation*, respectively. These values increase as control variables, *Firm sizes*, are added in model C to 0.122 and 0.277 for *New product innovation* and *Significantly improved product innovation* respectively. Adding control variables marginally improved the model fit.

Tables 7.17 and 7.18 present the logistic regression predicting the innovation from the independent variables. The variables indicate as following: one star 10%, 2 stars 5% and 3 stars 1%. While OLS coefficients measure how much the expected values of innovation change, the coefficients of logistic regression measure the changes in the log of odds (Burns and Burns, 2008). Logistic regression works out the changes in the log odds[39] of dependent value, not the changes in the dependent value as OLS does. The change in the odds of independent variable when one unit in the predictor increases is estimated by the odds ratio. The odds ratio is calculated by using the regression coefficient of the predictor as the exponent and it is automatically calculated by SPSS and presented as Exp(B) in the results Tables.

The values of 'odds ratio' will be reported in all the results tables in this chapter. If the value is larger than '1', the odds of an outcome happening increase (equivalent to a

[39] The odds of membership of the target group for a dichotomous variable are the same as the probability of membership in the target group divided by the probability of membership in the other group. Odds value ranges from 0 to infinity and the value tells us how much more likely an observation is a target group member rather than the other group member (Burns and Burns, 2008).

positive B coefficient) while if it is less then '1' then increase in the predictor result in the drop (equivalent to a negative B coefficient) in the odds of the outcome (innovation) happening.

If we look at model A and B in Table 7.17, we can see that *Internal* and *External R&D*, *proportion of researchers among permanent employees, Tax relief for technology development*, *Loans*, and *Cooperation* are statistically significant activities for *New product innovation*. Significant variables are the same in model C for *New product innovation* except in model C where small *firms with 10-49 and 50-99 employees* turned out to be negative.

Furthermore, model A in Table 7.18 shows that for *significantly improved product innovation*, *Internal R&D*, *Proportion of researchers among permanent employees*, *Marketing*, *Loans,* and *Cooperation* are the positive and significant activities. In model C, significant variables are identical with model A except when firm sizes were entered in model C *Firms with employees over 500* is positive and significant.

Adding control variables did not produce more significant variables in the dependent variables entered in model A.

Table 7.17 Logistic Regression Models with New Product Innovation as the Dependent Variable, 2005-2007

Dependent variable	New Product innovation				
Independent variables	Model A		Model B	Model C	
	B	Exp(B)	Exp(B)	B	Exp(B)
Internal R&D	1.066	2.905 (5.762) **	2.808 (5.296) **	0.973	2.646 (4.738) **
External R&D	0.281	1.325 (4.318) **	1.307 (3.820) *	0.237	1.267 (3.008) *
Proportion of MSc Holders	0.007	1.007 (0.545)	1.006 (0.335)	0.006	1.006 (0.438)
Proportion of Researchers among permanent employees	0.011	1.011 (0.041) **	1.010 (3.445) *	0.016	1.016 (8.305) **
Tax relief for technology development	0.341	1.406 (4.774) **	1.435 (5.248) **	0.31	1.363 (3.874) **
Support for technology development and funding	0.245	1.277 (0.442)	1.392 (0.803)		
Participation in government R&D project	-0.129	0.879 (0.305)	0.885 (0.267)	-0.184	0.832 (0.616)
Technical support from the government	-0.103	0.903 (0.149)	0.905 (0.139)	-0.062	0.940 (0.055)
Technology information provided by the Government	0.025	1.025 (0.01)	0.990 (0.002)	-0.026	0.974 (0.011)
Technicians and educational research	-0.012	0.988 (0.003)	1.042 (0.030)	-0.051	0.951 (0.047)
Procurement by the government or collective Purchasing	-0.297	0.743 (1.35)	0.746 (1.291)	-0.275	0.759 (1.158)
Marketing supported by the government	0.206	1.229 (1.141)	1.201 (0.885)	0.25	1.284 (1.685)
Internal Finance	0.207	1.231 (0.551)	1.200 (0.411)	0.136	1.146 (0.236)
Government Funding	-0.218	0.804 (0.356)	0.784 (0.445)	0.04	1.040 (0.067)
Loans	0.236	1.266 (3.057) *	1.276 (3.187) *	0.3	1.350 (4.806) **
Stock Issue	0.488	1.629 (1.665)	1.466 (0.992)	0.438	1.550 (1.335)
Cooperation in Product Innovation	1.015	2.758 (49.158) ***	2.816 (49.965) ***	0.966	2.628 (48.935) ***
Firms with 10-49 Employees				-0.527	0.590 (6.351) **
Firms with 50-99 Employees				-0.568	0.566 (5.163) **
Firms with 100-299 Employees				-0.358	0.699 (2.699)
Firms with 300-499 Employees					
Firms with over 500 Employees				-0.072	0.930 (0.106)
Region			(22.486) *		
Constant	-2.608	0.074 (25.903) ***		-2.122	0.120 (15.159) ***
Observations	1521		1521	1521	
Model Test: -2 Log likelihood	1791.888		1768.838	1781.401	
Nagelkerke R^2	0.113		0.132	0.122	
Cox & Snell R^2	0.081		0.095	0.087	
X^2 (d.f.)	128.780*** (17)		151.829*** (32)	139.266*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Table 7.18 Logistic Regression Models in Significantly Improved Product Innovation as Dependent Variable, 2005-2007

Dependent variable		Significantly Improved Product innovation			
Independent variables		Model A		Model C	
		B	Ext(B)	B	Exp(B)
Internal R&D		1.08	2.945 (10.066) **	0.929	2.531 (7.39) **
External R&D		0.112	1.118 (0.665)	0.002	1.002 (0)
Proportion of MSc Holders		-0.006	0.994 (0.398)	-0.008	0.992 (0.682)
Proportion of Researchers among permanent employees		0.013	1.013 (4.922) **	0.023	1.023 (12.921) ***
Tax relief for technology development		0.273	1.314 (2.543)	0.231	1.260 (1.748)
Support for technology development and funding		-0.479	0.620 (1.380)		
Participation in government R&D project		0.039	1.040 (0.024)	-0.063	0.939 (0.061)
Technical support from the government		-0.083	0.920 (0.079)	-0.03	0.971 (0.010)
Technology information provided by the Government		0.143	1.154 (0.281)	0.038	1.039 (0.019)
Technicians and educational research		-0.177	0.838 (0.499)	-0.211	0.809 (0.684)
Procurement by the government or collective Purchasing		0.142	1.153 (0.247)	0.170	1.185 (0.349)
Marketing supported by the government		0.499	1.646 (5.825) **	0.522 (6.221) **	1.685 (6.221) **
Internal Finance		0.183	1.200 (0.424)	0.155	1.167 (0.302)
Government Funding		0.579	1.783 (2.056)	0.175	1.191 (1.199)
Loans		0.256	1.292 (3.438) *	0.347	1.415 (6.066) **
Stock Issue		0.616	1.851 (1.658)	0.341	1.406 (0.522)
Cooperation in Product Innovation		2.210	9.120 (113.444) ***	2.195	8.984 (109.104) ***
Firms with 10-49 Employees				-0.282	0.755 (1.622)
Firms with 50-99 Employees				-0.403	0.668 (2.479)
Firms with 100-299 Employees				0.317	1.372 (1.872)
Firms with 300-499 Employees					
Firms with over 500 Employees				0.704	2.023 (7.889) ***
Constant		-1.704	0.182 (16.172) ***	-1.598	0.202 (11.53) **
Observations		1521		1521	
Model Test:	-2 Log likelihood	1750.657		1715.346	
	Nagelkerke R^2	0.252		0.277	
	Cox & Snell R^2	0.187		0.206	
	X^2 (d.f.)	315.617*** (17)		350.928*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

The results for *process innovation* are shown in Tables 7.19, 7.20 and 6.21. The Chi square value for model A (without any control variable) is highly significant ($p<0.001$, d.f.=17) with Chi-square values of 284.420 for *New or Significantly Improved production process innovation*, 224.779 for *New or Significantly Improved Logistics Methods*, 232.803 for *Support activity process innovation*.

The Chi square values for *New or significantly improved production process innovation* for model B is 313.751 (d.f.=32) and C is 314.802 (d.f.=20) while it is 311.399 (d.f.=20) for model C in the case of *New or significantly improved logistic process innovation*. The Chi square value for *New or significantly improved support activity process innovation* for model C is 290.341 (d.f.=20). They are statistically highly significant with $p<0.001$.

For *new or significantly improved production process innovation*, the Nagelkerke R^2 is 0.228 and 0.25 while the values for *new or significantly improved logistic process innovation* is 0.221 and 0.297, and 0.208 and 0.255 for *Support activity process innovation* in model A and C respectively.

As a whole, adding control variables improved the model fit slightly.

The explanatory variables that are statistically significant in model A in *New or significantly improved production process* are *Internal* and *External R&D*, *Proportion of Researchers among permanent employees*, *Tax relief*, *Marketing*, *Government Funding*, *Loans* and *Cooperation*. When Firm sizes are entered in model C, significant variables in model A remain the same except that *Tax relief* became insignificant but *firms with 10-49, 50-99 and 100-299 employees* came out as negative and significant indicating that smaller firm are less likely to be innovators.

The same variables turned out to be positive and significant for model B and D except *Marketing* that became insignificant when *region* was entered then became significant in model D where both *region* and *firm size* is entered. *Firms with 10-49, 50-99 and 100-299 was significant and negative in model B* when *firms with 300-499 and over 500 employees came out positive and significant in model D.*

Table 7.19 Logistic Regression Models in New or Significantly Improved Production Process Innovation as Dependent Variable, 2005-2007

Dependent variable		New or significantly improved production process			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		2.176 (5.101) **	2.144 (4.785) **	1.872 (3.248) *	1.802 (2.77) *
External R&D		1.510 (10.762) **	1.510 (10.447) ***	1.391 (6.647) **	1.381 (6.106) **
Proportion of MSc Holders		1.001 (0.006)	1.005 (0.236)	0.998 (0.027)	1.003 (0.113)
Proportion of Researchers among permanent employees		0.976 (17.205) ***	0.977 (15.654) ***	0.987 (4.751) **	0.989 (2.915) *
Tax relief for technology development		1.308 (2.797) *	1.289 (2.444)	1.247 (1.850)	1.214 (1.37)
Support for technology development and funding		0.753 (0.555)	0.697 (0.863)		0.667 (1.075)
Participation in government R&D project		0.950 (0.046)	0.949 (0.046)	0.872 (0.321)	0.889 (0.229)
Technical support from the government		1.197 (0.432)	1.161 (0.294)	1.237 (0.598)	1.196 (0.41)
Technology information provided by the Government		1.340 (1.387)	1.397 (1.758)	1.240 (0.73)	1.286 (0.962)
Technicians and educational research		0.743 (1.55)	0.751 (1.385)	0.686 (2.443)	0.679 (2.448)
Procurement by the government or collective Purchasing		0.734 (1.396)	0.787 (0.812)	0.770 (0.987)	0.842 (0.413)
Marketing supported by the government		1.406 (3.051) *	1.345 (2.236)	1.471 (3.838) **	1.441 (3.283) *
Internal Finance		1.257 (0.697)	1.284 (0.809)	1.149 (0.257)	1.139 (0.22)
Government Funding		1.929 (3.026) *	1.989 (3.210) *	1.553 (8.385) **	2.111 (3.755) *
Loans		1.819 (20.023) ***	1.827 (19.717) ***	2.041 (27.225) ***	2.091 (27.931) ***
Stock Issue		0.767 (0.445)	0.777 (0.396)	0.660 (1.098)	0.681 (0.905)
Cooperation in Process innovation		6.884 (104.265) ***	7.055 (104.715) ***	6.083 (88.273) ***	6.166 (87.179) ***
Firms with 10-49 Employees				0.354 (23.417) ***	0.796 (1.374)
Firms with 50-99 Employees				0.442 (10.786) **	
Firms with 100-299 Employees				0.538 (7.847) **	1.222 (0.932)
Firms with 300-499 Employees					2.607 (13.85) ***
Firms with over 500 Employees				0.757 (1.401)	2.004 (8.927) **
Region			(28.329) **		(34.454) **
Constant		0.176 (16.786) ***	0.178 (1.921)	0.415 (3.612)	0.224 (1.427)
Observations		1521	1521	1521	1521
Model Test:	-2 Log likelihood	1807.899	1778.568	1777.517	1740.982
	Nagelkerke R^2	0.228	0.249	0.250	0.276
	Cox & Snell R^2	0.171	0.186	0.187	0.206
	X^2 (d.f.)	284.420*** (17)	313.751*** (32)	314.802 *** (20)	351.337 *** (36)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

In model A in *new or significantly improved logistics,* as Table 7.20 shows, *External R&D* and *Cooperation* are positive and significant while *Proportion of researchers among permanent employees* is negative and significant.

When *firm sizes* are entered *Proportion of researchers among permanent employees* became insignificant while *Tax relief* is significant and negative in model C. *Firms with 10-49, 50-99 and 100-299 employees* are statistically negative and significant in model C as well.

Table 7.20 Logistic Regression Models in New or Significantly Improved Logistic methods Process Innovation as Dependent Variable, 2005-2007

Dependent variable		New or significantly improved logistics			
Independent variables		Model A		Model C	
		B	Exp(B)	B	Exp(B)
Internal R&D		0.571	1.770 (1.144)	0.052	1.054 (0.009)
External R&D		0.86	2.363 (30.128) ***	0.721	2.056 (19.639) ***
Proportion of MSc Holders		-0.002	0.998 (0.022)	-0.008	0.992 (0.331)
Proportion of Researchers among permanent employees		-0.023	0.977 (8.124) **	0.005	1.005 (0.45)
Tax relief for technology development		-0.148	0.862 (0.591)	-0.332	0.717 (2.8) *
Support for technology development and funding		0.247	1.280 (0.339)		
Participation in government R&D project		0.193	1.213 (0.485)	0.052	1.053 (0.033)
Technical support from the government		-0.234	0.792 (0.54)	-0.06	0.942 (0.034)
Technology information provided by the Government		0.345	1.412 (1.384)	0.145	1.156 (0.23)
Technicians and educational research		0.131	1.139 (0.233)	-0.024	0.976 (0.008)
Procurement by the government or collective Purchasing		0.287	1.333 (0.958)	0.385	1.470 (1.583)
Marketing supported by the government		0.095	1.100 (0.16)	0.194	1.214 (0.619)
Internal Finance		0.002	1.002 (0)	-0.356	0.700 (1.078)
Government Funding		-0.441	0.643 (1.106)	-0.093	0.911 (0.224)
Loans		0.017	1.017 (0.01)	0.28	1.324 (2.468)
Stock Issue		-0.162	0.851 (0.112)	-0.395	0.674 (0.649)
Cooperation in Process innovation		1.59	4.903 (95.894) ***	1.337	3.809 (62.676) ***
Firms with 10-49 Employees				-1.723	0.179 (41.027) ***
Firms with 50-99 Employees				-0.784	0.457 (7.057) **
Firms with 100-299 Employees				-0.675	0.509 (7.529) **
Firms with 300-499 Employees					
Firms with over 500 Employees				0.349	1.418 (2.178)
Constant		-2.667	0.069 (18.718) ***	-1.323	0.266 (4.102) *
Observations		1521		1521	
Model Test:	-2 Log likelihood	1257.236		1170.615	
	Nagelkerke R^2	0.221		0.297	
	Cox & Snell R^2	0.137		0.185	
	X^2 (d.f.)	224.779*** (17)		311.399*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

When we look at Table 7.21, in the case of *New or significantly improved support activities process innovation*, *External R&D* and *Tax relief, Technicians and educational research* and *Government funding* is significant in model A.

Technicians and educational research and *Government funding* became insignificant in model C where *firm sizes* are entered while *firms with over 500 employees* are positive and significant, and *firms with 10-49 and Firms with 50-99 Employees* are negative and significant.

Table 7.21 Logistic Regression Models in New or Significantly Improved Support Activity Process Innovation as Dependent Variable, 2005-2007

Dependent variable		New or significantly improved support activity			
Independent variables		Model A		Model C	
		B	Exp(B)	B	Exp(B)
Internal R&D		0.543	1.722 (1.482)	0.239	1.270 (0.28)
External R&D		0.574	1.775 (16.93) ***	0.447	1.564 (9.708) **
Proportion of MSc Holders		0.006	1.006 (0.339)	0.005	1.005 (0.191)
Proportion of Researchers among permanent employees		-0.008	0.992 (1.711)	0.008	1.008 (1.618)
Tax relief for technology development		0.44	1.552 (6.692) **	0.335	1.398 (3.715) *
Support for technology development and funding		0.435	1.546 (1.165)		
Participation in government R&D project		0.127	1.135 (0.25)	0.005	1.005 (0)
Technical support from the government		0.196	1.216 (0.459)	0.349	1.418 (1.432)
Technology information provided by the Government		-0.269	0.764 (0.949)	-0.423	0.655 (2.254)
Technicians and educational research		0.427	1.532 (2.999) *	0.336	1.399 (1.77)
Procurement by the government or collective Purchasing		0.197	1.218 (0.534)	0.225	1.252 (0.665)
Marketing supported by the government		0.094	1.099 (0.194)	0.191	1.211 (0.772)
Internal Finance		0.177	1.193 (0.313)	-0.023	0.977 (0.005)
Government Funding		-0.745	0.475 (3.456) *	-0.263	0.769 (2.221)
Loans		-0.035	0.966 (0.051)	0.14	1.150 (0.798)
Stock Issue		-0.181	0.834 (0.173)	-0.343	0.710 (0.615)
Cooperation in Process innovation		1.593	4.916 (102.484) ***	1.371	3.939 (71.509) ***
Firms with 10-49 Employees				-0.902	0.406 (15.033) ***
Firms with 50-99 Employees				-0.732	0.481 (6.969) **
Firms with 100-299 Employees				-0.365	0.694 (2.48)
Firms with 300-499 Employees					
Firms with over 500 Employees				0.567 (5.984) *	1.763 (5.984) **
Constant		-2.425	0.088 (20.791) ***	-1.657	0.191 (8.545) **
Observations		1521		1521	
Model Test:	-2 Log likelihood	1513.650		1456.112	
	Nagelkerke R^2	0.208		0.255	
	Cox & Snell R^2	0.142		0.174	
	X^2 (d.f.)	232.803*** (17)		290.341*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Tables 7.22 and 7.23 show that the Chi square value for model A for *New to market product innovation* is 747.532 and the value for *New to firm product innovation* is 1913.330 with the $p < 0.001$ and degree of freedom of 17.

In the case of *New to market product innovation*, the value for model B is 776.092 (d.f.=20) and the value for model C is 766.385 (d.f.=20) while it is 1948.236 (d.f.=20) for model C in *New to firm product innovation.* They are statistically highly significant with $p<0.001$.

The Nagelkerke R^2 for *New to market product innovation* and *New to market product innovation* are 0.40, 041 and 0.409 for models A, B and C while the values for *New to firm product innovation* are 0.661 and 0.669 for models A and C respectively. As a whole, adding control variable improves the model fit slightly.

In both models A and B, for *New to market product innovation*, *Internal* and *External R&D, Proportion of Researchers among permanent employees, Procurement by the government or collective purchasing, Marketing, Government Funding* and *Cooperation* are positive and significant while *Support for technology development and funding* is negative and significant.

When *firm sizes* are entered in model C, the variables that are significant in model A remain the same except *Support for technology development and funding* and *Government Funding* became insignificant while *Loans* became positive and significant and *firms with 10-49 Employees* came out as negative and significant in model C.

Table 7.22 Logistic Regression Models in New to Market Product Innovation as Dependent Variable, 2005-2007

Dependent variable	New to Market Product Innovation				
Independent variables	Model A		Model B	Model C	
	B	Exp(B)	Exp(B)	B	Exp(B)
Internal R&D	4.233	68.909 (41.577) ***	67.817 (40.837) ***	4.034	56.497 (37.522) ***
External R&D	0.442	1.556 (9.48) **	1.52 (8.233) **	0.359	1.432 (6.116) **
Proportion of MSc Holders	0.004	1.004 (0.204)	1.002 (0.025)	0.003	1.003 (0.101)
Proportion of Researchers among permanent employees	0.013	1.013 (5.859) **	1.012 (5.136) *	0.021	1.021 (13.018) ***
Tax relief for technology development	0.276	1.318 (2.889) *	1.334 (3.069) *	0.226	1.253 (1.888)
Support for technology development and funding	-0.91	0.403 (5.778) *	0.424 (5.067) *		
Participation in government R&D project	-0.259	0.772 (1.083)	0.773 (1.054)	-0.344	0.709 (1.920)
Technical support from the government	-0.112	0.894 (0.16)	0.89 (0.171)	-0.072	0.931 (0.066)
Technology information provided by the Government	0.106	1.112 (0.172)	1.106 (0.152)	-0.016	0.984 (0.004)
Technicians and educational research	-0.014	0.986 (0.003)	1.028 (0.013)	-0.093	0.911 (0.145)
Procurement by the government or collective Purchasing	0.51	1.664 (3.823) *	1.682 (3.854) *	0.571	1.771 (4.756) *
Marketing supported by the government	0.403	1.496 (4.053) **	1.486 (3.849) *	0.42	1.521 (4.357) *
Internal Finance	0.32	1.377 (1.063)	1.388 (1.071)	0.24	1.271 (0.595)
Government Funding	0.77	2.160 (4.267) **	2.18 (4.311) *	0.027	1.028 (0.028)
Loans	0.168	1.183 (1.352)	1.168 (1.121)	0.285	1.329 (3.766) *
Stock Issue	0.449	1.566 (1.343)	1.541 (1.196)	0.303	1.354 (0.619)
Cooperation in Process innovation	0.684	1.981 (20.846) ***	2.053 (22.334) ***	0.600	1.823 (15.85) ***
Firms with 10-49 Employees					0.590 (5.483) *
Firms with 50-99 Employees					0.679 (2.106)
Firms with 100-299 Employees					0.711 (2.130)
Firms with 300-499 Employees					
Firms with over 500 Employees					1.450 (2.587)
Region			(24.309) **		
Constant	-6.325	0.002 (119.627) ***		-5.854	0.003 (90.766) ***
Observations	3078		3078	3078	
Model Test: -2 Log likelihood	1634.332		1605.772	1615.479	
Nagelkerke R^2	0.400		0.414	0.409	
Cox & Snell R^2	0.216		0.223	0.220	
X^2 (d.f.)	747.532*** (17)		776.092*** (32)	766.385*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

The positive and significant innovation activities for *New to firm product innovation* in models A are *Internal R&D, External R&D, Proportion of Researchers among permanent employees, Tax relief, Marketing supported by the government, Internal Finance, Loans* and *Cooperation. Procurement by the government or collective purchasing* is negative and significant in model A.

External R&D and Tax relief became insignificant in model C while *Government funding* came out as positive and significant when *firm sizes* are entered. *Firms with over 500 employees* are positive and significant while *firms with 10-49* and *50-99 employees* is negative and significant in model C.

In general, adding firm sizes as control variables in model C left most of the significant variables in model A unchanged while the coefficients on different firm size variables were either positive (for larger firms) or negative (for smaller firm sizes) and significant.

Table 7.23 Logistic Regression Models in New to firm Product Innovation as Dependent Variable, 2005-2007

Dependent variable	New to firm Product Innovation			
Independent variables	Model A		Model C	
	B	Exp(B)	B	Exp(B)
Internal R&D	3.146	23.253 (72.22) ***	2.924	18.623 (62.647) ***
External R&D	0.281	1.325 (4.072) **	0.181	1.198 (1.604)
Proportion of MSc Holders	-0.013	0.987 (1.707)	-0.015	0.985 (2.343)
Proportion of Researchers among permanent employees	0.012	1.012 (4.387) **	0.023	1.024 (13.351) ***
Tax relief for technology development	0.329	1.389 (3.533) *	0.272	1.312 (2.319)
Support for technology development and funding	-0.259	0.772 (0.386)		
Participation in government R&D project	-0.062	0.940 (0.057)	-0.164	0.849 (0.38)
Technical support from the government	0.259	1.295 (0.702)	0.313	1.367 (0.999)
Technology information provided by the Government	0.03	1.030 (0.011)	-0.067	0.935 (0.055)
Technicians and educational research	-0.018	0.982 (0.005)	-0.061	0.940 (0.053)
Procurement by the government or collective Purchasing	-0.582	0.559 (3.74) *	-0.555	0.574 (3.372) *
Marketing supported by the government	0.491	1.634 (5.281) **	0.512	1.669 (5.588) *
Internal Finance	1.348	3.850 (22.586) ***	1.283	3.607 (20.827) ***
Government Funding	0.533	1.704 (1.663)	0.336	1.399 (4.156) **
Loans	0.346	1.414 (5.978) **	0.449	1.566 (9.66) **
Stock Issue	0.244	1.276 (0.284)	0.023	1.023 (0.003)
Cooperation in Product innovation	2.458	11.679 (118.643) ***	2.432	11.382 (113.531) ***
Firms with 10-49 Employees				0.531 (7.735) **
Firms with 50-99 Employees				0.484 (7.674) **
Firms with 100-299 Employees				1.051 (0.044)
Firms with 300-499 Employees				
Firms with over 500 Employees				1.271 (0.877) ***
Constant	-4.915	0.007 (314.913) ***	-4.4	0.012 (159.57)
Observations	3078		3078	
Model Test: -2 Log likelihood	1799.550		1764.645	
Model Test: Nagelkerke R^2	0.661		0.669	
Model Test: Cox & Snell R^2	0.463		0.469	
Model Test: X^2 (d.f.)	1913.330*** (17)		1948.236*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

REGRESSION ANALYSIS FOR KIS 2010 (2007-2009)

Table 7.24 provides descriptive statistics for the dependent and independent variables that have been used for four models for 2007-2009:

DESCRIPTIVE STATISTICS (2007-2009)

Table 7.24 Descriptive Statistics, 2007-2009

	N	Mean	Stand. Dev.	Min.	Max.
1 New Product Innovation	2496	.29	.46	0	1
2 Significantly Improved Product Innovation	2496	.63	.48	0	1
3 New or significantly improved production process	2496	.46	.50	0	1
4 New or significantly improved logistics	2496	.18	.39	0	1
5 New or significantly improved support activity	2496	.28	.45	0	1
6 New to Market Product Innovation	3925	.17	.38	0	1
7 New to firm Product Innovation	3925	.40	.49	0	1
8 Internal R&D	3925	.61	.49	0	1
9 External R&D	3925	.22	.42	0	1
10 Proportion of MSc or higher degree holders among permanent employees	3794	2.49	5.94	0	88.51
11 Proportion of Research staff among permanent employees	3904	7.46	10.45	0	95.83
12Tax relief for technology development	3904	.18	.39	0	1
13 Support for technology development and funding	3925	.23	.42	0	1
14 Participation in government R&D project	3925	.21	.41	0	1
15 Technical support from the government	3925	.17	.38	0	1
16 Technology information provided by the government	3925	.18	.38	0	1
17 Technicians and educational research	3925	.18	.38	0	1
18 Procurement by the government or collective purchasing	3925	.15	.36	0	1
19 Marketing supported by the government	3925	.20	.40	0	1
20 Internal Finance	3925	.58	.49	0	1
21 Government Funding	3925	.23	.42	0	1
22 Loans	3909	.20	.0	0	1
23 Stock Issue	3925	.01	.10	0	1
24 Cooperation in Product Innovation	3926	.14	.35	0	1
25 Cooperation in Process Innovation	3926	.09	.29	0	1
26 Firms with 10-49 Employees	3926	.53	.49	0	1
27 Firms with 50-99 Employees	3926	.13	.33	0	1
28 Firms with 100-299 Employees	3926	.21	.41	0	1
29 Firms with 300-499 Employees	3926	.06	.23	0	1
30 Firms with over 500 Employees	3926	.07	.26	0	1
31 Regions	3925	7.64	4.54	1	16

CORRELATION MATRIX, 2007-2009

Table 7.25 displays the Correlation Matrix between dependent and independent variables for 2007-2009:

Table 7.42 Correlation Matrix between Measurements of Innovation and Aspects of Innovation Activities using the Data for the Whole of Korea, 2007-2009

	1	2	3	4	5	6	7	8
1 New Product Innovation	1							
2 Significantly Improved Product Innovation	.234**	1						
3 New or significantly improved production process	.138**	.209**	1					
4 New or significantly improved logistics	.142**	.147**	.314**	1				
5 New or significantly improved support activity	.148**	.197**	.289**	.413**	1			
6 New to Market Product Innovation	.419**	.344**	.144**	.155**	.150**	1		
7 New to firm Product Innovation	.343**	.800**	.211**	.127**	.188**	.326**	1	
8 Internal R&D	.096**	.175**	.017	.050**	.031	.357**	.622**	1
9 External R&D	.165**	.239**	.218**	.243**	.269**	.301**	.406**	.380**
10 Proportion of MSc or higher degree holders among permanent employees	.076**	.070**	.013	.007	.063**	.171**	.206**	.274**
11 Proportion of Research staff among permanent employees	.114**	.130**	-.046*	-.028	-.006	.280**	.384**	.538**
12Tax relief for technology development	.132**	.161**	.156**	.146**	.160**	.266**	.326**	.374**
13 Support for technology development and funding	.153**	.163**	.154**	.123**	.118**	.304**	.355**	.431**
14 Participation in government R&D project	.141**	.165**	.140**	.137**	.167**	.296**	.344**	.412**
15 Technical support from the government	.154**	.159**	.148**	.141**	.173**	.291**	.310**	.357**
16 Technology information provided by the government	.148**	.172**	.161**	.141**	.181**	.287**	.320**	.362**
17 Technicians and educational research	.149**	.177**	.154**	.138**	.188**	.280**	.329**	.370**
18 Procurement by the government or collective purchasing	.134**	.131**	.121**	.101**	.138**	.257**	.268**	.307**
19 Marketing supported by the government	.148**	.163**	.120**	.115**	.139**	.278**	.325**	.360**
20 Internal Finance	.005	.015	.000	.022	.035	.318**	.540**	.838*
21 Government Funding	.153**	.162**	.155**	.123**	.117**	.304**	.355**	.431**
22 Loans	.014	.017	.001	-.056**	-.060**	.119**	.249**	.353**
23 Stock Issue	.059**	.052**	.005	.002	.049*	.089**	.083**	.072**
24 Cooperation in Product Innovation	.203**	.351**	.169**	.160**	.157**	.321**	.431**	.328**
25 Cooperation in Process Innovation	.073**	.101**	.318**	.266**	.295**	.164**	.206**	.258**
26 Firms with 10-49 Employees	-.053**	-.102**	-.155**	-.204**	-.208**	-.170**	-.286**	-.369**
27 Firms with 50-99 Employees	-.005	-.016	.001	-.053**	-.021	-.026	.031	.039**
28 Firms with 100-299 Employees	.008	.041*	.047**	.058**	.090**	.087**	.147**	.207**
29 Firms with 300-499 Employees	.017	.056**	.055**	.094**	.056**	.084**	.125**	.151**
30 Firms with over 500 Employees	.063**	.070**	.126**	.210**	.171**	.150**	.171**	.200**
31 Regions	-0.02	-0.03	.059**	-0.008	-.046*	-.032*	-.056**	-.034*

	9	10	11	12	13	14	15	16
9 External R&D	1							

10 Proportion of MSc or higher degree holders among permanent employees	.223**	1						
11 Proportion of Research staff among permanent employees	.269**	.439**	1					
12Tax relief for technology development	.332**	.240**	.291**	1				
13 Support for technology development and funding	.408**	.268**	.386**	.515**	1			
14 Participation in government R&D project	.430**	.283**	.353**	.539**	.671**	1		
15 Technical support from the government	.392**	.242**	.291**	.515**	.616**	.791**	1	
16 Technology information provided by the government	.401**	.245**	.291**	.529**	.591**	.769**	.892**	1
17 Technicians and educational reseaarch	.393**	.246**	.310**	.535**	.575**	.742**	.834**	.847**
18 Procurement by the government or collective purchasing	.333**	.206**	.267**	.468**	.520**	.680**	.787**	.785**
19 Marketing supported by the govt.	.364**	.220**	.295**	.488**	.556**	.668**	.726**	.731**
20 Internal Finance	.371**	.217**	.435**	.328**	.342**	.352**	.301**	.312**
21 Government Funding	.409**	.269**	.387**	.514**	.999**	.670**	.615**	.590**
22 Loans	.095**	.093**	.231**	.083**	.152**	.102**	.071**	.077**
23 Stock Issue	.081**	.051**	.066**	.091**	.115**	.116**	.110**	.107**
24 Cooperation in Product Innovation	.427**	.103**	.214**	.293**	.340**	.340**	.325**	.328**
25 Cooperation in Process Innovation	.309**	.099**	.102**	.238**	.260**	.279**	.272**	.255**
26 Firms with 10-49 Employees	-.295**	-.081**	0.024	-.285**	-.216**	-.270**	-.236**	-.242**
27 Firms with 50-99 Employees	0	-.003	-.007	.004	.006	-.024	-.002	.005
28 Firms with 100-299 Employees	.157**	.026	-.034**	.130**	.133**	.142**	.132**	.139**
29 Firms with 300-499 Employees	.135**	.063**	.022	.154**	.075**	.128**	.112**	.117**
30 Firms with over 500 Employees	.200**	.070**	-.003	.201**	.132**	.215**	.148**	.138**
31 Regions	-.048**	-.061**	-.018	-.053**	.009	-.037*	-.022	-.022

	17	18	19	20	21	22	23
17 Technicians and educational research	1						
18 Procurement by the govt. or collective purchasing	.774**	1					
19 Marketing supported by the government	.741**	.758**	1				
20 Internal Finance	.316**	.259**	.311**	1			
21 Government Funding	.575**	.520**	.556**	.343**	1		
22 Loans	.096**	.104**	.119**	.184**	.151**	1	
23 Stock Issue	.098**	.100**	.105**	.052**	.115**	.093**	1
24 Cooperation in Product Innovation	.321**	.281**	.304**	.280**	.339**	.085**	.072**
25 Cooperation in Process Innovation	.251**	.210**	.233**	.207**	.054**	.260**	.040*
26 Firms with 10-49 Employees	-.247**	-.181**	-.198**	-.371**	-.043**	-.215**	-.083**
27 Firms with 50-99 Employees	.013	-.008	-.006	.041*	.058**	.006	-.006
28 Firms with 100-299 Employees	.142**	.102**	.113**	.202**	.003	.133**	.086**
29 Firms with 300-499 Employees	.101**	.079**	.077**	.159**	.006	.075**	0.01
30 Firms with over 500 Employees	.146**	.128**	.143**	.204**	-.001	.132**	.024
31 Regions	-.064**	-.032*	-.031	-.059**	.017	.008	-.019

	24	25	26	27	28	29	30	31
24 Cooperation in Product Innovation	1							
25 Cooperation in Process Innovation	.314**	1						
26 Firms with 10-49 Employees	-.204**	-.226*	1					
27 Firms with 50-99 Employees	.021	-.01	-.409**	1				
28 Firms with 100-299 Employees	.080**	.102**	-.549**	-.198**	1			
29 Firms with 300-499 Employees	.079**	.089**	-.263**	-.095**	-.127**	1		
30 Firms with over 500 Employees	.171**	.209**	-.297**	-.107**	-.144**	-.069**	1	
31 Regions	-.041*	-.021	.080**	.009	.019	-.072**	-.132**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Looking at the correlations among dependent variables, 1 to 7, we can see generally weak to moderate correlations. *Significantly improved product innovation* and *New to firm product innovation,* however, show very strong correlation with r=0.80.

The correlations between the independent variables, 8 to 25, are weak to strong with a very strong correlation between *Support for technology development and funding* and *Government Funding* with r=0.99. The Variance Inflation Factor check has been carried out as below and the value for these two variables is over 10 and therefore has been treated by removing one.

<u>Model A: Without controls</u>

A multicollinearity test has been carried out and *Support for technology development and funding* and *Government Funding* has the VIF value of 543.84 and 543.09 respectively. These exceed the recommended cut off value of 10 and therefore the variable with the highest VIF and theoretically less important, that is *Support for technology development and funding* has been removed making the VIF of *Government Funding* become 1.75 and the rest of the variables ranging between 1.02 and 5.60.

<u>Model B: Region</u>

A multicollinearity test has been carried out and *Technology development and funding* and *Government Funding* have serious multicollinearity by having a VIF value of 544.03 and 543.20 respectively. The variable with the highest VIF and theoretically less important, that is *Technology development and funding* has been removed and the VIF of *Government Funding* has been reduced to 1.76. The VIFs of all the variables now range between 1.02 and 5.60.

<u>Model C: Firm Size</u>

A multicollinearity test has been carried out and *Firms with 300-499 employees* has been removed because of collinearity. Moreover, *Technology development and funding* and *Government Funding* have serious multicollinearity by having VIF values of 544.16 and 543.43 respectively. This has been treated by removing *Technology development and funding* that has the highest VIF value and theoretically less important and the VIF of *Government Funding* has been reduced to 1.76. The VIFs of all the variables now range between 1.02 and 5.60.

Model D: Firm Size and Region

A multicollinearity test has been carried out and *Technology development and funding* and *Government Funding* have serious multicollinearity by having VIF values of 544.2 and 543.5 respectively. This has been treated by removing *Technology development and funding* that has the highest VIF value and theoretically less important and the VIF of *Government Funding* has been reduced to 1.76. The VIFs of all the variables now range between 1.02 and 5.60.

REGRESSION RESULTS

The table below lists the logit coefficients, Wald chi square value in bracket, pseudo R squared values (Nagelkerke and Cox and Snell), and Chi square statistic by Logistic analysis for the four models mentioned above.

The Chi square for our model A (without any control variable) is highly significant ($p<0.001$, d.f.=16) with a Chi-square value of 166.343 for *New product innovation* and 492.979 for *Significantly improved product innovation*. Our new model, therefore, is significantly better than the model without any independent variable.

The Chi square value changes only as control variables are included in model B, C and D and the values are 198.200 (d.f.=31), 169.331 (d.f.=20) and 200.136 (d.f.=35) while they are 521.420 (d.f.=31), 505.263 (d.f.=20) and 536.550 (d.f.=35) for *New product innovation* and *Significantly improved product innovation* respectively. They are statistically highly significant with $p<0.001$.

Nagelkerke R squared values as Table 7.26 are 0.098, 0.115, 0.069 and 0.117 in *New product innovation*, while they are 0.258, 0.272, 0.264 and 0.279 as seen in Table 7.27 for models A, B, C and D respectively in *Significantly improved product innovation*.

Adding control variables very slightly improved the model fit.

As Table 7.26 shows, *Internal* and *External R&D*, *proportion of researchers among permanent employees*, *Loans* and *Cooperation* are statistically significant and positive for both models A, C and D in *New product innovation*. *Loans* became insignificant in model B and no *firm sizes* are significant in model C.

Table 7.26 Logistic Regression Models in New Product Innovation as Dependent Variable, 2007-2009

Dependent variable		New Product Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		3.345 (8.977) **	3.373 (9.027) ***	3.183 (8.202) ***	3.239 (8.380) ***
External R&D		1.462 (12.545) ***	1.439 (11.240) ***	1.420 (10.393) ***	1.409 (9.719) ***
Proportion of MSc Holders		1.004 (0.316)	1.001 (0.041)	1.003 (0.178)	1.001 (0.015)
Proportion of Researchers among permanent employees		1.013 (8.743) **	1.012 (7.058) ***	1.017 (11.3) ***	1.015 (8.614) ***
Tax relief for technology development		1.157 (1.481)	1.112 (0.765)	1.119 (0.848)	1.085 (0.441)
Support for technology development and funding					
Participation in government R&D project		0.865 (0.768)	0.858 (0.834)	0.828 (1.258)	0.828 (1.238)
Technical support from the government		1.330 (1.410)	1.396 (1.901)	1.338 (1.464)	1.403 (1.945)
Technology information provided by the Government		0.919 (0.130)	0.931 (0.091)	0.928 (0.099)	0.938 (0.073)
Technicians and educational research		1.063 (0.095)	1.051 (0.061)	1.047 (0.053)	1.044 (0.047)
Procurement by the government or collective Purchasing		0.923 (0.170)	0.942 (0.095)	0.933 (0.128)	0.949 (0.073)
Marketing supported by the government		1.201 (1.311)	1.189 (1.151)	1.212 (1.442)	1.196 (1.224)
Internal Finance		1.136 (0.554)	1.119 (0.422)	1.110 (0.368)	1.103 (0.316)
Government Funding		1.206 (2.220)	1.190 (2.562)	1.219 (2.457)	1.205 (2.899)
Loans		1.204 (2.977) *	1.211 (2.251)	1.224 (3.468) *	1.217 (2.348) *
Stock Issue		1.524 (0.776)	1.329 (0.349)	1.452 (0.602)	1.284 (0.268)
Cooperation in Product Innovation		1.874 (30.559) ***	1.946 (33.333) ***	1.857 (29.5) ***	1.932 (32.452) ***
Firms with 10-49 Employees				0.831 (0.925)	0.775 (1.803)
Firms with 50-99 Employees				0.937 (0.096)	0.848 (0.655)
Firms with 100-299 Employees				0.968 (0.03)	0.875 (0.563)
Firms with 300-499 Employees					0.880 (0.325)
Firms with over 500 Employees				1.113 (0.235)	
Region			(30.471) **		(29.501) **
Constant		0.055 (44.834) ***	0.060 (8.569) ***	0.063 (34.755)	0.078 (6.800) ***
Observations		2351	2351	2351	2351
Model Test:	-2 Log likelihood	2667.138	2635.281	2664.150	2633.345
	Nagelkerke R^2	0.098	0.115	0.069	0.117
	Cox & Snell R^2	0.068	0.081	0.099	0.082
	X^2 (d.f.)	166.343*** (16)	198.200*** (31)	169. 331*** (20)	200.136*** (35)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

In *significantly improved product innovation*, as shown in Table 7.27, *Internal* and *External R&D*, *proportion of researchers among permanent employees, Tax relief, Loans*, and *Cooperation* are significant and positive, while *Procurement by the government or collective purchasing* are significant and negative in all four models. *Tax relief for technology development* turned out to be significant and positive in model A and B only. When *firm sizes* are entered in model C, however, *Tax relief* became insignificant while *Firm with 10-49, 50-99 and over 500 employees* was significant and negative.

Table 7.27 Logistic Regression Models in Significantly Improved Product Innovation as Dependent Variable, 2007-2009

Dependent variable		Significantly Improved Product Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		4.005 (26.386) ***	4.114 (26.942) ***	3.621 (22.257) ***	3.669 (22.237) ***
External R&D		2.034 (36.885) ***	2.079 (38.154) ***	1.900 (29.22) ***	1.930 (29.836) ***
Proportion of MSc Holders		1.000 (0.001)	0.998 (0.065)	0.999 (0.03)	0.997 (0.191)
Proportion of Researchers among permanent employees		1.020 (14.938) ***	1.018 (11.043) ***	1.028 (22.181) ***	1.026 (18.751) ***
Tax relief for technology development		1.331 (4.843) **	1.306 (4.128) **	1.228 (2.379)	1.199 (1.822)
Support for technology development and funding					
Participation in government R&D project		0.860 (0.719)	0.861 (0.706)	0.793 (1.651)	0.787 (1.736)
Technical support from the government		0.877 (0.237)	0.904 (0.136)	0.880 (0.226)	0.896 (0.159)
Technology information provided by the Government		1.316 (1.065)	1.370 (1.362)	1.324 (1.112)	1.381 (1.426)
Technicians and educational research		1.361 (1.919)	1.347 (1.721)	1.323 (1.567)	1.324 (1.517)
Procurement by the government or collective Purchasing		0.639 (3.992) **	0.642 (3.850) **	0.656 (3.517) *	0.659 (3.381) *
Marketing supported by the government		1.247 (1.575)	1.244 (1.516)	1.285 (2.025)	1.282 (1.950)
Internal Finance		1.293 (5.276)	1.274 (1.934)	1.237 (1.512)	1.225 (1.345)
Government Funding		1.008 (0.906)	1.001 (0.000)	1.025 (0.036)	1.310 (5.841)
Loans		1.286 (5.276) **	1.265 (4.497) **	1.328 (6.614) **	1.014 (0.010) **
Stock Issue		1.902 (0.906)	1.797 (0.731)	1.766 (0.707)	1.690 (0.583)
Cooperation in Product Innovation		10.129 (131.733) ***	10.577 (134.756) ***	10.118 (130.971) ***	10.626 (134.252) ***
Firms with 10-49 Employees				0.600 (6.233) **	0.608 (5.781)
Firms with 50-99 Employees				0.654 (3.679) *	0.649 (3.794)
Firms with 100-299 Employees				0.861 (0.545)	0.911 (0.216)
Firms with 300-499 Employees					1.081 (0.098)
Firms with over 500 Employees				0.903 (0.171) ***	
Region			(27.977) **		(30.716) **
Constant		0.139 (38.746) ***	0.093 (7.778) ***	0.214 (17.27)	0.158 (4.424) **
Observations		2351	2351	2351	2351
Model Test:	-2 Log likelihood	2604.503	2576.063	2592.219	2560.932
	Nagelkerke R^2	0.258	0.272	0.264	0.279
	Cox & Snell R^2	0.189	0.199	0.193	0.204
	X^2 (d.f.)	492.979 *** (16)	521.420 *** (31)	505.263 *** (20)	536.550 *** (35)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Our model A (without any control variable) is highly significant ($p<0.001$, d.f.=16), as shown in Tables 7.28, 7.29 and 7.30, with the Chi square value of 328.107 for *New or Significantly Improved production process innovation*, 229.068 for *New or Significantly Improved Logistics Methods* and 300.615 for *Support activity process innovation*. Our new model, therefore, is significantly better than the model without any independent variable.

The Chi square values for *New or significantly improved production process innovation* for models B, C and D are 365.990 (d.f.=31), 336.994 (d.f.=20) and 378.248 (d.f.=35) while they are 265.276 (d.f.=31), 304.177 (d.f.=20) and 337.162 (d.f.=35) respectively for *New or significantly improved logistic process innovation*. The Chi square value for *New or significantly improved support activity process innovation* for model C is 341.391 (d.f.=20). They are all statistically highly significant with $p<0.001$.

Nagelkerke R^2 values in model A, 0.174 for *Production process innovation*, 0.154 for *Logistics Methods* and 0.174 for *Support activity process innovation.*

The Nagelkerke R^2 for *new or significantly improved production process innovation* are 0.193, 0.178 and 0.199 while it is 0.176, 0.201 and 0.221 for *new or significantly improved logistic process innovation* for models B, C and D while the value for *support activity* for model C is 0.196. Adding control variables slightly improved the model fit.

The innovation activities that are statistically significant and positive in all four models in *New or significantly improved production process* are *External R&D*, *Tax relief for technology development*, *Technology information provided by the government, Government funding*, *Loans*, and *Cooperation*. *Proportion of Researchers among permanent employees* is significant and negative in model A, B and C then became insignificant in model D where both region and firm sizes are entered. *Participation in government R&D project* became significant and negative in model C and D. *Firm size with 10-49 employees* was significant and negative in model C, while *firm size with 10-49, 50-99* and *100-299 employees* turned out as significant and negative in model D.

Table 7.28 Logistic Regression Models in New or Significantly Improved Production Process Innovation as Dependent Variable, 2007-2009

Dependent variable		New or Significantly Improved Production Process Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		0.978 (0.01)	1.018 (0.006)	0.901 (0.204)	0.925 (0.112)
External R&D		1.765 (31.976) ***	1.758 (30.699) ***	1.681 (25.879) ***	1.665 (24.250) ***
Proportion of MSc Holders		0.998 (0.1)	0.997 (0.120)	0.996 (0.283)	0.996 (0.285)
Proportion of Researchers among permanent employees		0.987 (9.042) **	0.986 (9.296) ***	0.992 (2.669) ***	0.992 (2.368)
Tax relief for technology development		1.313 (5.386) **	1.332 (5.791) **	1.234 (3.107) **	1.241 (3.188) *
Support for technology development and funding					
Participation in government R&D project		0.808 (1.732)	0.826 (1.363)	0.752 (2.976) *	0.756 (2.807) *
Technical support from the government		0.818 (0.698)	0.812 (0.727)	0.829 (0.601)	0.820 (0.657)
Technology information provided by the Government		1.536 (3.374) *	1.488 (2.807) *	1.553 (3.53) *	1.507 (2.980) *
Technicians and educational research		1.304 (1.844)	1.383 (2.635)	1.280 (1.575)	1.376 (2.520)
Procurement by the government or collective Purchasing		0.873 (0.472)	0.920 (0.178)	0.889 (0.357)	0.937 (0.107)
Marketing supported by the government		0.867 (0.801)	0.841 (1.158)	0.880 (0.638)	0.853 (0.969)
Internal Finance		1.061 (0.133)	1.063 (0.138)	1.017 (0.01)	1.019 (0.013)
Government Funding		1.433 (8.833) **	1.374 (6.687) **	1.463 (9.774) **	1.397 (7.355) ***
Loans		1.202 (3.274) *	1.184 (2.685) *	1.230 (4.08) *	1.216 (3.540) *
Stock Issue		0.538 (1.421)	0.551 (1.267)	0.498 (1.791)	0.511 (1.577)
Cooperation in Process Innovation		6.115 (132.316) ***	6.329 (135.051) ***	5.818 (123.733) ***	5.979 (125.549) ***
Firms with 10-49 Employees				0.694 (3.856) *	0.548 (9.937) ***
Firms with 50-99 Employees				0.843 (0.725)	0.664 (4.036) **
Firms with 100-299 Employees				0.873 (0.556)	0.716 (3.348) *
Firms with 300-499 Employees					0.847 (0.535)
Firms with over 500 Employees				1.114 (0.235)	
Region			(36.744) ***		(39.841) ***
Constant		0.490 (6.796) **	0.240 (2.340)	0.662 (1.611)	0.447 (0.723)
Observations		23251	2351	2351	2351
Model Test:	-2 Log likelihood	2914.544	2876.661	2905.658	2864.404
	Nagelkerke R^2	0.174	0.193	0.178	0.199
	Cox & Snell R^2	0.130	0.144	0.134	0.149
	X^2 (d.f.)	328.107 *** (16)	365.990*** (31)	336.994 *** (20)	378.248*** (35)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

As Table 7.29 shows, in the case of *new or significantly improved logistics*, model A and B produced the same variables as significant and they are *External R&D, Proportion of researchers among permanent employees, Tax relief for technology development* and *Cooperation*, while the significant variables for model C and D are *External R&D, Proportion of MSc or higher degree holders* and *Cooperation*. These variables are significant and positive except *Proportion of researchers among permanent employees* and *Proportion of MSc or higher degree holders* that are significant and negative.

Firms with 10-49, 50-99, and *100-299 employees* are significant and negative while *Firms with over 500 employees* is significant and positive in model C. *Firms with 10-49, 50-99, 100-299* and *over 500 employees* are significant and negative in model D.

Table 7.29 Logistic Regression Models in New or Significantly Improved Logistic methods Process Innovation as Dependent Variable, 2007-2009

Dependent variable		New or Significantly Improved Logistic Method Process Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		1.867 (2.592)	1.997 (3.103)	1.410 (0.754)	1.498 (1.007)
External R&D		2.587 (58.489) ***	2.540 (54.680) ***	2.264 (41.255) ***	2.244 (39.310) ***
Proportion of MSc Holders		0.990 (1.107)	0.985 (2.207)	0.982 (3.157) *	0.980 (3.823) *
Proportion of Researchers among permanent employees		0.988 (4.312) **	0.987 (4.315) **	1.008 (1.634)	1.007 (1.290)
Tax relief for technology development		1.388 (5.306) **	1.363 (4.638) **	1.143 (0.839)	1.137 (0.755)
Support for technology development and funding					
Participation in government R&D project		0.995 (0.001)	0.959 (0.045)	0.736 (2.217)	0.712 (2.678)
Technical support from the government		1.172 (0.328)	1.268 (0.707)	1.231 (0.523)	1.319 (0.890)
Technology information provided by the Government		0.987 (0.002)	0.994 (0.000)	1.060 (0.044)	1.056 (0.037)
Technicians and educational research		1.330 (1.487)	1.319 (1.375)	1.281 (1.059)	1.322 (1.311)
Procurement by the government or collective Purchasing		0.686 (2.639)	0.702 (2.287)	0.711 (2.07)	0.727 (1.772)
Marketing supported by the government		1.022 (0.012)	0.982 (0.009)	1.069 (0.112)	1.020 (0.009)
Internal Finance		1.054 (0.058)	1.020 (0.008)	0.909 (0.181)	0.897 (0.228)
Government Funding		1.041 (0.067)	0.866 (1.080)	1.148 (0.765)	0.966 (0.059)
Loans		0.881 (0.863)	1.045 (0.077)	0.988 (0.007)	1.121 (0.511)
Stock Issue		1.309 (0.221)	1.178 (0.082)	0.958 (0.006)	0.881 (0.046)
Cooperation in Process Innovation		3.108 (67.813) ***	3.199 (65.998) ***	2.693 (49.393) ***	2.718 (48.890) ***
Firms with 10-49 Employees				0.276 (33.518) ***	0.178 (61.233) ***
Firms with 50-99 Employees				0.396 (14.88) ***	0.253 (33.696) ***
Firms with 100-299 Employees				0.669 (4.183) *	0.442 (19.113) ***
Firms with 300-499 Employees					0.640 (3.806) *
Firms with over 500 Employees				1.480 (3.04) *	
Region			(30.669) **		(28.838) **
Constant		0.061 (40.546) ***	0.000 (0.00)	0.159 (14.558) ***	0.000 (0.000)
Observations		2351	2351	2351	2351
Model Test:	-2 Log likelihood	1953.156	1916.948	1878.047	1845.062
	Nagelkerke R^2	0.154	0.176	0.201	0.221
	Cox & Snell R^2	0.093	0.107	0.121	0.134
	X^2 (d.f.)	229.068 *** (16)	265.276 *** (31)	304.177 *** (20)	337.162 *** (35)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Table 7.30 shows that for *New or significantly improved support activities process innovation*, *External R&D*, *Tax relief for technology development*, *Technicians and educational research* and *Cooperation* are significant in all models.

Tax relief for technology development became insignificant while *firms with 10-49 employees is* significant but negative, and *firms with over 500 employees* are significant and positive in model C.

Table 7.30 Logistic Regression Models in New or Significantly Improved Support Activity Process Innovation as Dependent Variable, 2007-2009

Dependent variable		New or significantly improved support activity Process innovation			
Independent variables		Model A		Model C	
		B	Exp(B)	B	Exp(B)
Internal R&D		0.081	1.084 (0.085)	-0.122	0.885 (0.189)
External R&D		0.878	2.407 (66.54) ***	0.776	2.173 (50.19) ***
Proportion of MSc Holders		0.009	1.009 (1.325)	0.005	1.005 (0.455)
Proportion of Researchers among permanent employees		-0.008	0.992 (2.394)	0.006	1.006 (1.271)
Tax relief for technology development		0.278	1.320 (4.821) **	0.152	1.164 (1.39)
Support for technology development and funding					
Participation in government R&D project		-0.064	0.938 (0.128)	-0.236	0.790 (1.687)
Technical support from the government		0.052	1.053 (0.043)	0.085	1.089 (0.113)
Technology information provided by the Government		0.169	1.184 (0.485)	0.208	1.231 (0.719)
Technicians and educational research		0.569	1.767 (7.645) **	0.524	1.689 (6.308) **
Procurement by the government or collective Purchasing		-0.266	0.767 (1.602)	-0.234	0.791 (1.224)
Marketing supported by the government		-0.107	0.899 (0.371)	-0.076	0.927 (0.181)
Internal Finance		0.215	1.240 (1.267)	0.119	1.127 (0.38)
Government Funding		-0.161	0.851 (1.388)	-0.113	0.894 (0.664)
Loans		-0.06	0.942 (0.262)	0.013	1.013 (0.013)
Stock Issue		-0.03	0.971 (0.003)	-0.238	0.788 (0.192)
Cooperation in Process Innovation		1.294	3.646 (97.381) ***	1.193	3.279 (80.903) ***
Firms with 10-49 Employees				-0.719	0.487 (13.01) ***
Firms with 50-99 Employees				-0.272	0.762 (1.656)
Firms with 100-299 Employees				-0.019	0.981 (0.01)
Firms with 300-499 Employees					
Firms with over 500 Employees				0.378	1.460 (2.949) *
Constant		-1.92	0.147 (33.756) ***	-1.428	0.240 (14.242) ***
Observations		2351		2351	
Model Test:	-2 Log likelihood	2440.335		2399.559	
	Nagelkerke R^2	0.174		0.196	
	Cox & Snell R^2	0.120		0.135	
	X^2 (d.f.)	300.615 *** (16)		341.391*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

As Tables 7.31 and 7.32 show, the Chi square value for model A, B, C and D for *New to market product innovation* is 904.977 (d.f.=16, $p<0.001$), 932.998 (d.f.=31, $p<0.001$), 917.980 (d.f.=20, $p<0.001$) and 945.765 (d.f.=35, $p<0.001$), while the values for *New to firm product innovation* is 2180.773 (d.f.=16, $p<0.001$), 2212.836 (d.f.=31, $p<0.001$), 2186.934 (d.f.=20, $p<0.001$) and 2219.688 (d.f.=35, $p<0.001$) respectively. They are statistically highly significant with $p<0.001$.

Nagelkerke R squared values for the four models in *New to Market product innovation* are 0.361, 0.371, 0.365 and 0.375 for models A, B, C, and D respectively while the values for *New to firm product innovation* are 0.597, 0.603, 0.598 and 0.604.

For *New to market product innovation*, *Internal* and *External R&D, Proportion of Researchers among permanent employees, Marketing supported by government, Internal Finance, Government Funding, Stock issue*, and *Cooperation* are significant and positive in model A. The same variables are significant in model B and C except *Marketing* that became insignificant. In model D, *Stock option* also became insignificant.

Firms with 50-99 and 100-299 employees came out as significant and negative in model C while *firms with 10-49 and 50-99 employees* came out as significant and negative in model D.

Table 7.31 Logistic Regression Models in New to Market Product Innovation as Dependent Variable, 2007-2009

Dependent variable		New to Market Product Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		83.481 (36.425) ***	83.203 (36.303) ***	75.713 (34.705) ***	75.204 (34.519) ***
External R&D		1.481 (12.389) ***	1.475 (11.813) ***	1.405 (8.959) **	1.405 (8.740) ***
Proportion of MSc Holders		1.005 (0.414)	1.001 (0.038)	1.003 (0.174)	1.000 (0.002)
Proportion of Researchers among permanent employees		1.016 (11.317) **	1.015 (9.577) ***	1.021 (15.768) ***	1.019 (13.330) ***
Tax relief for technology development		1.213 (2.439)	1.183 (1.809)	1.150 (1.234)	1.128 (0.903)
Support for tech. dev. and funding					
Participation in government R&D project		0.908 (0.321)	0.898 (0.384)	0.821 (1.288)	0.813 (1.379)
Technical support from the government		1.432 (2.123)	1.463 (2.341)	1.448 (2.233)	1.479 (2.443)
Technology information provided by the Government		1.057 (0.052)	1.085 (0.111)	1.080 (0.1)	1.101 (0.154)
Technicians and educational research		0.835 (0.743)	0.83 (0.781)	0.837 (0.717)	0.846 (0.624)
Procurement by the government or collective Purchasing		1.074 (0.129)	1.099 (0.221)	1.083 (0.162)	1.106 (0.253)
Marketing supported by the government		1.201 (1.216) *	1.191 (1.081)	1.213 (1.343)	1.197 (1.139)
Internal Finance		1.556 (5.412) **	1.535 (4.944) **	1.519 (4.771) **	1.515 (4.594) **
Government Funding		1.335 (4.902) **	1.061 (0.262) **	1.375 (5.881) **	1.387 (6.038) **
Loans		1.075 (0.406)	1.359 (5.365)	1.124 (1.04)	1.109 (0.789)
Stock Issue		2.701 (4.127) **	2.413 (3.207) *	2.486 (3.448) *	2.251 (2.693)
Cooperation in Product Innovation		2.119 (41.767) ***	2.184 (43.918) ***	2.118 (41.275) ***	2.189 (43.676) ***
Firms with 10-49 Employees				0.682 (3.77)	0.640 (5.164) **
Firms with 50-99 Employees				0.559 (6.928) *	0.509 (9.572) ***
Firms with 100-299 Employees				0.845 (0.786) **	0.794 (1.587)
Firms with 300-499 Employees					0.914 (0.158)
Firms with over 500 Employees				1.061 (0.07)	
Region			(26.581) **		(26.444) **
Constant		0.001 (89.394) ***	0.001 (31.289) ***	0.002 (74.762) ***	0.001 (26.403) ***
Observations		3769	3769	3769	3769
Model Test:	-2 Log likelihood	2471.430	2443.410	2458.427	2430.643
	Nagelkerke R^2	0.361	0.371	0.365	0.375
	Cox & Snell R^2	0.213	0.219	0.216	0.222
	X^2 (d.f.)	904.977*** (16)	932.998*** (31)	917.980*** (20)	945.765*** (35)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Table 7.32 demonstrates that the significant innovation activities for *New to firm product innovation* are *Internal* and *External R&D, Proportion of Researchers among permanent employees, Tax relief for technology development, Marketing supported by the government, Internal Finance, Loans* and *Cooperation* is significant and positive in all four models except *Tax relief for technology development* which became insignificant in models B, C, and D. No *firm sizes* are significant when they are entered in models C and D.

Table 7.32 Logistic Regression Models in New to firm Product Innovation as Dependent Variable, 2007-2009

Dependent variable		New to Firm Product Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		31.549 (168.279) ***	33.336 (171.770) ***	29.074 (157.913) ***	30.271 (159.581) ***
External R&D		2.130 (43.164) ***	2.150 (43.114) ***	2.033 (36.968) ***	2.045 (36.668) ***
Proportion of MSc Holders		1.004 (0.249)	1.002 (0.066)	1.003 (0.116)	1.001 (0.015)
Proportion of Researchers among permanent employees		1.013 (6.652) **	1.010 (4.001) **	1.018 (10.95) **	1.016 (8.056) ***
Tax relief for technology development		1.247 (3.044) *	1.211 (2.244)	1.178 (1.616)	1.143 (1.059)
Support for technology development and funding					
Participation in government R&D project		0.831 (1.151)	0.827 (1.183)	0.788 (1.838)	0.783 (1.903)
Technical support from the government		0.903 (0.154)	0.982 (0.005)	0.911 (0.129)	0.984 (0.004)
Technology information provided by the Government		1.104 (0.146)	1.149 (0.284)	1.105 (0.15)	1.150 (0.286)
Technicians and educational research		1.211 (0.791)	1.133 (0.325)	1.176 (0.568)	1.109 (0.222)
Procurement by the government or collective Purchasing		0.703 (2.675)	0.703 (2.630)	0.718 (2.361)	0.718 (2.319)
Marketing supported by the government		1.442 (4.516) *	1.438 (4.381) **	1.471 (5.003) **	1.466 (4.836) **
Internal Finance		1.832 (13.875) ***	1.797 (12.737) ***	1.765 (12.083) **	1.738 (11.234) ***
Government Funding		0.993 (0.003)	1.006 (0.002)	1.004 (0.001)	1.014 (0.011)
Loans		1.546 (16.286) ***	1.525 (14.934) ***	1.571 (17.354) ***	1.553 (16.083) ***
Stock Issue		01.440 (0.359)	1.381 (0.273)	1.361 (0.255)	1.314 (0.194)
Cooperation in Process Innovation		5.879 (118.477) ***	6.030 (119.701) ***	5.822 (116.685) ***	5.983 (118.033) ***
Firms with 10-49 Employees				0.729 (2.569)	0.697 (3.232)
Firms with 50-99 Employees				0.889 (0.297)	0.834 (0.704)
Firms with 100-299 Employees				0.941 (0.095)	0.935 (0.122)
Firms with 300-499 Employees					0.979 (0.008)
Firms with over 500 Employees				1.014 (0.003)	
Region			(31.736) ***		(32.380) ***
Constant		0.013 (399.171) ***	0.010 (33.217) ***	0.017 (203.899) ***	0.014 (26.480) ***
Observations		3769	3769	3769	3769
Model Test:	-2 Log likelihood	2844.803	2812.739	2838.642	2805.887
	Nagelkerke R^2	0.597	0.603	0.598	0.604
	Cox & Snell R^2	0.439	0.444	0.440	0.445
	X^2 (d.f.)	2180.773*** (16)	2212.836*** (31)	2186.934*** (20)	2219.688*** (35)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

In general, adding *Firm sizes* as control variables did not improve the model fit.

Regression Analysis for KIS 2012 (2009-2011)

DESCRIPTIVE STATISTICS (KIS 2012)

Table 7.33 Descriptive Statistics for 2009-2011

	N	Mean	Stand. Dev.	Min.	Max.
1 New Product Innovation	4086	.08	.264	0	1
2 Significantly Improved Product Innovation	4086	.10	.304	0	1
3 New or significantly improved production process	4086	.06	.237	0	1
4 New or significantly improved logistics	4086	.02	.130	0	1
5 New or significantly improved support activity	4086	.04	.187	0	1
6 New to Market Product Innovation	4086	.054	.226	0	1
7 New to firm Product innovation	4086	.095	.293	0	1
8 Internal R&D	1093	.88	.326	0	1
9 External R&D	1093	.17	.374	0	1
10 Proportion of MSc or higher degree holders among permanent employees	4047	2.54	7.243	0	100
11 Proportion of Research staff among permanent employees	4086	5.92	11.207	0	90.63
12Tax relief for technology development	4086	.06	.243	0	1
13 Support for technology development and funding	4086	.14	.350	0	1
14 Participation in government R&D project	4086	.07	.253	0	1
15 Technical support from the government	4086	.04	.201	0	1
16 Technology information provided by the government	4086	.04	.193	0	1
17 Technicians and educational research	4086	.03	.183	0	1
18 Procurement by the government or collective purchasing	4086	.02	.139	0	1
19 Marketing supported by the government	4086	.04	.202	0	1
20 Internal Finance	4086	.223	.416	0	1
21 Government Funding	4086	.02	.139	0	1
22 Loans	4086	.02	.132	0	1
23 StockIssue	4086	.018	.000	0	1
24 Cooperation in Product Innovation	4086	.01	.150	0	1
25 Cooperation in Process Innovation	4076	5.92	0.119	0	1
26 Firms with 10-49 Employees	4086	0.682	0.466	0	1
27 Firms with 50-99 Employees	4086	0.127	0.333	0	1
28 Firms with 100-299 Employees	4086	0.126	0.332	0	1
29 Firms with 300-499 Employees	4086	0.019	0.135	0	1
30 Firms with over 500 Employees	4086	0.020	0.139	0	1
31 Regions	4086	7.537	4.512	1	16

The measurement of innovation is from variable numbers 1 to 7 in Table 7.33. Variable 1 and 2 is *product innovation*, variable numbers 3 to 5 is *process innovation* and variable 6 and 7 is *new to market* and *New to firm product innovation* respectively. Variables for innovation activities are from variable numbers 8 to 26.

CORRELATION MATRIX, 2009-2011

Table 7.34 displays the Correlation Matrix between dependent and independent variables for 2009-2011:

Table 7.34 Correlation Matrix between Measurements of Innovation and Aspects of Innovation Activities using the Data for the Whole of Korea, 2009-2011

	1	2	3	4	5	6	7	8
1 New Product Innovation	1							
2 Significantly Improved Product Innovation	.293**	1						
3 New or significantly improved production process	.240**	.241**	1					
4 New or significantly improved logistics	.176**	.203**	.309**	1				
5 New or significantly improved support activity	.147**	.170**	.166**	.347**	1			
6 New to Market Product Innovation	.498**	.436**	.196**	.111**	.110**	1		
7 New to firm Product Innovation	.565**	.649**	.215**	.157**	.151**	.304**	1	
8 Internal R&D	.145**	.132**	-.118**	-.008	-.147**	.116**	.163**	1
9 External R&D	.076**	.126**	.023	.054	-.029	.079**	.045	.107**
10 Proportion of MSc or higher degree holders among permanent employees	.127**	.143**	.034*	.050**	.052**	.098**	.118**	.084**
11 Proportion of Research staff among permanent employees	.212**	.305**	.118**	.094**	.081**	.179**	.278**	.218**
12Tax relief for technology development	.216**	.204**	.156**	.144**	.122**	.184**	.202**	.127**
13 Support for technology development and funding	.198**	.169**	.148**	.081**	.137**	.147**	.214**	.107**
14 Participation in government R&D project	.227**	.188**	.132**	.143**	.092**	.197**	.217**	.101**
15 Technical support from the government	.161**	.129**	.091**	.122**	.076**	.149**	.140**	.078*
16 Technology information provided by the government	.172**	.119**	.093**	.090**	.089**	.143**	.147**	.062*
17 Technicians and educational research	.144**	.156**	.066**	.120**	.092**	.127**	.149**	.069*
18 Procurement by the government or collective purchasing	.133**	.126**	.046**	.063**	.104**	.099**	.135**	.044
19 Marketing supported by the government	.141**	.204**	.095**	.131**	.127**	.170**	.168**	.071*
20 Internal Finance	.419**	.490**	.324**	.179**	.294**	.344**	.468**	.059*
21 Government Funding	.165**	.160**	.120	.049**	.057**	.137**	.164**	.030
22 Loans	.087**	.124**	.216**	.068**	.082**	.091**	.108**	-.047
23 Stock Issue	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}	.^{c}
24 Cooperation in Product Innovation	.259**	.335**	.189**	.143**	.109**	.217**	.285**	-.037
25 Cooperation in Process Innovation	.144**	.128**	.307**	.221**	.261**	.098**	.094**	-.061*
26 Firms with 10-49 Employees	-.093**	-.043**	-.063**	-.043**	-.077**	-.079**	-.073**	-.112**
27 Firms with 50-99 Employees	.008	.001	.012	-.011	.012	.013	.005	.064*
28 Firms with 100-299 Employees	.073**	.027	.038*	0.03	.068**	.060**	.061**	.053
29 Firms with 300-499 Employees	.057**	.067**	.057**	.066**	.041**	.039*	.054**	.029
30 Firms with over 500 Employees	.105**	.050**	.068**	.049**	.066**	.091**	.074**	.043
31 Regions	-0.005	-.034*	.014	-.007	-.014	.001	-0.026	-.033

	9	10	11	12	13	14	15
9 External R&D	1						
10 Proportion of MSc or higher degree holders among permanent employees	.149**	1					
11 Proportion of Research staff among permanent employees	.073*	.417**	1				
12Tax relief for technology development	.117**	.154**	.230**	1			
13 Support for technology development and funding	.133**	.153**	.215**	.381**	1		
14 Participation in government R&D project	.170**	.202**	.297**	.357**	.354**	1	
15 Technical support from the government	.136**	.125**	.175**	.336**	.348**	.467**	1
16 Technology information provided by the government	.110**	.112**	.152**	.349**	.301**	.396**	.605**
17 Technicians and educational research	.206**	.157**	.154**	.360**	.271**	.379**	.480**
18 Procurement by the govt. or collective purchasing	.081**	.061**	.113**	.327**	.265**	.311**	.365**
19 Marketing supported by the government	.163**	.150**	.210**	.380**	.339**	.346**	.389**
20 Internal Finance	-.145**	.166**	.347**	.196**	.178**	.148**	.145**
21 Government Funding	.153**	.120**	.176**	.173**	.263**	.219**	.197**
22 Loans	.056	.048**	.059**	.049**	.050**	.044**	.045**
23 Stock Issue	.c	.c	.c	.c	.c	.c	.c
24 Cooperation in Product Innovation	.132**	.048**	.117**	.128**	.114**	.152**	.130**
25 Cooperation in Process Innovation	.120**	.041**	.066**	.087**	.091**	.121**	.066**
26 Firms with 10-49 Employees	-.133**	-.046**	-0.019	-.094**	-.048**	-.143**	-.068**
27 Firms with 50-99 Employees	0.004	0.025	0.008	0.013	0.004	0.03	0.018
28 Firms with 100-299 Employees	0.053	0.022	0.024	.066**	.037*	.110**	.067**
29 Firms with 300-499 Employees	.066*	0.012	0.013	.069**	0.026	.092**	0.016
30 Firms with over 500 Employees	.129**	.057**	.035*	.093**	.067**	.087**	.031*
31 Regions	-0.038	-.057**	-.059**	-.034*	0.027	0.003	0.028

	16	17	18	19	20	21	22
16 Technology information provided by the government	1						
17 Technicians and educational research	.461**	1					
18 Procurement by the government or collective purchasing	.392**	.428**	1				
19 Marketing supported by the government	.377**	.445**	.408**	1			
20 Internal Finance	.154**	.108**	.094**	.152**	1		
21 Government Funding	.153**	.156**	.094**	.144**	-.076**	1	
22 Loans	.049**	.025**	.034*	.072**	-.072**	-.019	1
23 Stock Issue	.c	.c	.c	.c	.c	.c	.c
24 Cooperation in Product Innovation	.070**	.096**	.073**	.113**	.177**	.189**	.066**
25 Cooperation in Process Innovation	.082**	.123**	.027	.066**	.157**	.130**	.030
26 Firms with 10-49 Employees	-.074**	-.067**	-.029	-.033*	-.147**	-.008	-.011
27 Firms with 50-99 Employees	.014	.008	.01	-.011	.018	.035*	.01
28 Firms with 100-299 Employees	.065**	.054**	.01	.026	.125**	-.012	.021
29 Firms with 300-499 Employees	.019	.043**	.02	.061**	.092**	.006	-.005
30 Firms with over 500 Employees	.044**	.050**	.031	.040*	.139**	-.02	-.006
31 Regions	.002	-.036*	.003	.007	.001	-.012	.008

	23	24	25	26	27	28	29	30	31
23 Stock Issue	1								
24 Cooperation in Product Innovation	.c	1							
25 Cooperation in Process Innovation	.c	.241**	1						
26 Firms with 10-49 Employees	.c	-.039*	-.054**	1					
27 Firms with 50-99 Employees	.c	.005	.022	-.558**	1				
28 Firms with 100-299 Employees	.c	.011	.004	-.555**	-.145**	1			
29 Firms with 300-499 Employees	.c	.039*	.059**	-.202**	-.053**	-.052**	1		
30 Firms with over 500 Employees	.c	.072**	.086**	-.208**	-.054**	-.054**	-.02	1	
31 Regions	.c	-.025	-.011	-.017	.011	.057**	-.01	-.085**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Looking at the correlations among dependent variables 1 to 7, we can see generally weak to moderate correlations. *Significantly improved product innovation* and *New to firm product innovation*, however, show strong correlation with r = 0.65.

The correlations between the independent variables, 8 to 25, are in general weak to moderate. The highest correlation is between *Significantly improved product innovation* and *Internal Finance* with r = 0.49.

<u>Model A: Without control variable</u>

A multicollinearity test has been carried out and no VIF value exceeded the recommended cut off value of 10 with VIF ranging between 1.05 - 5.47. The variable 'Stock Issue' has been removed either because it has missing observation or is constant due to very low variability as few firms issue stocks.

<u>Model B: Region</u>

A multicollinearity test has been carried out and the VIF test due to collinearity. No VIF value of remaining variables exceeded the recommended cut off value of 10 with VIF ranging between 1.03 - 5.47. The variable 'Stock Issue' has been removed either because it has missing observation or is constant due to very low variability as few firms issue stocks.

Model C: Firm Size

A multicollinearity test has been carried out and VIF for *Firms with 10-49 Employees* is 30.55, *Firms with 50-99 employees* is 16.17, *Firms with 100-299 employees* is 20.11. Other VIFs range between 1 and 6.32. By removing the *Firms with 10-49 Employees*, the VIFs *Firms with 100-299 employees* is 1.16, *Firms with 300-499 employees* is 1.06 and the values of VIF for the rest of the variables ranged from 1.06 to 5.49. The variable 'Stock Issue' has been removed either because it has missing observation or is constant due to very low variability as few firms issue stocks.

Model D: Firm Size and Region

A multicollinearity test has been carried out and VIF for *Firms with 10-49 Employees* is 30.55, *Firms with 50-99 employees* is 16.17, and *Firms with 100-299 employees* is 20.11. Other VIFs range between 1 and 6.32. Correction of this has been done and by removing the *Firms with 10-49 Employees*, the VIFs *Firms with 100-299 employees* is 1.14, *Firms with 300-499 employees* is 1.16 and the values of VIF for the rest of the variables ranged from 1.06 to 5.49. The variable 'Stock Issue' has been removed either because it has missing observation or is constant due to very low variability as few firms issue stocks.

REGRESSION RESULTS

Table 7.35 lists the logit coefficients, Wald chi square value in bracket, pseudo R squared values (Nigelkerke and Cox and Snell), and Chi square statistic by Logistic analysis for the four models mentioned above.

The Chi square for our model A (without any control variable) is highly significant ($p<0.001$, d.f.=16) with a Chi-square value of 95.245 for *New product innovation*, 129.485 for *Significantly improved product innovation*, 107.654 for *New or Significantly Improved production process innovation*, 51.538 for *New or Significantly Improved Logistics Methods,* and 81.863 for *Support activity process innovation*.

The Chi square values change only slightly when control variables are included in model C and they are 97.354 (d.f.=20) for *New product innovation* and 147.245 (d.f.=20) for *Significantly improved product innovation*. They are all statistically highly significant with $p<0.001$. The Chi square values for B and D for *Significantly improved product innovation* are 156.218 (d.f.=31, $p<0.001$) and 176.100 (d.f.=36, $p<0.001$).

Nagelkerke R squared values in model A, as in Table 7.35, is 0.121 for *New product innovation* and as in Table 7.36, 0.153 for *Significantly improved product innovation.* The values are 0.124 for *New product innovation* and 0182, 0.173 and 0.204 for *significantly improved product innovation* for model B, C and D respectively. Adding control variables improved the model fit only slightly.

If we look at model A in *New Product Innovation*, Table 7.35, *Internal R&D*, *Participation in government R&D project*, and *Cooperation* are significant and positive in both model A and C.

No *firm sizes* turned out to be significant when they were entered in model C.

Table 7.35 Logistic Regression Models in New Product Innovation as Dependent Variable, 2009-2011

Dependent variable		New Product Innovation			
		Model A		Model C	
Independent variables		B	Exp(B)	B	Exp(B)
Internal R&D		1.252	3.496 (16.767) ***	1.254	3.505 (16.587) ***
External R&D		0.152	1.164 (0.631)	0.128	1.136 (0.429)
Proportion of MSc Holders		0.005	1.005 (0.353)	0.004	1.004 (0.304)
Proportion of Researchers among permanent employees		-0.005	0.995 (0.775)	-0.005	0.995 (0.64)
Tax relief for technology development		0.31	1.363 (2.188)	0.302	1.352 (2.067)
Support for technology development and funding		0.126	1.134 (0.467)	0.115	1.122 (0.391)
Participation in government R&D project		0.726	2.066 (10.117) **	0.702	2.018 (9.178) **
Technical support from the government		-0.508	0.602 (2.642)	-0.508	0.602 (2.61)
Technology information provided by the Government		0.389	1.476 (1.798)	0.394	1.483 (1.814)
Technicians and educational research		0.079	1.082 (0.803)	0.078	1.081 (0.06)
Procurement by the government or collective Purchasing		0.46	1.584 (1.621)	0.47	1.601 (1.693)
Marketing supported by the government		-0.327	0.721 (1.501)	-0.31	0.733 (1.345)
Internal Finance		0.977	2.656 (2.412)	0.958	2.606 (2.313)
Government Funding		0.93	2.534 (1.881)	0.96	2.613 (2.007)
Loans		0.803	2.233 (1.378)	0.801	2.228 (1.371)
Stock Issue					
Cooperation in Product Innovation		1.198	3.314 (24.824) ***	1.206	3.321 (24.817) ***
Firms with 10-49 Employees					
Firms with 50-99 Employees				-0.136	0.873 (0.4)
Firms with 100-299 Employees				0.097	1.102 (0.261)
Firms with 300-499 Employees				-0.194	0.824 (0.233)
Firms with over 500 Employees				0.31	1.364 (0.878)
Constant		-3.325	0.036 (24.413) ***	-3.315	0.036 (24.303) ***
Observations		1084		1084	
Model Test:	-2 Log likelihood	1193.063		1190.955	
	Nagelkerke R^2	0.121		0.124	
	Cox & Snell R^2	0.084		0.086	
	X^2 (d.f.)	95.245*** (16)		97.354*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Table 7.36 shows that *Internal* and *External R&D, proportion of researchers among permanent employees, Technical support from the government, Technicians and educational research, Marketing supported by the government* and *Cooperation* are significant and positive in model A in *significantly improved product innovation*. All these variables are significant and positive except *Technical support from the government* which is significant and negative. The same variables remain significant in model B except *Technicians and educational research.* In model C, *Participation in government R&D project and Technicians and educational research* are the variables that are added as significant and positive variables to the ones in model B.

Firms with 50-99, 100-299 and over 500 employees came out as significant and negative in model C while *firms with 100-299 and over 500 employees* came out as significant and negative in model D.

Table 7.36 Logistic Regression Models in Significantly Improved Product Innovation as Dependent Variable, 2009-2011

Dependent variable		Significantly Improved Product Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		2.400 (12.518) ***	2.422 (12.214) ***	2.670 (15.419) ***	2.738 (15.393) ***
External R&D		1.465 (4.343) **	1.484 (4.372) **	1.677 (7.516) **	1.689 (7.245) ***
Proportion of MSc Holders		0.993 (0.992)	0.993 (0.715)	0.993 (0.862)	0.994 (0.722)
Proportion of Researchers among permanent employees		1.021 (15.029) ***	1.023 (16.327) ***	1.016 (8.43) **	1.017 (8.926) ***
Tax relief for technology development		1.099 (0.203)	1.134 (0.344)	1.130 (0.33)	1.181 (0.589)
Support for technology development and funding		0.803 (1.49)	0.803 (1.425)	0.793 (1.632)	0.793 (1.562)
Participation in government R&D project		1.345 (1.616)	1.368 (1.711)	1.551 (3.363) *	1.588 (3.538) *
Technical support from the government		0.538 (3.741) *	0.564 (2.963) *	0.502 (4.508) **	0.537 (3.409) *
Technology information provided by the Government		0.672 (1.711)	0.676 (1.562)	0.696 (1.42)	0.711 (1.163)
Technicians and educational research		1.839 (3.608) *	1.658 (2.32)	1.976 (4.391) **	1.727 (2.63)
Procurement by the government or collective Purchasing		1.556 (0.363)	1.801 (2.511)	1.479 (1.141)	1.698 (1.992)
Marketing supported by the government		1.569 (3.192) *	1.543 (2.87) *	1.493 (2.442)	1.470 (2.197)
Internal Finance		0.964 (0.008)	1.054 (0.015)	1.072 (0.026)	1.220 (0.197)
Government Funding		0.753 (0.502)	0.833 (0.128)	0.737 (0.361)	0.839 (0.112)
Loans		0.990 (0)	1.065 (0.016)	1.025 (0.002)	1.144 (0.068)
Stock Issue					
Cooperation in Product Innovation		6.348 (47.315) ***	6.235 (44.244) ***	6.640 (48.176) ***	6.490 (44.877) ***
Firms with 10-49 Employees					0.536 (0.747)
Firms with 50-99 Employees				0.672 (3.82) *	0.359 (1.911)
Firms with 100-299 Employees				0.561 (9.557) **	0.288 (2.858) *
Firms with 300-499 Employees				0.733 (0.687)	0.381 (1.437)
Firms with over 500 Employees				0.328 (9.039) **	0.159 (5.161) **
Region			(23.904) *		(25.441) *
Constant		0.182 (13.832) ***	0 (0)	0.193 (12.51) ***	0 (0)
Observations		1084	1084	1084	1084
Model Test:	-2 Log likelihood	1312.225	1285.492	1294.466	1265.610
	Nagelkerke R^2	0.153	0.182	0.173	0.204
	Cox & Snell R^2	0.113	0.134	0.127	0.150
	X^2 (d.f.)	129.485*** (16)	156.218*** (31)	147.245*** (20)	176.100*** (36)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

The Chi square for our model A (without any control variable) is highly significant ($p<0.001$, d.f.=16) with a Chi-square value of 107.654 for *New or Significantly Improved production process innovation*, 51.538 for *New or Significantly Improved Logistics Methods,* and 81.863 for *Support activity process innovation*.

The Chi square values for *New or significantly improved production process innovation* for models B, C and D is 135.647 (d.f.=31), 107.997 (d.f.=20), and 136.239 (d.f.=36) respectively. The value for *New or significantly improved logistic process innovation* is 53.594 (d.f.=20). The Chi square value for *New or significantly improved support activity process innovation* for model C is 89.341 (d.f.=20). They are all statistically highly significant with $p<0.001$.

Nagelkerke R squared values in model A, B, C, and D, as in Table 7.37, are 0.145, 0.180, 0.145 and 0.181 for *Production process innovation*.

Table 7.37 shows that *Tax relief for technology development*, *Loans* and *Cooperation* are significant and positive in all four models in *New or significantly improved production process innovation* while *Internal R&D* and *Proportion of MSc and higher degree holders among permanent employees* are significant but negative in all models.

No *firm sizes* control variables turned out to be significant when added.

Table 7.37 Logistic Regression Models in New or Significantly Improved Production Process Innovation as Dependent Variable, 2009-2011

Dependent variable		New or Significantly Improved Production Process Innovation			
Independent variables		Exp(B)			
		Model A	Model B	Model C	Model D
Internal R&D		0.511 (8.909) **	0.564 (6.050) **	0.520 (8.175) **	0.572 (5.548) **
External R&D		1.019 (0.007)	1.048 (0.044)	1.032 (0.02)	1.056 (0.057)
Proportion of MSc Holders		0.972 (5.892) **	0.974 (4.785) **	0.972 (5.892) **	0.973 (4.896) **
Proportion of Researchers among permanent employees		0.990 (2.089)	0.990 (2.040)	0.989 (2.269)	0.989 (2.090)
Tax relief for technology development		1.753 (5.862) **	1.798 (6.217) **	1.756 (5.86) **	1.802 (6.232) **
Support for technology development and funding		1.242 (1.175)	1.257 (1.253)	1.235 (1.11)	1.249 (1.181)
Participation in government R&D project		1.368 (1.424)	1.271 (0.773)	1.393 (1.551)	1.293 (0.863)
Technical support from the government		0.980 (0.003)	0.963 (0.011)	0.979 (0.004)	0.961 (0.012)
Technology information provided by the Government		0.841 (0.253)	0.867 (0.163)	0.842 (0.248)	0.867 (0.163)
Technicians and educational research		0.641 (1.315)	0.636 (1.286)	0.641 (1.31)	0.635 (1.300)
Procurement by the gov. or collective Purchasing		0.845 (0.151)	0.922 (0.034)	0.839 (0.166)	0.912 (0.043)
Marketing supported by the government		0.927 (0.065)	0.937 (0.046)	0.925 (0.068)	0.946 (0.033)
Internal Finance		1.116 (0.049)	1.051 (0.10)	1.121 (0.052)	1.061 (0.014)
Government Funding		1.211 (0.110)	1.218 (0.114)	1.204 (0.103)	1.217 (0.112)
Loans		3.657 (5.644) **	3.545 (5.174) **	3.647 (5.615) **	3.574 (5.239) **
Stock Issue					
Cooperation in Process Innovation		8.014 (46.022) ***	8.587 (45.671) ***	7.989 (45.451) ***	8.554 (45.074) ***
Firms with 10-49 Employees					0.761 (0.094)
Firms with 50-99 Employees				0.958 (0.033)	0.746 (0.104)
Firms with 100-299 Employees				0.894 (0.273)	0.694 (0.163)
Firms with 300-499 Employees				0.879 (0.087)	0.615 (0.240)
Firms with over 500 Employees				1.007 (0)	0.843 (0.031)
Region			(26.798) **		(26.910) **
Constant		0.388 (3.581)	0 (0)	0.397 (3.382)	0 (0)
Observations		1084	1084	1084	1084
Model Test:	-2 Log likelihood	1038.518	1010.524	1038.174	1009.933
	Nagelkerke R^2	0.145	0.180	0.145	0.181
	Cox & Snell R^2	0.095	0.118	0.095	0.118
	X^2 (d.f.)	107.654*** (16)	135.647*** (31)	107.997*** (20)	136.239 *** (36)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Nagelkerke R squared values in model A, as in Table 7.38, 0.124 for *new or significantly improved logistic process innovation* and the value for model C is 0.129.

Tax relief for technology development, *Participation in government R&D project*, Marketing supported by the government, and *Cooperation* are significant and positive in model A in *New and significant logistic process innovation* while Government funding is significant but negative. *Marketing* became insignificant in model C. No *firm sizes* control variables turned out to be significant when added in model C.

Table 7.38 Logistic Regression Models in New or Significantly Improved Logistic methods Process Innovation as Dependent Variable, 2009-2011

Dependent variable	New or significantly improved logistics Methods			
Independent variables	Model A		Model C	
	B	Exp(B)	B	Exp(B)
Internal R&D	-0.164	0.849 (0.156)	-0.16	0.852 (0.147)
External R&D	0.122	1.130 (0.136)	0.099	1.104 (0.087)
Proportion of MSc Holders	-0.008	0.992 (0.255)	-0.008	0.992 (0.266)
Proportion of Researchers among permanent employees	0.001	1.001 (0.02)	0.002	1.002 (0.052)
Tax relief for technology development	0.748	2.113 (4.576) **	0.715	2.044 (4.075) **
Support for technology development and funding	-0.522	0.593 (2.207)	-0.531	0.588 (2.246)
Participation in government R&D project	0.86	2.363 (5.253) **	0.794	2.213 (4.246) **
Technical support from the government	0.569	1.767 (1.385)	0.592	1.807 (1.472)
Technology information provided by the Government	-0.592	0.553 (1.236)	-0.562	0.570 (1.088)
Technicians and educational research	0.169	1.184 (0.114)	0.205	1.227 (0.164)
Procurement by the government or collective Purchasing	-0.283	0.753 (0.214)	-0.241	0.786 (0.151)
Marketing supported by the government	0.642	1.901 (2.651) *	0.622	1.862 (2.454)
Internal Finance	-0.893	0.410 (1.862)	-0.922	0.398 (1.963)
Government Funding	-1.402	0.246 (2.84) *	-1.371	0.254 (2.678) *
Loans	-0.588	0.555 (0.575)	-0.577	0.562 (0.553)
Stock Issue				
Cooperation in Process Innovation	1.776	5.907 (24.12) ***	1.781	5.937 (23.554) ***
Firms with 10-49 Employees				
Firms with 50-99 Employees			-0.37	0.691 (0.680)
Firms with 100-299 Employees			0.116	1.123 (0.110)
Firms with 300-499 Employees			0.557	1.746 (0.949)
Firms with over 500 Employees			0.056	1.057 (0.009)
Constant	-2.208	0.110 (10.306) **	-2.193	0.112 (10.144) ***
Observations	1084		1084	
Model Test: -2 Log likelihood	456.675		454.620	
Model Test: Nagelkerke R^2	0.124		0.129	
Model Test: Cox & Snell R^2	0.046		0.048	
Model Test: X^2 (d.f.)	51.538*** (16)		53.594*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Nagelkerke R squared values in model A, as in Table 7.39, 0.133 for *Support activity process innovation* and 0.144 for model C.

For *New or significantly improved support activity*, *Support for technology development and funding*, *Procurement by the government or collective purchasing*, *Marketing* and *Cooperation*. *Internal R&D* and *Proportion of Researchers among permanent employees are* significant and negative in model A.

In model C where *firm sizes* are added, *Proportion of Researchers among permanent employees* became insignificant while *Firms with 100-299 employees* became significant and positive.

Table 7.39 Logistic regression Models in New or Significantly Improved Support Activity Process Innovation as Dependent Variable, KIS 2012

Dependent variable	New or significantly improved support activity			
Independent variables	Model A		Model C	
	B	Exp(B)	B	Exp(B)
Internal R&D	-1.003	0.367 (16.288) ***	-1.131	0.323 (19.446) ***
External R&D	-0.31	0.733 (1.232)	-0.385	0.681 (1.84)
Proportion of MSc Holders	0.001	1.001 (0.009)	0	1.000 (0.001)
Proportion of Researchers among permanent employees	-0.017	0.984 (3.537) **	-0.011	0.989 (1.598)
Tax relief for technology development	0.208	1.231 (0.544)	0.195	1.215 (0.479)
Support for technology development and funding	0.497	1.643 (4.459) **	0.538	1.713 (5.159) **
Participation in government R&D project	-0.17	0.844 (0.275)	-0.266	0.767 (0.653)
Technical support from the government	-0.372	0.690 (0.718)	-0.389	0.678 (0.774)
Technology information provided by the Government	-0.129	0.879 (0.095)	-0.134	0.874 (0.102)
Technicians and educational research	-0.074	0.928 (0.029)	-0.102	0.903 (0.054)
Procurement by the government or collective Purchasing	0.906	2.475 (4.448) **	0.963	2.621 (4.95) **
Marketing supported by the government	0.547	1.728 (2.85) *	0.593	1.809 (3.313) *
Internal Finance	1.082	2.950 (2.008)	1.072	2.922 (1.957)
Government Funding	0.551	1.734 (0.416)	0.632	1.882 (0.54)
Loans	1.063	2.896 (1.645)	1.118	3.059 (1.81)
Stock Issue				
Cooperation in Process Innovation	1.865	6.459 (35.967) ***	1.891	6.623 (35.983) ***
Firms with 10-49 Employees			0.258	
Firms with 50-99 Employees			0.635	1.294 (0.804)
Firms with 100-299 Employees			-0.012	1.886 (6.722) **
Firms with 300-499 Employees			0.574	0.988 (0.001)
Firms with over 500 Employees				1.775 (1.899)
Constant	-2.2	0.111 (8.321) **	-2.351	0.95 (9.458) **
Observations	1084		1084	
Model Test: -2 Log likelihood	778.641		771.164	
Nagelkerke R^2	0.133		0.144	
Cox & Snell R^2	0.073		0.079	
X^2 (d.f.)	81.863*** (16)		89.341*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

The Chi square value for model A for *New to market product innovation* is 61.119 and the value for *New to firm product innovation* is 105.158 with the $p < 0.001$ and degree of freedom of 16. The Chi square value for model C for *New to market product innovation* is 62.454 (d.f.=20) while it is 106.898 (d.f.=20) for *New to firm product innovation*. They are statistically highly significant with $p<0.001$.

Nagelkerke R squared values in model A, as in Table 7.40, is 0.087 and 0.089 for model C for *New to market product innovation.*

In the case of *New to market product innovation*, *Internal R&D, Participation in government R&D project*, Marketing and *Cooperation* is significant in both model A and C. No *firm sizes* came out as significant when added.

Table 7.40 Logistic Regression Models in New to Market Product Innovation as Dependent Variable, KIS 2012

Dependent variable		New to Market Product Innovation			
Independent variables		Model A		Model C	
		B	Exp(B)	B	Exp(B)
Internal R&D		1.135	3.111 (10.486) **	1.127	3.087 (10.211) **
External R&D		0.17	1.185 (0.678)	0.151	1.163 (0.517)
Proportion of MSc Holders		-0.002	0.998 (0.074)	-0.003	0.997 (0.094)
Proportion of Researchers among permanent employees		-0.002	0.998 (0.074)	-0.002	0.998 (0.061)
Tax relief for technology development		0.267	1.306 (0.116)	0.268	1.308 (1.389)
Support for technology development and funding		-0.219	0.803 (1.094)	-0.22	0.802 (1.1)
Participation in government R&D project		0.657	1.929 (7.194) **	0.643	1.903 (6.703) **
Technical support from the government		-0.064	0.938 (0.039)	-0.068	0.934 (0.043)
Technology information provided by the Government		0.125	1.133 (0.156)	0.111	1.117 (0.122)
Technicians and educational research		-0.054	0.948 (0.025)	-0.06	0.942 (0.031)
Procurement by the government or collective Purchasing		-0.036	0.965 (0.008)	-0.025	0.975 (0.004)
Marketing supported by the government		0.435	1.545 (2.669) *	0.457	1.580 (2.926) *
Internal Finance		0.937	2.552 (1.573)	0.927	2.526 (1.535)
Government Funding		0.954	2.597 (1.432)	0.966	2.627 (1.465)
Loans		0.969	2.635 (1.469)	0.966	2.628 (1.461)
Stock Issue					
Cooperation in Product Innovation		0.926	2.523 (14.203) ***	0.934	2.545 (14.371) ***
Firms with 10-49 Employees					
Firms with 50-99 Employees				0.017	1.017 (0.005)
Firms with 100-299 Employees				0.104	1.109 (0.243)
Firms with 300-499 Employees				-0.326	0.722 (0.509)
Firms with over 500 Employees				0.24	1.271 (0.442)
Constant		-3.603	0.027 (20.517) ***	-3.614	0.027 (20.644) ***
Observations		1084		1084	
Model Test:	-2 Log likelihood	1021.532		1020.197	
	Nagelkerke R^2	0.087		0.089	
	Cox & Snell R^2	0.055		0.056	
	X^2 (d.f.)	61.119*** (16)		62.454*** (20)	

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

Nagelkerke R squared values in model A, as in Table 7.41, 0.127 for *New to firm product innovation* while the value is 0.129 for model C.

Internal R&D, Proportion of Researchers among permanent employees, Support for technology development and funding, Participation in government R&D project and *Cooperation* are significant and positive in model A. *Proportion of MSc or higher degree holders among permanent employees* and *Technical support from the government* are significant but negative. No *firm sizes* was significant when added.

Table 7.41 Logistic Regression Models in New to Firm Product Innovation as Dependent Variable, KIS 2012

Dependent variable		New to firm Product Innovation			
Independent variables		Model A		Model C	
		B	Exp(B)	B	Exp(B)
Internal R&D		1.262	3.533 (21.305) ***	1.294	3.646 (22.115) ***
External R&D		-0.08	0.923 (0.186)	-0.053	0.948 (0.08)
Proportion of MSc Holders		-0.013	0.987 (2.889) *	-0.013	0.987 (2.841) *
Proportion of Researchers among permanent employees		0.014	1.014 (6.713) **	0.013	1.013 (5.248) **
Tax relief for technology development		-0.031	0.969 (0.023)	-0.029	0.972 (0.02)
Support for technology development and funding		0.319	1.376 (3.376) *	0.317	1.373 (3.309) *
Participation in government R&D project		0.709	2.032 (9.822) **	0.736	2.087 (10.253) **
Technical support from the government		-0.829	0.436 (7.04) **	-0.85	0.427 (7.324) **
Technology information provided by the Government		0.122	1.130 (0.181)	0.14	1.151 (0.236)
Technicians and educational research		0.388	1.475 (1.561)	0.412	1.509 (1.747)
Procurement by the government or collective Purchasing		0.358	1.430 (0.998)	0.359	1.432 (1.003)
Marketing supported by the government		0.026	1.027 (0.011)	0.004	1.004 (0.000)
Internal Finance		-0.142	0.868 (0.108)	-0.116	0.890 (0.072)
Government Funding		-0.339	0.713 (0.458)	-0.325	0.722 (0.42)
Loans		-0.157	0.855 (0.1)	-0.148	0.862 (0.089)
Stock Issue					
Cooperation in Process Innovation		1.323	3.753 (28.979) ***	1.33	3.779 (29.131) ***
Firms with 10-49 Employees					
Firms with 50-99 Employees				-0.216	0.806 (1.128)
Firms with 100-299 Employees				-0.067	0.935 (0.138)
Firms with 300-499 Employees				-0.045	0.956 (0.015)
Firms with over 500 Employees				-0.305	0.737 (0.821)
Constant		-2.013	0.134 (18.078) ***	-1.997	0.136 (17.657) ***
Observations			1084		1084
Model Test:	-2 Log likelihood		1302.911		1301.171
	Nagelkerke R^2		0.127		0.129
	Cox & Snell R^2		0.092		0.094
	X^2 (d.f.)		105.158*** (16)		106.898*** (20)

Note: *p<0.1, **p<0.05, ***p<0.01 and values shown in parentheses are Wald values

In general, adding *regions* and *Firm sizes* as control variables individually or two together make littledifference in the model fit.

7.3.4 Discussion

In this section, the regression analysis carried out in section 7.3.3 is discussed in accordance with the hypotheses developed in section 7.2. Over the three KISs (2008, 2010 and 2012) that cover the time periods of 2005-07, 2007-09 and 2009-11 the hypotheses developed in Chapter 5 have been examined. This section summarises the findings from the above regression analysis.

RESEARCH AND DEVELOPMENT

Looking at model A where no control has been entered in the 2008 survey, either *internal or external R&D* or both are positively associated with product and process innovation.

The same is true in 2010 and there is strong support that both *Internal* and *external R&D* play important roles in production of product innovation with only *external R&D* positively associated with process innovation. Interestingly in 2012 however, *internal R&D* is positively associated with *New product innovation* while *internal R&D* is negatively associated with *New or significantly improved production process* and *Support activities process innovation*. *New or significantly improved logistic process innovation* is not associated with *Internal* and *External R&D.*

Internal and/or *External R&D* are all positively associated with *new to market* and *new to firm product innovation* in KIS 2008 and in 2010. In 2012, however, only *Internal R&D* is significant for *New to market* and *New to firm product innovation*.

While product innovation is more associated with *internal R&D*, process innovation is more positively associated with *external R&D* in general. Due to tacit knowledge and knowledge spillover effects production process is closely related to *internal R&D* activities while *external R&D* usually results in process innovation introducing new production equipment or renewed or improved operational processes.

Thus, in general either Internal or external R&D, or both turned out to be significant. The first hypothesis (*H1*) that 'R&D activities, internal and external, provide a positive influence on producing all types of innovations is, therefore, supported.

HUMAN CAPITAL

Strong evidence from the results for 2008, 2010 and 2012 show that the second hypothesis is not supported. The second hypothesis (*H2*) is 'MSc or higher degree holders have a positive influence on innovation.' The variable, *Proportion of Master or higher degree holders* does not have positive association with producing innovation. There is no association between the *proportion of MSc or higher degree holders* and the production of any kind of innovation except in model C in *New or significantly improved production process* and *New to Firm product innovation* in both models in 2012 where they all show a negative association.

In chapter 3, education was identified as an important element for economic development but little role has been played by Korean universities in innovation and research (Pinheiro and Pillay, 2016, p. 159) although they satisfied the supply of large numbers of human capital demanded for rapid industrialisation. The finding from the empirical analysis is that the proportion of MSc or higher degree holders among permanent employees do not have significance in producing innovation. The reason for this could perhaps be explained by lack of absorptive capacity to realise technology transfer (Frenz, Michie and Oughton, 2004, p. 16).

The earlier discussion emphasised that human capital is one of the prerequisite resources affecting innovation and research staff is obviously an important human capital of firms in the innovation process (Szczepańska-Woszczyna, 2014). The results for 2008 support this in the case of product innovation including *new to market and new to firm product innovation*. *The proportion of research staff among permanent employees*, however, has a negative impact on process innovation except in the *new or significantly improved support activity process innovation* that does not show any relation.

In the case of 2010, a strong positive relationship can be found from product innovation including *new to market and new to firm product innovation* while a negative relationship is found for process innovation except in *new or significantly improved support activity* *process innovation* where there is no relation. This is positively associated with *significantly improved product innovation* and with *new to firm product innovation* in 2012 but does not have any association with *New product innovation* or with process innovation.

The results show a strong and positive association of *proportion of research staff among permanent employees* with innovation and the third hypothesis (*H3*) 'having staff especially devoted to research is necessary to drive innovation and therefore the *proportion of research staff among permanent employees* is expected to have a positive impact on product innovation' is supported.

PUBLIC POLICY

Tax relief for technology development, *Support for technology development and funding*, *Participation in government R&D project*, *Technical support from the government*, *Technology information provided by the government*, *Technicians and educational research*, *Procurement by the government or collective purchasing*, and *Marketing supported by the government* are the detailed supports provided by government.

From the results of 2008, we can see that public support has a positive association with product and process innovation except for the *new or significantly improved logistics* where there is no relation. For product innovation, only one of the public supports is associated with the innovations while *new to market* and *New to firm product innovation* is associated with more than two supports. *Support for technology development and funding* and *Procurement by the government or collective purchasing* are negatively associated with *new to market* and *new to firm product innovation* respectively. We can expect social benefits when knowledge spills over to other agents from the original conceiver of it as Nelson argued (1959) and this motivates the intervention from government by providing various supports including funding for research, procurement, etc. (Bonnyai, 2013).

In 2010, no public support impacted on *New product innovation* but *Tax relief for technology development* and *Procurement by the government or collective purchasing* have positive and negative impacts, respectively on *significantly improved product innovation*. Process innovations are all positively associated with public support, except *new or significantly improved logistics* where there is no relation, *Tax relief for technology development* while *new or significantly improved support activity* is also positively associated with *Technicians and educational research*. *New to market* and *new to firm product innovation* is positively associated with public support, *Marketing supported by the government*.

There is a positive association between *Participation in government R&D project* and *New product innovation,* and positive and negative association between *Technicians and educational research* and *Technical support from the government* and *significantly improved product innovation* respectively in 2012. Public supports provide a positive impact on Process innovation. *New to market product innovation* is positively associated with *Participation in government R&D project* and the number of public supports have an impact on *new to firm product innovation*. While *participation in government R&D project* is positive, *Technical support from the government* is negative.

In general, at least one of the public supports provided positive or sometimes negative association with innovation and therefore the fourth hypothesis (*H4*), 'the interaction between public and private sector is important in systems of innovation and therefore, public support provides a positive impact on innovation' is part supported.

COOPERATION

There is strong support for the fifth hypothesis (*H5*) that is 'cooperative activity with other institutes or firms in innovation activity has positive influence on innovation'. In all survey years, the hypothesis is strongly supported since *product*, *process*, *new to market* and *new to firm product innovation* are all positively associated with *cooperation* with other institutes and firms when carrying out innovation activity.

Based on this result we can agree with Liefner *et al.* (2006) that innovation is a process of interaction that leads to the development of a new product or process. Furthermore, this is supported by the importance of continuous cooperation among actors in the process of innovation that have been much emphasised in the interactive models of innovation (Kline and Rosenberg, 1986).

ACCESS TO INNOVATION FINANCE/FUNDS

Loans is positively associated with *New product innovation, Significantly improved product innovation, new or significantly improved production process innovation, new to firm product innovation* in 2008. *Government funding* provide positive relation with *New or significantly improved product innovation, new or significantly improved production process innovation, New to market and New to firm product innovation* while it has negative relation with *New or significantly improved support activity* in model A. *Internal finance is positively associated with new to firm product innovation*.

According to the 2010 results, *Loans* is positively associated with *New product innovation, significantly improved product innovation,* and *new or significantly improved production process.* We can find positive impact of *Internal Finance, Government Funding* and *Stock issues* on *new to market product innovation* while *Internal Finance* and *Loans* have a positive impact on *new to firm product innovation*.

In the case of 2012, there is no positive association between *access to innovation finance/funds with product innovation* or with *process innovation* except that *Loans* provide a positive impact on *new or significantly improved production process innovation. Government funding* provides negative impact on *significantly improved logistic process innovation.* We cannot see any support for the importance of *access to innovation finance/funds* on *new to market* and *new to firm product innovation* in 2012.

Except in few cases, the overall analysis suggests internal funds, loans are positively associated with innovation while government funding is sometimes negatively associated. The sixth hypothesis (*H6*) is 'having access to innovation finance/funds for innovation activities is important in production of innovation'. Finance is important in activities of firms and this can lead to economic growth and provide positive influence on innovation (Kim *et al.,* 2016; Wang, 2014), and the hypothesis is supported by the analysis.

REGIONS

Hypothesis 7 (*H7*) was 'Regional factors including local knowledge creation, diffusion and application, and cultural embeddedness influence innovation'. Regression analysis was carried out adding 15 regional dummy variables for the 16 regions (with one dropped as required) in models B and D. In no regression for any of the innovation types, did 'region' turn out to be significant. However, in several of the models 'region' was jointly significant. The lack of significance in some models is at odds with the analysis of the descriptive statistics in Chapter 6 where it could be seen that there was regional variation in types of innovation and innovation activities. One possible explanation for this could be that regional variation is already explained by all the other factors included in model A (without control), and C with (firm sizes as the control variable).

FIRM SIZE

In 2008 when firm sizes are entered as control variables, *firms with 10-49, 50-99 employees* provide negative impact in model C in *New product innovation* while *Firms with 300-499* provide positive impact on the innovation. *Firms with 10-49, 50-99, 100-299 employees* had negative impact in model C in *New or Significantly Improved production process.*

Firms with 10-49, 50-99, 100-299 employees have negative impact in model C in *New or significantly improved logistic process innovation* while *firms with over 500 employees have negative and positive impact in the innovation respectively. Firms with 10-49, 50-99 employees* are significant and negative while *firms with over 500 employees* are significant and positive in *New to firm product innovation.*

In 2010, *firms with 10-49 and 50-99 employees* have negative impact in *New product innovation. Firms with 10-49, 50-99,* and *over 500 employees* have negative impact in *New or Significantly Improved product innovation* as well. *Firms with 10-49 employees* have negative impact in *New or Significantly Improved production process innovation. Firms with 10-49, 50-99* and *100-299 employees* have negative impact while *firms with over 500 employees* have positive impact in *New or Significantly Improved logistics process innovation.*

Firms with 10-49 employees is negative and *firms with over 500 employees in model C* have positive impact in *New or significantly improved support activities process innovation.*

In the case of 2012, *firms with 50-99, 100-299 and over 500 employees* have a negative impact in *New or significantly improved product innovation. Firms with 100-299 employees provide positive impact in New or significantly improved support activities process innovation.*

In general, the results suggest the larger the firm size the more positively associated with innovation and therefore, hypothesis 8 (*H8*) 'Firm size influences innovation: larger firms find it easier to innovate, while smaller firms find it more difficult to innovate.' is supported.

Chapter 8

INDUSTRY CASE STUDIES

This chapter provides analysis and discussion of two industry case studies in order to shed light on non-quantifiable aspects of relationships between different innovation actors using data I collected during fieldwork in Korea in 2015.

Semi-structured interviews were carried out with key actors in universities, industry, and government. Analysis for these case studies has been conducted using the systems of innovation approach and the Triple Helix model as a framework (Etzkowitz and Leydesdorff, 1995). Together with the interview data, secondary data and qualitative information were also collected and these provide the basis for this study.

8.1 SELECTION OF INDUSTRIES

The industry case studies were drawn from different ends of the technological spectrum: one from high-technology industries and one from traditional or sunset industries. The games industry was chosen from the high technology sector. Developing games software is a knowledge intensive activity that forms part of the creative economy. The creative economy is built on the foundations of education, knowledge, creative works, and intellectual property which drive the creative economy. In this transformation period, creativity, and knowledge contribute towards competitive advantage and economic development. This is possible through generating creative assets (Kim, forthcoming).[40]

The process of development of the game can be viewed as a service sector activity but when the game is produced as a CD and goes on sale it can be considered as a manufactured product. For this reason, games software development and supply falls under the service sector within the Korea Standard Industry Code (KSIC) 582, however the physical production of material, such as CDs that include games falls under the manufacturing sector KSIC 182. Therefore, the choice of the games industry enables me to look at innovation that spans two sectors: services and manufacturing.

In contrast, the footwear industry was chosen to observe the interactive relationship of the innovation actors in a low-tech industry. The footwear industry falls within manufacturing industry KSIC 152 and is often viewed removed from concepts of

[40] http://t10.cgpublisher.com/proposals/298/index_html

innovation since it is a labour intensive traditional industry. In comparison with the high-tech games industry it provides an interesting case study of the nature and extent of innovation in a traditional sector.

8.2 HIGH TECH INDUSTRY – THE GAMES INDUSTRY

The importance of creative industries and their contribution to economic growth in the 21st century is widely recognised in both developed and developing countries. To compare Korea with other developed countries, I searched the case of the UK in terms of categorisation of the games industry. According to the 'Creative industries mapping documents 1998' produced by the UK Department for Digital, Culture, Media and Sport, creative industry fields include: advertising; antiques; architecture; crafts; design; fashion; film; music; performing arts; publishing; software; TV and radio; and leisure software (Gov.uk., 2017). Furthermore, employing the definition given by the Ministry of the Arts of the Australian Government that is 'creative industries possess their own originality in individual creativity, skill and talent'.

By looking into the classification of the games industry in the UK we find the same split between services and manufacturing as in Korea. The games industry is classified as UKSIC 58210 as part of the leisure software industry while the reproduction of recordings i.e. games on CDs are categorised as the UKSIC 18203. The overall industry characteristics and brief history of the industry will be reviewed and then the focus will shift to explore how the innovation activities are carried out.

8.2.1 The Games Industry in Seoul

The Games industry in Korea used to be considered one of the most competitive in the world (KERI, 2016) taking up 10.6% of the market size of Content industry[41] and 55.3% of the total Content exports (Park *et al.*, 2013). The number of games firms in 2009 was 30,533 but this had fallen to 14,440 by 2014. The number of employees in the games firms had, however, increased to more than double from 43,365 in 2009 to 87,281 in 2014.

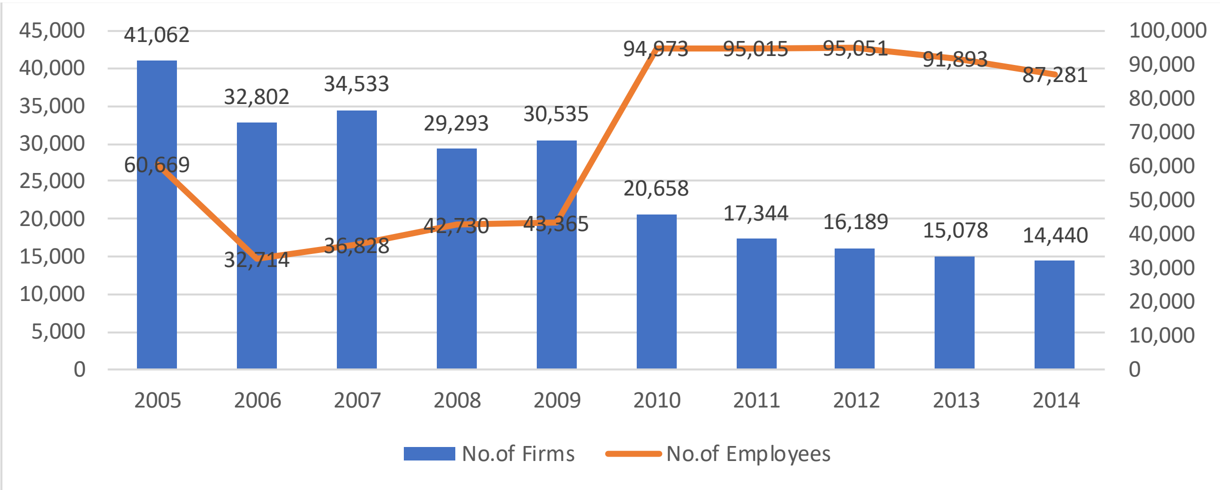
From Figure 8.1, we can see that the number of firms and the number of employees were not much different until 2009 indicating that there were many firms with only one or two staff. However, the number of games firms fell by more than half between 2009 and 2014. Games industry consolidation is observed in post 2010. A difficult business

[41] Contents industry include broadcasting, games, character, animation, and cartoon.

environment, including tough controls and regulations imposed on the industry, led to the survival of only the strong and healthy firms. The surviving firms hired increased numbers of employees among whom previous individual entrepreneurs were included.

Games firms that were previously concentrated in Seoul are currently being spread out to Kyunggi region. Kyunggi is now believed to be the number one region for the games industry. Seven of the top ten firms are in Kyunggi (Moon *et al.*, 2014, p. 6).

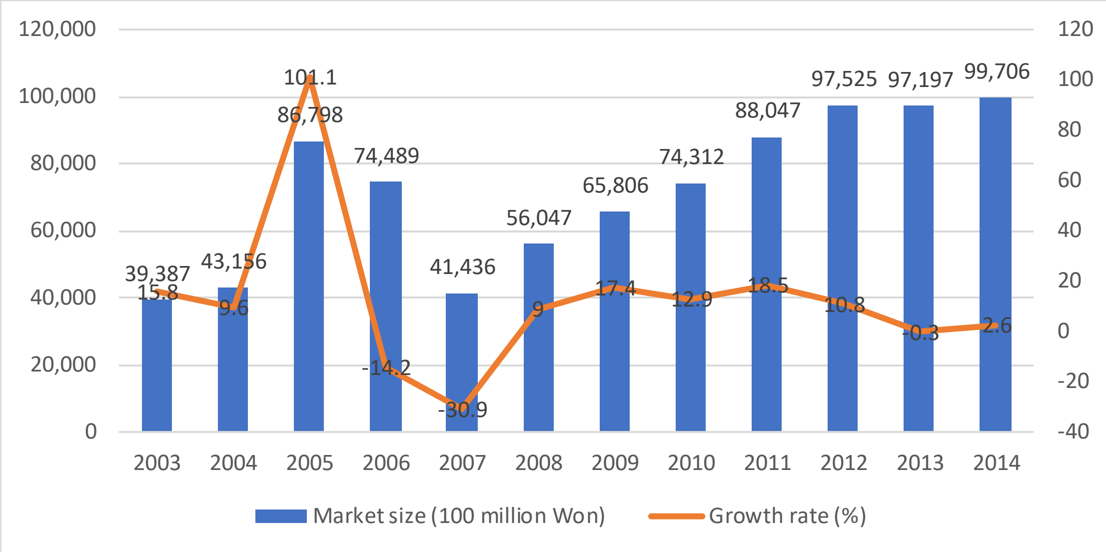
Figure 8.1 Number of games firms and employees



(Source: KOSISa)

As Figure 8.2 shows, the growth rate from 2004 in sales was 101.1% amounting to some 8,680,000,000,000 Korean Won in 2005 before falling dramatically by -30.9%, to 5,144,000,000,000 Korean Won in 2007. This was followed by a gradual increase to 2011 after which the growth rate turned negative in 2013 followed by positive growth in 2014.

Figure 8.2 The Korean Games Market – Size and the Growth Rate in Sales Revenue



(Source: KOSIS$_b$)

The reason for the huge decrease in the sales growth rate in 2007 springs from the case of the 'Bada Story' after which an extremely thorough review system of adult games was introduced. Since 2001, the government promoted the games industry and allowed gift vouchers to be used as awards of games for adults. This attracted more and more people to gambling through games. The situation reached a peak when the 'Bada Story' game was introduced in 2006. The Bada story is an adult game that was installed in arcades and encouraged a large number of adults to engage in gambling (MSCT and KOCCA, 2008).

According to Korean Gambling law, since the review, Korean citizens are strictly forbidden to gamble both inside and outside of the country. Foreigners, however, do not have any restrictions in gambling in any legally established casinos in Korea according to the Tourism Promotion Law (Ministry of Government Legislation).

As a consequence, the market size in sales for the adult arcades games sector had fallen by 95% by the end of 2007 (KOCCA publication). During the same period, however, PC rooms and video games rooms increased their sales by 11.6% and 6.2% respectively (KOCCA[42], 2010).

In terms of government policy, improvement in the industry required regulation. Out of the many controls and regulations related to the games industry, one of the most

[42] Korea Creative Content Agency

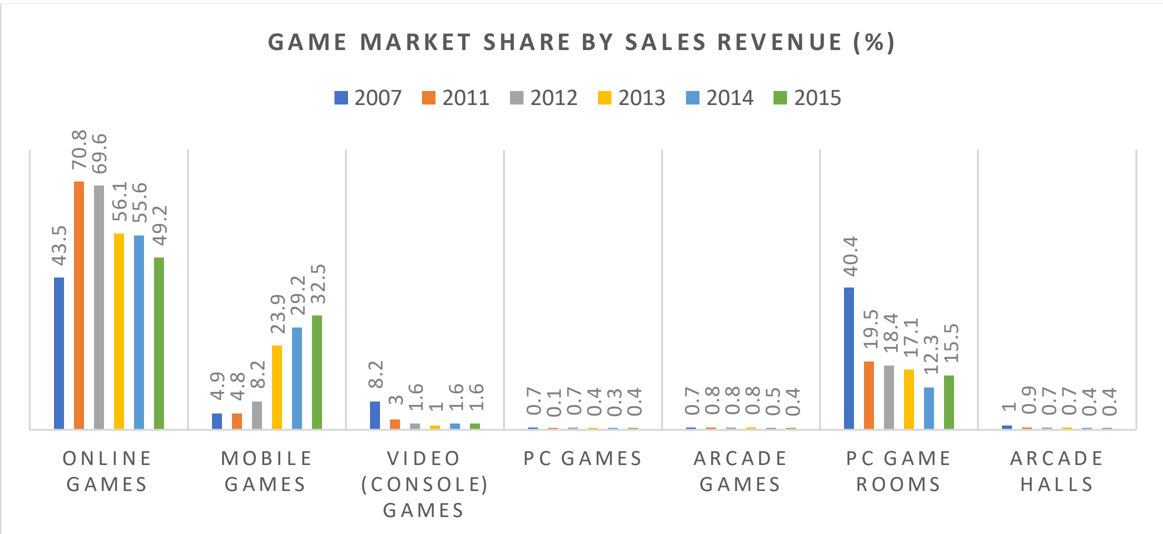
influential was the 'Shutdown system' that was introduced by the Ministry of Gender Equality and Family in November 2011 in an effort to protect young people from addiction to games. Under this regulation no youth under 16 can play games after 22.00 hours until 7.00 hours the next day (Park *et al.*, 2013).

Another influential restriction in the game industry, the 'Law on the Promotion of the Game Industry' was announced by the Ministry of Culture, Sports and Tourism in June, 2012, prohibiting the trading of games money, and games items.

Throughout this transformation, an increasing number of online games firms abandoned their online business. Some firms expanded their business to other areas unrelated to games, reducing their online games business to a minimum. This phenomenon was affected by the rapid expansion of the Chinese mobile games market (Lee, 2014).

Figure 8.3 illustrates how the market share of different segments of the games industry has been changing. The most notable phenomenon is that while the share of online games and PC games fell from 70.8% in 2008 to 49.2% in 2015, the share of mobile games increased by more than six fold from 4.9% in 2007 to 32.5% in 2015.

Figure 8.3 Game Market Share by Sales Revenue between 2007 and 2014



(source: compiled using White Paper on Korean Games 2008, 2012, 2013, 2014, 2015, and 2016)

Since the saturation of the mobile games market and the domination by larger firms in Korea, medium sized firms adopted the Global One Build strategy[43] to be sustainable in securing a user database to underpin the success of their games (White paper, 2015). The games industry has been prospering even with the restrictions and regulations imposed. What lies behind the development of the games industry and the role of innovation is discussed below.

The following discussion is based on information collected through interviews I carried out during fieldwork in 2015 as mentioned in Chapter 4.1.1. After identifying relevant people in government, universities and industry through searches and recommendations, semi-structured interviews were conducted with official A in STEPI, B and C in KOCCA and D in KISTEP at the government level; Professor A in university A, Professor B in university B at the university level; CEO A in games firm A. All interviews were held in the offices of interviewees and each interview lasted for around 2 hours.

PUBLIC SUPPORT

In order to get an insight into public support in the games industry, I interviewed officials B and C from KOCCA[44] and D from KISTEP[45] individually.

The following paragraphs describe public policy in the games industry using information obtained from an interview with official D at the Korea Institute of S&T Evaluation and Planning (KISTEP) where the policies related to science and technology research are decided. The policies are set after numerous meetings and investigations including surveys collecting information on the current situation and needs of firms in the industry.

There are supporting government organisations for small and medium-sized firms. Medium-sized firms with their own brands are supported by the Ministry of Trade, Industry and Energy and smaller sized firms are supported by the Small and Medium Business Agency.

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[43] According to this strategy, local and international users are able to play games as they are released simultaneously in the international market and the Korean market.

[44] Interview (No. 2) with B held on 27th March 2015 at 2 pm in KOCCA, Main office, Seoul
Interview (No. 3) with C held on 7th April 2015 at 5 pm in KOCCA, Yeoksam branch office, Seoul

[45] Interview (No. 4) with D held on 9th April 2015 at 3 pm in KISTEP, Seocho-Gu, Seoul

Unbalanced economic development in Korea has been an issue and the Ministry of Trade, Industry and Energy thus promoted co-operation projects between regions, and support to strengthen an industry in each region over the last 15 years. The capital which is already well developed is excluded from this project because the main idea behind this project is balancing economic development throughout the country.

In 2014, the Ministry of Science, ICT and Future Planning introduced a policy to establish Creative Innovation Centres (CICs). Consequently 18 centres were established in 17 cities and provinces between September 2014 and July 2015 (Creative Korea). The first centre was opened in Daegu in September 2014 and the last one opened in Ulsan in July 2015. CIC is designed to provide a one-stop service to all firms that require assistance, including on R&D activities. Firms can approach CIC with whatever query they have and the staff direct the enquirer to the right point of contact. CIC itself is, however, more focused on start-ups.

Furthermore, the Small and Medium Business Agency and Techno Parks are present in each region and these organisations work in collaboration with the CIC. The central government is deliberately trying to encourage regional government, universities, and firms to work together by introducing different kinds of open contests, including contests for new content ideas (discussed in more detail below).

Although regional governments gained much autonomy following the regionalisation in 1995 according to the Presidential Decree of the Local Autonomy Act No. 14703 (Korea Legislation Research Institute), the power of central government remains very strong. I believe that an effort to make regional government more autonomous is needed for stronger regional development to promote regional convergence.

According to official B from KOCCA, the Korea Creative Content Agency (KOCCA) plays a critical role when it comes to public support for the games industry. KOCCA is a sub division of the Ministry of Culture, Sports and Tourism in Korea (MCST). MCST promotes all areas of the media 'content' industry including broadcasting, games, character[46], animation, and cartoon. The agency executes government policy for the content industry so that as many firms as possible in the industry benefit.[47]

These correspond to the argument by Oughton *et al.* (2002) that grant-based incentives for R&D are important due to well-known market failures in R&D and innovation. This is especially the case for smaller firms and for first-time innovators as well as for firms located in the rural areas.

In order to enhance the level of export growth, KOCCA provides necessary infrastructure, marketing support and so on, which enables domestic games firms to serve overseas users. KOCCA supports the annual international games exhibition, G-Star, that takes place in Busan through which firms can strengthen their international business network between home and abroad.

Through official open contests for new content ideas, KOCCA together with specialists in the area select the best ideas from firms, excluding large firms, and provide funds to the successful contestants. Firms are assessed after the agreed contractual period to ensure appropriate use of funds. The main intention of this policy is to transform small and medium-sized 'weak' firms into small and medium-sized 'strong' firms. KOCCA allocated a budget of approximately 187,200 million Korean won to cover several hundred content contests.

When small firms are involved in disputes with other firms or customers, Dispute Resolution Committees are in place under KOCCA to offer legal advice and provide government employed solicitors when necessary. Together with provision of funds and infrastructure, KOCCA also promotes development of creative human capital through a one-to-one mentoring service. KOCCA select mentors and mentees based on proposals under their 'Mentor training Mentees' project. When selected, mentor and mentees receive monthly allowances to facilitate the training. Around 200 mentees are trained annually through this project.

SMEs receive tax relief for employees under 30 years old and the government provides the employees with a reduction or exemption in income tax and residents' tax. Another

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[46] An animated figure is the figure appearing in animation i.e. Pokemon, Wallace & Gromit etc. that can be used in commercialising the character such as cell phone accessories.

[47] The health (financial and organisational) of the firm/organisation, proposal (creativity and innovativeness, possibility of realisation) and capability of the people who will be involved in the project are the main criteria of KOCCA when awarding the funding.

benefit available from the government is that if a firm recruits a person who is registered with the Job Centre, the government pays a portion of this person's salary. In addition, the government introduced a scheme to encourage firms to employ postgraduates by bearing part of the salary when a firm employs postgraduates. Firms have to retain them in employment for over a certain period of time, i.e. 6 months.

SME INNOVATION

There is a number of large game firms, such as Nexon, NCSOFT, Net Marble in the games industry, but I selected a small games firm with less than 30 employees with the intention of attaining insight into innovation in firms with less internal resources or innovation production. The games firm I visited is a member firm of the Online Game Industry Association. Rather than receiving benefits from the association, the member firms pay fees to keep the association alive so that they can raise a collective voice when necessary.

The CEO of the firm[48] I visited and interviewed explained that the games industry is negatively perceived in the country due to addictiveness and game-related critical incidents, and as a result the government is unsure whether to encourage or discourage the industry via regulation. This perceived ambivalent attitude of government has encouraged firms to distrust government policy towards the games industry. The perception is that there are too many restrictions imposed on the industry at present.

In the case of this particular firm, the sound part of the games programme is 100 percent outsourced while game planning, programming, concept design, 3D characters, user interface, animation, and effects are all performed within the firm. Development is carried out by the firm, publishing by a partner firm and all technical issues are handled within the firm itself. This firm was not in receipt of any benefit from the government at the time of my visit and the CEO claimed that most games firms the size of his are in a similar situation.

Every procedure of games development has to be done by people and almost 100% of the expenditure of the games firm is allocated to employees' salaries, thus the games industry can be seen as a modern labour intensive industry. The firm, therefore tends to recruit experienced staff to improve efficiency owing to the characteristics of this fast moving

[48] Interview with A (No. 7) held on 27th March 2015 at 4:30 pm in his office in Digital Industrial Cluster, Seoul

industry. When new graduates are employed, however, the firm offers training under the supervision of a team leader.

UNIVERSITIES AND HUMAN CAPITAL

Professor A[49] from the postgraduate school of Game Studies in University A claims that the presence of a games cluster is important in boosting the industry and submitted the proposal of the Game Industry Cluster, G2I2, to the government. The proposal was accepted in 2015 and the government is seeking an appropriate location for it to be built. Professor A argues that five elements, Academy, Business centre, R&D, Funding and Interactive museum are essential for the proposed cluster model.

Although many regions claim that their region is best suited for the cluster Professor A argues that having sufficient funding or land does not mean the cluster will be successful, rather he emphasised that it is human capital that is the key to successful realisation of the plan. Currently, there is insufficient human capital in the industry. The lack of teachers and lecturers in games studies is a significant weakness affecting the industry.

Seminars and Cyber academies are tools employed by firms to develop human capital. An example is the Founders Course which is run by universities to educate founders in relation to setting up a firm. Too nurture creative designers and other human capital that have the capacity to advance technology development, Korean universities, academies and international universities are linked together. Overall, the Korean government has invested approximately 8,190 million Korean won budgets to spend each year in developing human capital in the contents industry.

KOCCA introduced the Link Project to provide funds to universities to create departments designed to train students to meet the particular needs of participating firms so that when they graduate they will be equipped with all the necessary skills firms require. By announcing an open contest, it supports universities to develop joint curricula of two subjects e.g. art plus technology for students to be educated in creative and practical elements that are relevant for the games industry. In 2015, out of many universities that submitted applications for the contest, 12 universities were funded through this particular project. There are about 5,000 appraisers specialised in different areas with whom KOCCA work when they select successful applicants for the open

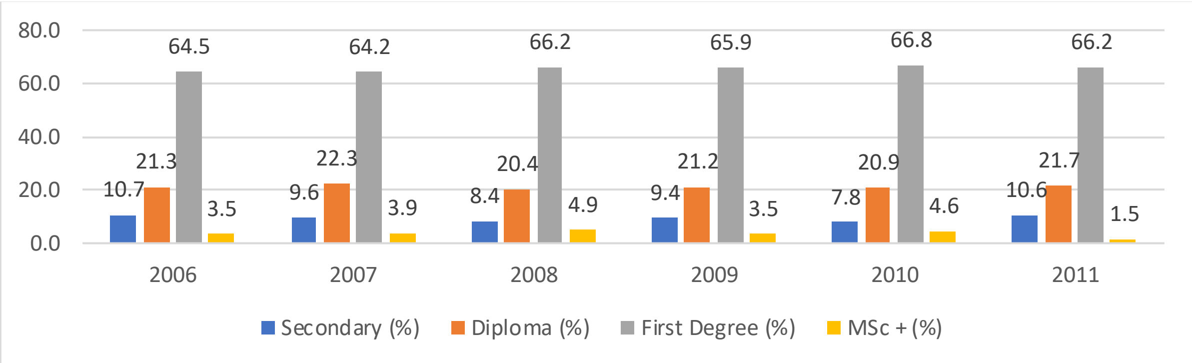
[49] Interview with A (No. 5) held on 25th March 2015 at 4:30 in his office in the university, Seoul

contests. Professor A claims that a good government funding system is critical in training students to be equipped with the skills required by the industry.

In an effort to enhance the level of employment opportunities, university B in Seoul arranges internships for all students in the department and professors visit firms to monitor the progress of students. Students are encouraged to create their own games programme and firms evaluate them and decide whether or not to recruit the students at the end of the intern period.

Often the CEOs of games firms are invited as judges for a Graduation Game Programme Exhibition held by each university before graduation. Students exhibit the games programme they developed and CEOs of games firms often select students for their internship based on the quality of the games programme. As Figure 8.4 shows, the proportion of employees with a Masters or higher degree is very low while diploma and first degree holders make up over 85% of total employees in all years. It can be seen that Masters level education is not significant in the games industry yet due to the nature of the industry researchers (programmers) seem essential.

Figure 8.4 Percentages of Employees' Academic Background out of the Total Employees in Games Firms



(Source: KOSIS)

According to a CEO of the games firm I visited in Seoul, games firms are usually contacted by universities seeking co-operation. The firms offer internship places to students and also visit universities to provide seminars on the most recent working knowledge of the industry.

R&D and COOPERATION

Firms need well-qualified and trained staff for productive outcomes that lead to the growth of the firm; universities have been fulfilling this role over a long period. It is common for universities in Korea to carry out R&D in co-operation with both government and firms. For example, in 2013, Professor B[50] from the Department of Multimedia Engineering where computer games is taught as an application in university B in Seoul, was selected by the Ministry of Science, ICT and Future Planning to run the Platform Information Technology Research Centre funded by the government. The research includes the Natural User Interface (NUI) and Natural User Experience (NUX) which are both projects within the university funded initially for 3 years with an additional 2 years depending on the outcome.

Together with this Department, joint R&D is taking place between the Games Architecture and Multi-media Applications laboratory, Intelligent Game Engine laboratory etc, in the university. In depth games-related curricula and the presence of various laboratories provides an environment conducive to human capital development and training to supply suitably qualified graduates to work in the games industry after graduation.

Cooperation between firms and universities in terms of knowledge spillovers take place. As Powell (1998) has agreed, collaboration between firms and universities in R&D in technology intensive industries provide a resource as well as a signal to markets that the firm has the capability for quality activities and products. Games firms often approach the university to introduce and sell their game engine[51] and if the engine is purchased by the university, the firm provides the school with related seminars and training thus providing an extra source of knowledge accumulation.

In the same vein, sometimes the university invites influential people in the industry to offer seminars and workshops to students and staff to enable them to catch up with the most up-to-date knowledge on the technologies utilised in the field.

Government financial support peaked between 2005 and 2007. This support has spread throughout the 'content' industry. During this period, the Department in University B incubated a games firm. This is consistent with the argument by many including Griliches (1986, 1995), Rosenberg (1990), Beise and Stahl (1999), Stiglitz and Wallsten (1999) that public support in terms of public investment provides a positive influence on private R&D

[50] Interview (No. 6) with held on 25th March 2015 at 2pm in her office in the university, Seoul

[51] Game engine is used to lay the software framework so that computer or video games can be built and created. Game engines provide the games developers with tools to create gaming applications. These engines can be reused to create other games therefore making it a valuable investment.

activity and potentially on business performance. Following the critical incidents related to gambling such as the Bada story in Korea mentioned earlier, however, support for the games industry from the public and government decreased.

Professor A[52] from University A stated that on occasions government and SMEs co-finance a department in a university with the intention of recruiting well qualified graduates from the department to firms. Well qualified graduates from high ranking universities, however, prefer to go to big firms rather than SMEs. Professor A argues that this kind of co-work between government and SMEs would be more suitable for universities in regional cities rather than Seoul and surrounding regions.

Through Link Projects, government funded projects that involve cooperation between universities and firms are encouraged. In the application stages, usually firms look for well-known professors in the games industry and approach them to ask for help in designing proposals to compete in an open contest when government announces a new Link Project. Firms treat successful past R&D history of universities as important in this process since their trust is based on the past achievements of the university. If the application is successful, a wider team to carry out the project is formed including students. When deciding which students to take on board for a Link Project, the partner firm for the project sends HR staff to interview applicants in conjunction with the university.

Furthermore, the Small and Medium Business Agency (SMBA) also plays an important role in driving SME-led innovation in each region. Again, a good proposal and a creative idea is vital for firms to obtain funds from SMBA.

As Etzkowitz *et al.* (2000) identified, universities can play an important role in technological innovation and provide cost effectiveness and creativity as well as playing a key role as transfer agent of knowledge and technology. Likewise, universities in Korea work closely with games firms in the field and the Games department of University A works with six game firms. Games firms produce games software while the university performs Quality Assurance tests. In the case of functional games, games firms liaise with relevant industries such as medical equipment firms[53], teaching academies etc. New curricula are introduced in response to fast changing industry needs.

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[52] Interview (No. 5) with A was held on 25th March at 4:30 pm in his office in the university, Seoul

[53] Games that are specially programmed to aid the treatment of patients

Cooperation among games firms takes place within the Korea Mobile Games Association, the Korea Internet & Digital Entertainment Association, and the Korea Wireless Internet Content Association. The Korea Wireless Internet Content Association encompasses four 'content' associations: cartoons; games; music; and publications. The Korea Mobile Games Association[54] represents small and medium-sized mobile firms specialised in mobile technology in order to help revitalise the Korean games industry after the downturn as shown in Table 8.2. The Korea Mobile Games Association was founded to represent the voice of small and medium-sized games firms since the existing Korea Wireless Internet Content Association failed to do so (MCST and KOCCA, 2015).

The Korea Internet & Digital Entertainment Association focuses on making G-STAR, the biggest games show in Korea, to reflect the shift of the games market into mobile games adding a fun factor for visitors and attracting international games firms to the show. In 2015, the Korea Mobile Games Association and the Korea Internet & Digital Entertainment Association agreed to cooperate in various joint projects with regard to games related policies and regulations (MCST and KOCCA, 2015) to help further development of the industry.

[54] Spin off association from the Korea Wireless Internet Content Association

8.3 A CASE STUDY OF THE KOREAN FOOTWEAR INDUSTRY IN BUSAN

The following discussion is based on information collected through interviews I carried out during fieldwork in 2015 as mentioned in Chapter 4.1.1. Semi-structured interviews were conducted with official A in FIPC and B in KFIA at the government level; Professor A in university C, Professor A in university D and Professor C in university E at the university level; a member of staff A in footwear firm A. in Busan. All interviews were held in the offices of interviewees and each interview lasted for around 1/2 to 2 hours.

The footwear industry was first developed in the 1920s with influence from Japan but only from the 1940s did the footwear industry consolidate its presence in the country. The Korean War in 1950 forced many footwear firms in other cities to close however Busan produced military boots and production survived during the war. In the 1960s a high proportion of footwear products were imported from Japan on OEM[55] basis but production switched to Korea to take advantage of lower labour costs.

An official B[56] from the Korea Footwear Industries Association (KFIA) explained that Busan became the heart of the Korean footwear industry from the mid-1970s until the late 1980s and around 80% of the world's well-known brands of footwear were produced through OEM in Busan with the remaining 20% produced in Taiwan and China.

8.3.1 Footwear Industry in Busan

The footwear industry made a huge contribution to the Korean economy between 1970 and 1980 mainly through exports. While shoemaking techniques have been gradually upgraded over time, large firms, such as Taehwa, Samhwa and Kukje had to close down due to changes in the business environment. Labour costs in Korea increased in the 1990s and this influence was felt throughout the industry when production shifted abroad.

Figure 8.5 shows a large fall in total production between 1990 and 2000 with production falling by more than 50 per cent. The industry experienced a further decline from 2000

[55] OEM (Original Equipment Manufacturer): A firm produces a product which is then sold to other firms to be sold under their own name or brand

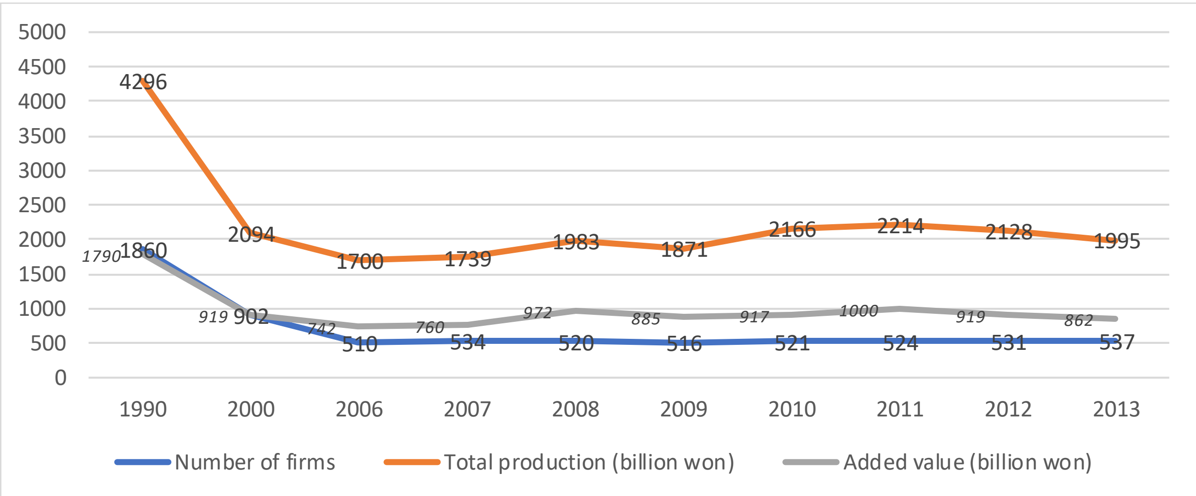
[56] Interview (No. 9) with B was held on 31st March at 12:00 pm in the office in Noksan Industrial Cluster, Busan

until 2006 followed by low but steady growth until 2011 and then a slight drop between 2012 and 2013. The number of footwear firms[57] fell from 1860 in 1990 to 902 firms in 2000 and then to 510 in 2006. The number of existing firms remained fairly constant between 2006 and 2013.

The industry could revive its production level based on the production techniques they accumulated over the past several decades and by moving the production lines abroad where cheap labour is available, leaving their headquarters mainly in Busan. Planning and marketing is done in Busan but the production now takes place overseas, mainly in China, Vietnam and Indonesia. Around 50% of footwear firms in the whole of Korea are located in Busan (KFIA, 2015). Changshin (Nike), Taekwang (Nike), and Hawseung (Adidas and Le Caf) are currently amongst the large firms operating in the industry.

The footwear industry went through a difficult period between 1990 and 2006 but has been reviving (KFIA, 2015). Innovation activity in the footwear industry is examined in the following discussion.

Figure 8.5 Footwear Market in Korea



(FIPC, 2007 & 2015)

PUBLIC POLICY AND SUPPORT

Almost all the interviewees in the footwear industry I met during my fieldwork claimed that footwear is no longer a low tech industry since each step of the shoe making process requires significant use of technology. Marketing is also very important. Korean firms

[57] Firms with more than 10 employees

possess world standard technologies but have limited funds for marketing compared to world leading footwear firms, such as Nike and Adidas. According to the official A[58] from the Footwear Industrial Promotion Centre (FIPC), the FIPC assists firms in their global marketing but this is not sufficient for the firms to gain international brand awareness against well-known international brands that allocate large amounts of money to marketing and advertising.

Official B explained that the Korea Footwear Industries Association (KFIA), the KFIA helps in promoting and advocating the needs of the industry, including making the case for the attainment of budgets from central government. The association gathers as many firms' voices as possible to help demonstrate the need for government funding. The association has about 162 member firms out of 1,400 (mostly small in size) throughout Korea.

In response to the difficulties the industry faced, the Korean government established the Korea Institute of Footwear and Leather Technology (KIFLT) in 1987 to carry out national level footwear R&D.

The government also opened the Busan industrial science high school and designated Kyoungnam College of Information and Technology (KCIT) to offer footwear engineering courses in 1998. KCIT was established with government funding and both of these schools have proved very successful in providing high quality footwear education.

Another example of public support to revive the industry can be found from the fact that the central government and Busan metropolitan city jointly established the Footwear Industrial Promotion Centre (FIPC) to support footwear firms in 2004.

The purpose of FIPC is to support the early stages of business such as establishing a concept, product design and marketing. For the development stage, the centre is equipped with expensive machinery for firms who cannot afford to purchase such equipment to come and utilise them. At the beginning of every year the centre contacts each firm to identify their needs and to try and fulfil them as far as possible.

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[58] Interview (No. 8) with A was held on 31st March 2015 at 10:20 am in his office in Noksan Industrial Cluster, Busan

FIPC realise there is lack of trust among key actors in the footwear industry. In an effort to enhance the level of trust among firms, universities and government the 'Shoenet.org' website was established in order to share information on all aspects of the industry.

When small firms have an idea of a particular type of shoe but lack the necessary technology, they approach the FIPC to make a pair of shoes based on their idea bearing the expenses involved themselves. The centre assists the firm to draw up a business plan to apply for funding from central government. In 2014, for example, the centre was involved in around 20 - 30 projects of this nature.

In 2008, the central government introduced a footwear luxury-branding project as another means of promoting the industry. Five firms each year are selected through open competition to receive government funding. This provides firms with encouragement and motivation to generate creative and innovative ideas. Footwear specialists invited for the selection process include a designer, a footwear performance appraiser, officials from KIFLT and FIPC, and a staff member from the Busan economy promotion agency.

Recently, luxury branding and shoes produced with smart technology have become more popular. However, there is still a tendency for people to look down on the footwear industry as it used to be a labour intensive industry based on an OEM production system. As well as production/process technologies, information technology (IT) and biotechnology (BT) is being used to upgrade the industry. Process innovation includes automated production which can be located even in cities where the price of land and rents of building spaces are high. According to footwear professionals, design is still considered to lag behind that of advanced countries, and firms that require assistance with designing footwear collaborate with the Korea Design Promotion Agency.

Furthermore, when a firm has a new idea some firms approach universities as mentioned earlier but others approach FIPC which assists with the preparation of the proposal and its submission to the central government for funding. If successful, government provides R&D funding to the firm. When it comes to a mega project, the KIFLT and universities work together. Financial assistance can be given through application to the Busan Economy Promotion Agency (BEPA) or Busan Small and Medium Business Agency (BSMBA).

Approximately 189 Korean footwear firms in Indonesia have automated production lines and professors in the footwear field persuade small-sized footwear firms to learn about automating production lines. Realisation of automation of production lines is critical especially when labour costs are high and professors in the footwear field in the universities, the KFIA, FIPC, and firms campaign for funding for automation to central government.

A good example is a Korean firm operating in Indonesia that developed robots to undertake footwear production. This enabled the firm to be extremely competitive in terms of reducing production time and the quality of the products they produce as well as lowering production costs including labour costs. Through this process innovation the firm was able to attract many more production deals with large international firms.

To encourage universities in non-capital regions, the Ministry of Education introduced Brain Korea (BK). The government holds open competitions for universities to submit proposals for innovation to help develop industries in their regions. University E in Busan was one of the successful universities to attain grants from this scheme/policy. Four projects were awarded grants and three of them are for the funding of 243 million Korean won per year for three years. The fourth project – the Footwear Specialisation Project - attained funding of 812.5 million Korean won per year for five years.

Large firms such as Taekwang, Changsin, and Hwaseung are all based on OEM production for Nike, Adidas, and New Balance. Changshin, for example, has 650 employees in Busan but has 10,000 employees in Chingtao, China, 10,000 employees in Jakarta, Indonesia, and 25,000 employees in Vietnam. Even with this many employees the firm lacks appropriately qualified people at the managerial level. Professor C from University E in Busan explains that with the globalisation of production and sales there is a need for managers who have good communication and marketing skills, including fluency in English.

The government funded Noksan Footwear Industrial cluster in Busan opened in 2016. The cluster is designed to attract foreign footwear buyers attracted by its automated production lines utilising advanced technology, R&D facilities and world class infra-structure. Firms that relocated their production lines abroad will be and are bringing their lines back to Korea and this will create employment which will generate further positive effects, including growth of the local economy.

The government offers various incentives to firms to bring their production lines back to Korea, such as financial support, tax reduction, better tariffs, and so on. Furthermore, the government selects leading firms in strategic industrial areas every two years and if a firm is selected they are provided with many supports such as tax relief, low interest loans or funding etc. to encourage firms in the industry to improve so that they can get a better chance to be chosen in future.

TERTIARY EDUCATION AND HUMAN CAPITAL

The Kyungnam College of Information and Technology (KCIT) was chosen for my case since this was the very first college to open a Footwear Engineering Department (FED) to produce shoe experts in an effort by the central government to revive the industry in 1998.

The FED runs a two-year course that boasts high employment rates and co-operation between firms and the college. Many second year students chosen by firms are trained in the firm during the day and attend evening lectures in the college. They become permanent employees at the firm as soon as they graduate.

A member of Staff A[59] in the footwear firm A in Busan I interviewed during a visit to the company was a graduate of Kyoungnam College of Information and Technology. There are many opportunities to gain training or go on overseas study visits facilitated by universities, local government and also firms who have been granted government funding. The Footwear Industrial Promotion Centre (FIPC) offers various education and training programmes to current employees. Trainers and trainees are mostly working during the day and therefore training takes place in the evenings. When small firms develop new types of shoes, the Footwear Industrial Promotion Centre (FIPC) provides performance appraisal of the shoes.

In addition to professors who are specialised in the footwear industry giving lectures at the college, footwear professionals in the field and relevant civil servants are invited regularly to offer seminars on the most recent technologies, trends and industry regulations. To help students gain hands-on knowledge from the beginning of the course, the college has put together an entire shoe production line in the laboratory.

The Kyoungnam College of Information and Technology uses college holidays for student placement periods in the footwear firms. Firms cooperate in this programme bearing the costs of training students and, in return, the college provides firms with the

[59] Interview (No. 13) with A was held on 2nd April 2015 at 3:00 pm in a computer room in the company in Jin-gu, Busan

use of expensive test facilities and shoe development equipment in their laboratory. Mutually beneficial cooperation is therefore a key feature of this scheme.

While professionals in the footwear industry visit footwear related departments in college/university to deliver seminars, college/university professors also visit firms to update them with the current state of footwear industry technology and encourage them to adapt and innovate. In addition, the footwear association and college/university professors carry out advocacy work to make Members of Parliament aware of poor policies in place in the footwear industry and encourage them to make policy reforms.

A common misperception that the footwear industry is low tech makes students reluctant to choose the subject as their major. Another weakness is that professors and lecturers teaching in the universities have limited knowledge of near-market aspects of the footwear industry.

Professor A [60] from Kyoungnam College of Information and Technology (KCIT) explained that it was innovative to create a department that is purely geared towards the industry. While the majority of other universities approach the industry academically, KCIT offers a more vocational-oriented approach and almost 100% of the students from this department achieve employment even though the national unemployment rate for between 15 and 29 year olds was approaching almost 11.1% as of 2015 (KOSIS). [61]

Around 180 well-trained students per year graduate from Busan Industrial Science High School which was established specifically for the footwear industry. Unfortunately, as mentioned above, due to misperceptions of the footwear industry, only academically worse off students enter the school. There is an urgent need to propagate the fact that the shoe industry is now involved with high technologies, bio-technologies, and sophisticated design to attract high calibre students into the industry.

A similar phenomenon arises in footwear firms. The current misperception of the footwear industry based on its status during the period 1970-80 when it was relatively low tech, has arguably made well-educated people reluctant to seek careers in the industry. There is an increasing need for well qualified personnel who can communicate with their

[60] Interview (No. 10) with A held on 1st April 2015 at 11 am in his office in the college, Busan
[61] Accessed on 2 May 2017

foreign counterparts in English. As a participant in Brain Korea project, University E[62] in Busan aims to train students and to equip them with skills that meet firms' needs.

Using the funds that the university received through the project, they introduced the Footwear Young Lions (FYLs) programme with the aim of making graduates from the course recognised as well educated and trained to start working in the industry. The three core objectives of the course are training in English fluency, special knowledge in Global Business Studies, and Fashion Studies.

Excellent students are offered opportunities for internships and recommended for vacancies in well-performing firms. During term time, selected students are sent to overseas shoe firms for study tours. Through this course, students are expected to change their perception of the industry and become more enthusiastic in beginning their career.

The local government who obtained the budget from central government also supports professors and researchers by funding study visits to advanced countries for knowledge exchange. They then share this with other firms in the industry in Korea to maximise the effect.

In the past local government tended to focus on developing new industries in order to get more funding from central government but due to increasing unemployment this tendency is changing. Now, local governments try to promote traditional industries, such as footwear in the case of Busan via the application of technology, human capital and design so that the region can reduce its unemployment rate.

New ideas in footwear such as developing smart shoes using electric energy that is generated by movement from walking is a trend in Korea. A Creative Innovation Centre (CIC) was established in each region linking the regional traditional industry and a large firm, e.g. the large firm 'Lotte' is appointed as partner firm of Busan to assist in the promotion and boost of the representative traditional industries, footwear and fishcake.

[62] Interviewed (No. 11) B on 2nd April 2015 at 9.30 am in the Footwear Young Lions Project conference room in the university E, Busan

FUNDING OF R&D

Footwear firms carry out their own R&D but they can also seek financial assistance through the Small and Medium Business Administration, Korea Technology Finance Corporation if they have innovative technology or creative ideas requiring further R&D.

A significant amount of R&D for the footwear industry takes place nationally at KIFLT. Ideally, when the KIFLT develops a new technology they should share the knowledge openly since the institute is government owned but in reality they own the intellectual property and small firms have to pay to access them. This results in limited knowledge spillovers.

The existing dilemma related to this is that if the government asks them to share the results in the public domain the researchers will not work hard to develop a new technology. Hence, the government allowed individual researchers in the institute to hold patent rights for their research results to encourage more active research.

The government regularly announces R&D projects, firms apply and sometimes universities and institutes approach firms to do the projects jointly. Most small firms have very limited provision for R&D and research staff cannot fully concentrate on research as they are involved in other tasks.

The current central government is investing heavily in R&D. One concern is that some of the funds earmarked for R&D may be spent on other operations, which is not permitted. To the extent that this is a problem, there is a need for tight oversight/auditing of government-funded projects.

Once new footwear products and processes are developed they need to be tested by the footwear performance appraisal committee which consists of professors, doctors, and specialists from many other fields and the university helps firms to use the test results in their marketing.

In 2014, the central government approved a budget of approximately 12,220 million Korean won for a five-year project to establish a standardised Appraisal/Evaluation system for newly developed footwear product and processes for the footwear industry to utilise. On completion of the first year of the five-year project in 2016, Korea Human Performance Laboratory (KHPL) was opened which has similar facilities to world-famous footwear R&D centres like Nike's R&D centre in Calgary. Evaluation and appraisal of new footwear products will be carried out in this laboratory (Busan Economic Promotion Agecy).

Some firms and universities cooperate on joint R&D projects. Firms work with relevant research institutes when they develop new technologies. When government first began investing in R&D, firms did not recognise the need for new technology development but now most firms realise its importance. However, there is generally a lack of co-operation between firms in sharing 'knowledge' and this has to be improved.

With new funding from the government, the 'K-Shoes Business Centre' is going to be built. This centre will be used as a meeting place for footwear business with domestic/foreign buyers, product launching presentation etc. The centre will also house a footwear industry museum, footwear promotion centre, and footwear engineering training centre. Many boroughs of Busan campaigned to have it in their borough, but it will be opened in Busan Jin-Gu which was the heart of the shoe industry in the 1970s and 80s. This building will symbolise footwear as the main industry of Busan.

COOPERATION

Fashionable and functional design that has been added to the present technology in moulding, materials and, colouring, has been developed since the 1970s and 80s and has enabled the Korean footwear industry to position itself at the top of the 'league'.

The Korean footwear industry has mass production capability. A large number of stages are involved in the production of one pair of shoes from blue print design to manufacture and sale. Many firms have their own partner design firm. Some firms use overseas design firms to meet world-class design standards. Small firms specialised in different parts of the production procedure play a key role in the supply chain and large firms assemble all the parts of the shoes collected from the small firms. In this aspect, co-operation is the key to success for small firms.

KCIF is equipped with a large variety of footwear production machinery and is open to start-up firms in need of them almost free of charge, since the facilities are run with the government fund to assist start-ups.

Professor C[63] explained that University C in Busan is another example of a Footwear Department that was opened with the support of government. Common forms of firm-

[63] Interview (No. 12) with C was held on 31 March at 2 pm in his office in university C, Busan

university co-operation include help with technological development for new products and processes. For example, many firms take part in national funding projects by applying through open competition. Since firms do not have the ability to compile full proposals they approach universities for assistance.

Firms also approach universities to enquire about performance testing of their footwear products and the universities co-operate to provide technological assistance that firms need, using their laboratories and test equipment.

A different picture can be seen for large international firms that appoint some Korean firms to produce their shoes. Nike, for example, encourages competition among them so that firms are in competition to come up with new ideas. Once any one firm develops an innovative material or technology, Nike asks them not to sell it to any other firm but only to them for an attractive fee. These firms then no longer feel the need to share the technology with others. Among firms working for large international firms, competition rather than co-operation is encouraged. At the same time there is cooperation between small and large firms via the supply chain.

Professor A from Kyoungnam College of Information and Technology, however, argues that co-operation is key to the success of the industry and that this could go further with large firms opening their facilities to study visits by CEOs of small firms so that small firms can learn from them. Meetings of the 'Shoe Cluster' were created by university academics and footwear firm owners to offer seminars and study visits to successful firms to enhance the level of footwear knowledge by CEOs of footwear firms and professors in the universities.

Between firms, co-operation over sharing knowledge and assistance is made easier when there are alumni in other firms. How each individual CEO perceives knowledge sharing is important in this regards.

There are different kinds of firms: firms producing parts of shoes, OEM firms, branding firms that undertake design and marketing and many small firms work with them in partnership. It is very rare for small firms to have their own brand.

Footwear firm A is specialised in producing 'lasts' for OEM firms, and lasts especially designed for disabled people. In making footwear, a last is essential and firm A is the only firm producing lasts using 3D computing systems out of three last producing firms in Busan in 2015. The Korea Institute of Footwear and Leather Technology and Footwear (KIFLT) and the firm cooperate in developing a method to reduce faulty rates of lasts.

8.4 DISCUSSION AND ANALYSIS

Following the empirical analysis in Chapter 7, this chapter has examined non-quantifiable aspects of relationships between actors by focusing on the games and footwear industries. The findings presented in this chapter provide a deeper understanding of innovation in Korea within the systems of innovation approach and the Triple Helix model. Key findings are discussed below by types of innovation activity:

R&D

The accumulation of R&D and human capital is emphasised by economic theory as a determinant of economic growth (Aghion and Howitt, 1992). Furthermore, the role of R&D in producing innovation is critical (Griffiths, 2000). Games firms in Korea invest heavily in R&D to produce games that are competitive in the market place. Based on the earlier findings, however, firms in the footwear industry are much more geared to imitating products although this is also the type of innovation that results in new to the firm innovation as well as technological process and product innovation.

Imitation can be costly since by nature, knowledge is tacit and transferring knowledge to others involves time and effort either through explaining or through manuals and textbooks. This is backed up by research carried out by Mansfield, Schwartz and Wagner (1981). According to their results, in general around 65% of total innovation costs and 70% of innovation time is spent in imitation. Thus, the role of R&D includes producing new to market innovations as well as in improving the ability of firms to imitate (Griffiths, 2000) or produce new to the firm innovations.

In Korea, games firms usually carry out their own R&D although they are involved in joint R&D with universities and other firms. In the footwear industry, usually government owned research institutes carry out R&D but firms in partnership with universities perform R&D if they jointly won the government funding contest. Universities in Korea in general are not geared to R&D yet, rather their role is more towards production of skilled human capital. This finding is consistent with the argument by Bartzokas (2005, p. 8) that the main function of Korean universities is to train and develop human capital rather than conducting basic or applied research.

Although, more universities now participate in government funded R&D projects to work with local firms, they still tend to be more focused on applied rather than basic research. An official D in the KISTEP stated that, a large amount of investment in R&D has been made, but the outcomes do not necessarily match the investment and therefore, efficiency of the R&D investment needs to be re-evaluated.

COOPERATION

Innovation is seen as a process of interaction that leads to new product or process development and the innovation process involves basic and applied research, product or process development, market entrance (Liefner et al., 2006). As Kline and Rosenberg (1986) argue, in interactive models of innovation, cooperation among actors is an important part of the innovation process.

Interviews with key actors in the games and footwear industries have confirmed that with evidence of growing cooperation between universities and firms, and between firms in both industries, are often stimulated by government policy initiatives. Cooperation between firms and universities usually occurs via government research funding but there is also evidence that individual professors co-operate independently with firms in the industry.

Cooperation between firms can be more easily observed – for example, between large and small firms in the footwear supply chain. Knowledge sharing between firms and universities is more commonplace, usually catalysed by firm-university partnerships for government sponsored open competition. This is in line with Abramosvsky *et al.* (2005) who found, based on their research on four European countries, France, the UK, Germany, and Spain, firms in receipt of public support tend to cooperate more than firms who do not.

As Koschatzky and Sternberg (2000) argue, firms in traditional industries demonstrate low needs in integration into networks and they require rather low innovation intensity but the case study and empirical findings suggest the level of technology intensity of the industry today is much higher and indeed the integration of cooperative networks has become the norm. The footwear industry exhibits cooperation with other firms throughout the supply chain as firms are usually specialised in a single stage of the shoe production process.

Furthermore, Dodgson (1994) stresses that high-tech industries tend to cooperate more on R&D activities arguing that there is a greater need to obtain knowledge through innovation linkages when the industry has higher technological intensity. There is high technological intensity in the games industry in Korea, meaning that innovation actors often cooperate, but this is more common at the end of the production stage (rather than during production), particularly with marketing.

ACCESS TO INNOVATION FUNDS

Economic growth and innovation can be realised via access to innovation funds (Kim *et al.*, 2016; Wang, 2014; Brown *et al.*, 2009; Cincera and Santos, 2015) and the case studies carried out in this thesis have demonstrated that government funding for R&D and new product innovation is important for both industries in Korea. R&D funding has been made available through open contests and competition is strong.

The majority of small firms, however, tend not to apply due to the low possibility of being selected. The reason behind this can be found from the argument of Lee *et al.* (2015) who identified that small and innovative firms face more difficulties and constraints to have access to innovation funds because their projects and business models are usually riskier.

The empirical analysis showed that loans are significant and a positive element for innovation while government funding turned out to be significant and mostly positive but negative for new or significantly improved logistics and support activity process innovation. Thus, even if government offers R&D funding, small firms find it difficult to attain bank loans for risky projects nor do they have a high chance of winning government contests. The government should find ways of helping SMEs to attain necessary funding since the number of firms taking advantage of government support is limited.

PUBLIC POLICY AND SUPPORT

After the declaration of the era of regional autonomy in 1995 in Korea, the majority of plans and regulations are controlled by central government but the regions that have more resources and infrastructure have a higher tendency to get additional support from the central government. As Asheim and Isaksen (1997) and Han (2014) have identified, the central government of Korea controls the framework for regional level institutions and therefore it can be argued that Korea has a regionalised national systems of innovation. Stronger regional autonomy in terms of budget control and implementation, and policy and regulation setting have to be granted to facilitate more balanced development.

Each government has their own motto i.e. Creative Korea for president Park Geunhye administration, and Brain Korea for the previous government, president Lee myungbak administration, etc. Rather than developing or strengthening policies from previous governments, new governments tend to introduce their own new policies and projects from scratch. This results in wasted time, money and effort. Firms, especially in the games industry, find it difficult to catch up with new rules and regulations.

As Griliches (1995) argues, public support for innovation should provide a positive influence on innovation when the standard optimising conditions are met. According to the empirical analysis eight different public supports turned out to be significant and positive while sometimes negative as well. Firms in both industries in Korea, however, feel they receive no, or very limited support from the government for their innovation activities.

The reason behind this could be explained by the fact that among firms, the most required assistance from the government is funding._ This is quite a controversial situation since government does provide funding to the firms that show their ability to produce good business plans or show proof of concept for innovations but few firms have the ability to attain this government support.

In the case of the footwear industry, production automation is being realised throughout the industry and consequently unemployment rates will increase. The government, therefore, needs to work out an alternative way to create employment in collaboration with firms.

Thus, innovation and shifting production towards higher value added segments of the supply chain with, for example, greater employment in design and R&D, may be part of the solution as well as part of the problem.

HUMAN CAPITAL

The common issue of having insufficient specialist professors and teachers was raised by interviewees in both industries. Although both industries provide a major source of income to Korea, these industries (for different reasons) suffer from negative perception by the people as mentioned in the earlier findings section. The government, together with the industries, needs to find ways to transform these perceptions in order to attract capable and talented people for education and training in these particular industries. When such people are employed by firms in these industries, the level of innovation output will be improved as a result.

This phenomenon is backed up by Jacobs (1961) who argues that talented people are attracted by open and creative local environments and this contributes to the capacity to innovate. Lee *et al.* (2010) follow Jacob's argument and emphasise that innovation is a joint product of human capital and creativity. They further state that the ability of a region to attract human capital and lower entry barriers for creative and talented people is key to building innovation capacity.

Although universities nowadays put much more emphasis on research participating in joint research activities with local firms and national projects, universities in Korea still seem to be focusing on producing well trained and qualified graduates in order to supply firms' labour needs. This finding supports the arguments by Kim (1993) and Chang (2004) and is also consistent with the empirical analysis result where university graduates with MSc or higher degree holders were insignificant for most of the innovation production.

In an effort to improve knowledge transfer and commercialisation from public sector research, the Korean government set up the 'Technology Holding Firm System', the 'Leaders in Industry University Programme', and the 'Brain Korea'. The Technology Holding Firm System encourages universities and research institutes to set-up venture firms. On the other hand, leaders in Industry University and the Brain Korea programme promote collaboration between academia and industry (OECD.org$_b$, 2016).

In many cases, collaboration between firms and universities takes place when firms want to apply for government funds since professors are more capable of preparing theoretical and professional project proposals and firms possess practical expertise. If the proposal is successful the firm and university attain government funds to carry out the proposed project, which are usually more applied than basic research.

Chapter 9
CONCLUSION

This chapter discusses the main findings of this thesis, the policy implications, limitations and the scope for future research. The aim of this thesis was to identify and empirically test the factors that shape innovation and innovation activities at the business and regional level, using the innovation systems approach. Following a literature review, hypotheses were developed and empirically tested. A mix of quantitative and qualitative research methods was employed including cross section econometric analysis and industry/regional case studies.

In order to test the hypotheses, Korea Innovation Survey data for 2008, 2010, and 2012 was used – these surveys covered the period 2005-2011. This time frame was chosen to observe the changes in innovation performance of firms before and after the 2008 financial crisis.

Firm level and regional level analysis has been carried out to examine the elements involved in the innovation process in each survey period. Furthermore, analysis of the survey results across the three survey periods allows us to identify changes in innovation over time.

Industry case studies were carried out in order to gain a deeper understanding of the processes underlying relationships between innovation activities and products, processes and organisational and marketing innovations.

9.1 Objectives of thesis and Methodology

Economic performance in Korea has been shaped by economic development strategies since the 1960s. More recently, government strategy has focused on innovation and policy measures designed to support innovation as well as measures to promote balanced regional development. The main objective of this thesis was, therefore, to understand what factors influence the innovation performance of firms in Korea and if innovation activities and performance are evenly distributed across geographic regions.

The literature review in Chapter 3 found that the national systems of innovation approach - and developments such as regional systems of innovation - provide a comprehensive theoretical framework for the analysis of the internal and external factors that influence the innovation performance of firms and regions. Elements of innovation activities have been identified by the systems of innovation approach, and hypotheses were developed. Quantitative techniques were used to empirically test the hypotheses.

The quantitative analysis focused on firm and regional influences on innovation in order to test these hypotheses using the Korea Innovation Surveys data for 2008, 2010, and 2012. The empirical analysis was supplemented by qualitative analysis in the form of two industry/regional case studies, one on the high-technology games industry in Seoul and the other on the more traditional footwear industry around the Busan region.

9.2 Key Findings

The linear model of innovation is one of the most traditional theoretical frameworks developed to understand the relationship between research, science and technology and innovation but this model is seen as limited (Rosenberg, 1994, p. 139). As stated in Chapter 3, the linear model has been overtaken by the systems approach that explains complex and multiple interactions and relationships between institutions and firms and explains how knowledge and innovation is generated and diffused (Edquist and Hommen, 1999).

Edquist (2005) claims that the systems of innovation approach is a conceptual framework, where the factors shaping innovation are identified rather than a tight theory where propositions and causal relations are specified. In this context, the systems of innovation approach has been employed in this thesis to identify and empirically examine the relationship between various innovation activities and innovation outputs at the firm and regional levels.

Rapid economic development in Korea since the 1960s (from a country with GDP per capita of $91 in 1962 to $28,180 in 2014) was partly the result of government policies. More recently, there has been a further shift in firm behavior, from imitator to innovator, as government policy became more focused on innovation activities and outcomes.

Looking at Gross Regional Domestic Product (GRDP) per capita from 2005 until 2011, the period covered in this thesis, Ulsan has always had the highest and Daegu the lowest GRDP per capita. Even with the enactment of the Balanced Regional Development Act

(Act No. 7061, 2004) (National Law Information Centre), GRDP per capita between the regions has been diverging rather than converging in Korea.

9.2.1 Types of Innovation

The four different types of innovation - product, process, marketing, and organisational innovation - identified in the European Commission's Green Paper on Innovation (1995, p. 7) and the Oslo Manual (2005, 3rd edition) were studied. Product innovation is sub-categorised into: *new product innovation* and *significantly improved product innovation* while *process innovation* is sub-categorised into: *new or significantly improved manufacturing method*; *new or significantly improved logistics*; *delivery or distribution methods*; and *new or significantly improved supporting activities*. *New product innovation* has been further categorised into *new to market* and *new to company product innovation*.

Organisational innovation combines: the *introduction of changes to business practices for organising procedures*; *knowledge management*; *methods of organising work*; *responsibility*; and *methods of organising external relations with other organisations*. *Marketing innovation* combines: *the introduction of significant changes to the aesthetic design or packaging of goods*; *new media or techniques for product promotion*; *new sales strategies such as new methods for product placement or sales channels*; and *new methods of pricing goods*.

Product innovation and its sub-product, innovation categories, together with *process innovation* and its sub-categories, have been used as measures of innovation for the firm level analysis. Organisational innovation and marketing innovation (including all their sub-categories) have also been used in the regional analysis.

Through an examination of the relevant literature and theories regarding systems of innovation, various variables that influence innovation were identified. These include *research and development* that is internal or external to the firm, human capital (represented by *the proportion of Masters or higher degree holders* and *the proportion of research staff among permanent employees*), *cooperation* among firms and institutions, *public support* that includes *tax relief for technology development, support for technology development and funding, participation in government R&D projects, technical support* *from the government, technology information, technicians and educational research, procurement by government or collective purchasing, marketing*, and *access to innovation funds* including *internal funds that combines a company's own funds and funds from subsidiary or affiliated companies, government funds, loans* (bank loans and company bonds) and *stock issues*. These variables have been used in the hypotheses examined in this thesis. *Firm size* and *region* have been used as control variables.

9.2.2 Findings from the Descriptive Analysis of Data from the Korean Innovation Surveys of Firms 2008, 2010 and 2012

The results discussed in Chapter 7 show that the larger the firm size, the higher the percentage of firms that introduced all four types of innovation in Korea. Large firms produced the highest percentage of product, process, organisation and marketing innovation. Virtually all firms (99% or more) that were product innovators conducted research and development activity, regardless of firm size between 2005 and 2007.

During this period small and medium-sized firms that produced product innovation(s) used government support with *public support for technology development and funding* being the most common types of support. This finding supports the Almeid and Fernandes argument (2008, p. 13) that small and medium-sized firms have less advantage in the market in terms of having access to financial resources and they rely on government support for technology development and funding. For large firms, *participation in government research and development project(s)* was the most important type of policy utilised.

Among innovative firms, the proportion of firms that carried out one or both of *internal* and *external R&D,* increased from 97.06% in 2005-2007 to 98.06% in 2007-2009 then dropped to 58.25% in 2009-2011. The use of at least one of the eight *public supports* also increased from 57.95% in 2005-2007 to 60.15% in 2007-2009 but dropped to 40.11% in 2009-2011. Out of the eight *public supports, procurement and collective purchasing* was used by the lowest proportion of firms, while *technology development and funding* was used by the highest proportion, followed by *participation in government research project* in all three surveys.

In 2007-2009, *product innovation* was the most common type of innovation for large and small firms, while it was *organisation innovation* for medium-sized firms. Interestingly, public support measures were accessed by medium-sized firms the most in 2007-2009. For large firms, *tax relief for technology development* was used the most among the supports for all four innovations, while *support for technology development and funding* was the most frequently used government support for small firms.

As in 2005-2007, during 2007-2009 all three classes of firm size – small, medium and large - that were innovators, used their own funds; indeed a *company's own fund* was the most prevalent source of innovation funding for all types of innovation, followed by *government funding*. The next most used source of innovation funding for small and medium-sized firms was *bank loans*, while for large firms it was *funds from subsidiary or affiliated firms*.

In 2009-2011, among firms that were innovators, the most important policy support measure for all three size classes was *support for technology development and funding*. Large firms that produced *organisation* and *marketing innovation* used *tax relief for technology development* the most. Few small firms used *tax relief*. This contradicts the argument by Craig *et al.* (2007) that *tax relief*, together with direct and indirect subsidies, are important policies to promote small businesses. As a whole, throughout the empirical analysis it was large firms that made use of *tax relief* the most.

9.2.3 Findings from Innovation Activities Performed by Innovating Firms, by Region

Regional analysis was carried out for different types of innovation and innovation activities for all 3 surveys, 2008, 2010 and 2012, covering the period 2005-2011.

The regional variation in firms' access to innovation funds increased between 2005 and 2011 while *the proportion of firms employing MSc or higher degree holders*, and the proportion engaged in *cooperation* decreased between 2005-2007 and 2007-2009, before increasing in 2010-2012. The value for the coefficient of variation for *the presence of research staff* continued to increase between 2005 and 2011 meaning the regional variation of this variable widened as time progressed.

The values for the coefficient of variation of sub-innovation activities declined between 2005 and 2009 before increasing between 2009-2011 suggesting convergence followed by divergence. Similarly, the regional variations of *tax relief* and *technology development and funding* fell between 2005 and 2009 but increased again during 2009-2011 but to below their 2005-2007 level.

The general trend showed that the regional variation of innovation activities became narrower from 2008 to 2010 then later widened in 2012. This serves as good evidence of convergence followed by divergence and therefore no consistent pattern of convergence.

9.2.4 Findings from Empirical results from Regression Analysis and Case Study

Tables 9.1 to 9.7 provide a summary of the empirical findings from the logistic regression analysis discussed in detail in chapter 7, using data for over 11,000 firms that responded to the 2008, 2010 and 2012 Korean Innovation Surveys covering the time periods of 2005-07, 2007-09 and 2009-11. The variables in black show positive and significant associations, while those in red show negative and significant associations with the relevant innovation dependent variables. The text in blue refers to the dummy variable(s) *region* in cases where the dummy variables for the 15 regions were jointly significant. The following discussion is ordered in accordance with the hypotheses developed in section 5.1.3.

RESEARCH AND DEVELOPMENT

Either *internal R&D* or *external R&D* or both are significantly associated with the majority of innovation types supporting the argument by Schumpeter (1942), Acs and Audretsch (1988), Cassiman and Veugelers (2006) and many others that a firm's research and development activity is important for innovation performance.

While *product innovation* is more associated with *internal R&D*, *process innovation* is more positively associated with *external R&D* in general. Due to tacit knowledge and knowledge spillover effects product innovation is closely related to *internal R&D* activities while *external R&D* usually results in *process innovation*, introducing new production equipment or renewed or improved operational processes. The first hypothesis (*H1*) that 'Research and Development activities, internal and external, provide a positive influence on producing all types of innovations' is, therefore, supported.

The case study also supported this result in that games firms usually carry out their own R&D; although they do get involved in joint R&D with universities and other firms when there are opportunities for government funding. Similarly, in the footwear industry, government-owned research institutes usually carry out R&D, but firms also perform R&D in partnership with universities if they jointly win a government funding contest. Although more universities now participate in government funded R&D projects in order to work with local firms, they still tend to be more focused on applied rather than basic research.

HUMAN CAPITAL

As Korea has evolved from a developing to a developed country, the role of the university sector as a generator of human capital has started to receive more focus (Lee, 2014); but the empirical results covering the survey years of this thesis as a whole show no association between the *proportion of MSc or higher degree holders* and innovation.

In Korea, the main function of universities is to train and develop human capital rather than conduct basic or applied research. Although universities nowadays put much more emphasis on research, participating in joint research activities with local firms and national projects, universities in Korea still appear to focus on producing well trained and qualified graduates in order to supply firms' labour needs.

The empirical results suggest that having a higher proportion of MSc or higher degree holders - the first proxy variable for human capital - has no effect. Hence the data do not support the second hypothesis (*H2*) which is that 'MSc or higher degree holders have a positive influence on innovation.'

According to Szczepańska-Woszczyna (2014), human capital is considered to be one of the requirements for innovation performance and research staff are an important source of firms' human capital in the innovation process. This is consistent with the results from the empirical analysis, where researchers, the second proxy variable for human capital, turned out to be significant and positively associated with some types of innovation while at the same time being negative and significant for other types. The third hypothesis (*H3*), that 'having staff especially devoted to research is necessary to drive innovation and therefore the proportion of research staff among permanent employees expected to have a positive impact on product innovation' is, therefore, partly supported.

As the case study findings suggest, due to misperceptions of both industries in Korea, as discussed in Chapter 8, recruiting good quality graduates to relevant departments seems a difficult task. The government, together with industry, therefore, needs to find ways to transform these perceptions to attract capable and talented people to be educated and trained for these particular industries.

PUBLIC POLICY

We can expect social benefits when knowledge spills over to other agents from the original conceiver, as Nelson (1959) argued and this motivates intervention from government by providing various forms of support, including funding for research, procurement, etc. (Bonnyai, 2013).

Firms in both of these case study industries, feel they receive no, or very limited support, from the government for their innovation activities. Among firms, the most required assistance from the government is funding. This is quite an ironic situation since government does provide funding to firms, but only to those that demonstrate their ability to produce good business plans or show proof of concept for innovations. Not many firms have the ability to attain this government support.

According to the regression analysis, however, public support measures provide a positive and also negative impact on innovation. *Tax relief, Participation in the government R&D project, Marketing* and *Technicians and educational research* was positive and significant in *product innovation* between 2005 and 2011 while procurement by the government or collective purchasing, *technical support from the government*, is negative and significant.

For *process innovation, tax relief, participation in the government R&D project,* and *marketing* show positive and significant association while *support for technology development funding*, and *procurement by the government or collective purchasing* showed negative and significant association.

Thus, measures of the public policy[64] provide a positive and sometimes negative impact on innovation and thus the fourth hypothesis (*H4*), that 'the interaction between public and private sector is important in systems of innovation' is partly supported.

COOPERATION

Innovation is a process of interaction that leads to the development of a new product or process (Liefner *et al.*, 2006) and continuous cooperation among actors in the process of innovation is important in interactive models of innovation (Kline and Rosenberg, 1986).

Cooperation turned out to have a positive association with all types of innovation and this supports the idea that the systems of innovation approach, where there are interactions and networks among firms and institutions, are important (Freeman, 1987; Oughton and Whittam, 1997).

In all survey years, *product innovation including new to market* and *new to firm product innovation* and *process innovation* are all positively associated with *cooperation* with other institutes and firms when carrying out innovation activity. The fifth hypothesis (*H5*), that 'cooperative activity with other institutes or firms in innovation activity has a positive influence on innovation', therefore, is strongly supported.

Cooperation between firms was also easily observed in case studies – for example, between large and small firms in the footwear supply chain. Knowledge sharing between firms and universities is more commonplace, usually catalysed by firm-university partnerships for government sponsored open competitions.

Similarly, the higher technological intensity of the games industry in Korea means that innovation actors often cooperate, but is more common at the end of the production stage, particularly during marketing. In contrast, the footwear industry exhibits cooperation

[64] The detailed supports provided by government are *Tax relief for technology development*, *Support for technology development and funding*, *Participation in government R&D project*, *Technical support from the government*, *Technology information provided by the government*, *Technicians and educational research*, *Procurement by the government or collective purchasing*, and *Marketing supported by the government*.

with other firms throughout the supply chain, since businesses are usually specialised in a single stage of the shoe production process.

ACCESS TO INNOVATION FINANCE/FUNDS

Except in a few cases, the overall analysis suggests *internal funds* and *loans* are positively associated with innovation while *government funding* in a few cases shows a negative and significant association.

Finance is important in innovation activities of firms and this can lead to economic growth and provide a positive influence on innovation (Kim *et al.*, 2016; Wang, 2014). The sixth hypothesis (*H6*), 'having access to innovation finance/funds for innovation activities is important in the production of innovation', is supported by the analysis.

Firms find government funding for R&D and new product innovation to be important for both the games and footwear industry in Korea. R&D funding, however, has been made available mainly only through open contests and the competition has been strong. The majority of small firms, therefore, tend not to apply due to the low possibility of selection.

Thus, ironically, although government invests heavily in R&D funding, small firms feel they have a low chance of winning government contests whilst also finding it difficult to attain bank loans for risky projects. The government should arguably find a way of helping more SMEs attain necessary funding, since the number of firms taking advantage of government support is limited.

REGIONS

Hypothesis 7 *(H7)* states that 'Regional factors including local knowledge creation, diffusion and application, and cultural embeddedness influence innovation'. Regression analysis was carried out adding 15 regional dummy variables (with one region as a reference point) in models B and D. In no regression for any of the innovation types, were the individual regional coefficients significant, however, in several regressions they were jointly significant.

The descriptive analysis of regional data in Chapter 6, however, showed that there was variation in regional innovation performance and activities. One possible explanation for the weak performance of the regional dummies in some regressions could be that regional variation is already captured by all the other explanatory variables (which show variation across regions) included in model A (which does not control for firm size), and model C where 'firm size' was incorporated as dummy control variables (with dummy variables for 4 firm size classes included with a 5th size class as a reference point).

FIRM SIZE

In general, the results suggest that while larger firms are more likely to innovate, smaller firms are less likely to do so. This is especially so for *new and significantly improved product innovation*, and *new or significantly improved production process*, *logistics process innovation, process innovation for support activity, new to firm product innovation*. It is worth noting here that large firms, however, turned out not to be significant in producing *new to market product innovation*.

This in general is in line with Schumpeter's argument that larger firms are in a better position to innovate due to their monopolising power. Hypothesis 8 (*H8*) which posits that 'Firm size influences innovation: larger firms find it easier to innovate, while smaller firms find it more difficult to innovate.', therefore, is generally supported.

Table 9.1 Factors Influencing New Product Innovation

Innovation	Model	2008	2010	2012
NewProduct Innovation	A	Internal R&D, External R&D, Researchers, Tax relief, Loans, Cooperation	Internal R&D, External R&D, Researchers, Loans, Cooperation	Internal R&D, Participation in the govt. R&D project, Cooperation
	B	Internal R&D, External R&D, Researchers, Tax relief, Loans, Cooperation, Region	Internal R&D, External R&D, Researchers Cooperation, Region	Internal R&D, Participation in the govt. R&D project, Cooperation, Region
	C	Internal R&D, External R&D, Researchers, Tax relief, Loans, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees	Internal R&D, External R&D, Researchers, Loans, Cooperation	Internal R&D, Participation in the govt. R&D project, Cooperation
	D	Internal R&D, External R&D, Researchers, Tax relief, Loans, Cooperation, Firms with 300-499, Region	Internal R&D, External R&D, Researchers, Loans, Cooperation, Region	Internal R&D, Participation in the govt. R&D project, Cooperation, Region

Table 9.2 Factors Influencing Significantly Improved Product Innovation

Innovation	Model	2008	2010	2012
Significantly Improved Product Innovation	A	Internal R&D, Researchers, Marketing, Loans, Cooperation	Internal R&D, External R&D, Researchers, Tax relief, Procurement by the govt. or collective purchasing, Loans, Cooperation	Internal R&D, External R&D, Researchers, Technical support from the government, Technicians and educational research, Marketing, Cooperation
	B	Internal R&D, Researchers, Marketing, Loans, Cooperation, Region	Internal R&D, External R&D, Researchers, Tax relief, Procurement by the govt. or collective purchasing, Loans, Cooperation, Region	Internal R&D, External R&D, Researchers, Technical support from the government, Marketing, Cooperation, Region
	C	Internal R&D, Researchers, Marketing, Loans, Cooperation, Firms with over 500 employees	Internal R&D, External R&D, Researchers, Procurement by the govt. or collective purchasing, Loans, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with over 500 employees	Internal R&D, External R&D, Researchers, Participation in government R&D project, Technical support from the government, Technicians and educational research, Cooperation, Firms with 50-99 employees, Firms with 100-299 employees, Firms with over 500 employees
	D		Internal R&D, External R&D, Researchers, Procurement by the govt. or collective purchasing, Loans, Cooperation, Firms with 10-49 employees, Region	Internal R&D, External R&D, Researchers, Participation in government R&D project, Technical support from the government, Cooperation, Firms with 50-99 employees, Firms with 100-299 employees, Firms with over 500 employees, Region

Table 9.3 Factors Influencing New or Significantly Improved Production Process Innovation

Innovation	Model	2008	2010	2012
New or significantly improved production process	A	Internal R&D, External R&D, Researchers, Tax relief, Marketing, Govt. funding, Loans, Cooperation	External R&D, Researchers, Tax relief, Technology information provided by the govt., Govt. funding, Loans, Cooperation	Internal R&D, MSc holders, Tax relief, Loans, Cooperation
	B	Internal R&D, External R&D, Researchers, Govt. funding, Loans, Cooperation, Region	External R&D, Researchers, Tax relief, Technology information provided by the govt, Govt. funding, Loans, Cooperation, Region	Internal R&D, MSc holders, Tax relief, Loans, Cooperation, Region
	C	Internal R&D, External R&D, Researchers, Marketing, Govt. funding, Loans, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with 100-299 employees	External R&D, Researchers, Tax relief, Technology information provided by the govt., Participation in government R&D project, Govt. funding, Loans, Cooperation, Firms with 10-49 employees	Internal R&D, MSc holders, Tax relief, Loans, Cooperation
	D	Internal R&D, External R&D, Researchers, Marketing, Govt. funding, Loans, Cooperation, Firms with 300-499 employees, Firms with over 500 employees, Region	External R&D, Tax relief, Technology information provided by the govt., Participation in government R&D project, Govt. funding, Loans, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with 100-299 employees, Region	Internal R&D, MSc holders, Tax relief, Loans, Cooperation, Region

Table 9.4 Factors Influencing New or Significantly Improved Logistics Process Innovation

Innovation	Model	2008	2010	2012
New or significantly improved logistics	A	External R&D, Researchers, Cooperation	External R&D, Researchers, Tax relief, Cooperation	Tax relief, Participation in govt. R&D project, Marketing, Govt. funding, Cooperation
	B		Internal R&D, External R&D, Researchers, Tax relief, Cooperation, Region	
	C	External R&D, Tax relief, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with 100-299 employees	External R&D, MSc holders, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with 100-299 employees, Firms with over 500 employees	Tax relief, Participation in govt. R&D project, Marketing, Govt. funding, Cooperation
	D		External R&D, MSc holders, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with 100-299 employees, Firms with 300-499 employees, Region	

Table 9.5 Factors Influencing New or Significantly Improved Support Activity Process Innovation

Innovation	Model	2008	2010	2012
New or significantly improved support system	A	External R&D, Tax Relief, Technicians and educational research, Govt. funding, Cooperation	External R&D, Tax relief, Technicians and educational research, Cooperation	Internal R&D, Resarchers, Sppt. for tech. dev. funding, Procurement by the govt. or collective purchasing, Marketing, Cooperation
	B			
	C	External R&D, Tax Relief, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with over 500 employees	External R&D, Technicians and educational research, Cooperation, Firms with 10-49 employees, Firms with over 500 employees	Internal R&D, Sppt. for tech. dev. funding, Procurement by the govt. or collective purchasing, Marketing, Cooperation, Firms with 100-299
	D			

Table 9.6 Factors Influencing New to Market Product Innovation

Innovation	Model	2008	2010	2012
New to Market Product Innovation	A	Internal R&D, External R&D, Researchers, Tax relief, Sppt. for Tech. dev. and funding, Procurement by the govt. or collective purchasing, Marketing, Govt. funding, Cooperation	Internal R&D, External R&D, Researchers, Marketing, Internal finance, Govt. funding, Stock, Cooperation	Internal R&D, Participation in govt. R&D project, Marketing, Cooperation
	B	Internal R&D, External R&D, Researchers, Tax relief, Sppt. for Tech. dev. and funding, Procurement by the govt. or collective purchasing, Marketing, Govt. funding, Cooperation, Region	Internal R&D, External R&D, Researchers, Internal finance, Govt. funding, Stock, Cooperation, Region	
	C	Internal R&D, External R&D, Researchers, Procurement by the govt. or collective purchasing, Marketing, Cooperation, Firms with 10-49 employees	Internal R&D, External R&D, Researchers, Internal finance, Govt. funding, Stock, Cooperation, Firms with 50-99 employees, Firms with 100-299 employees	Internal R&D, Participation in govt. R&D project, Marketing, Cooperation
	D		Internal R&D, External R&D, Researchers, Internal finance, Govt. funding, Stock, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Region	

Table 9.7 Factors Influencing New to Firm Product Innovation

Innovation	Model	2008	2010	2012
New to Company Product Innovation	A	Internal R&D, External R&D, Researchers, Tax relief, Procurement by the govt. or collective purchasing, Marketing, Internal finance, Loans, Cooperation	Internal R&D, External R&D, Researchers, Tax relief, Marketing, Internal finance, Loans, Cooperation	Internal R&D, Researchers, Sppt. for tech. dev. funding, Participation in govt. R&D project, Tech'l sppt from the govt., Cooperation
	B		Internal R&D, External R&D, Researchers, Marketing, Internal finance, Loans, Cooperation, Region	
	C	Internal R&D, Researchers, Procurement by the govt. or collective purchasing, Marketing, Internal finance, Govt. funding, Loans, Cooperation, Firms with 10-49 employees, Firms with 50-99 employees, Firms with over 500 employees	Internal R&D, External R&D, Researchers, Marketing, Internal finance, Loans, Cooperation	Internal R&D, Researchers, Sppt. for tech. dev. funding, Participation in govt. R&D project, Tech'l sppt from the govt., Cooperation
	D		Internal R&D, External R&D, Researchers, Marketing, Internal finance, Loans, Cooperation, Region	

9.2.5 The fall in the Proportion of Innovators in 2009-2011

The results set out above include changes in the proportion of innovators over time with an increase from 2005-2007 to 2007-2009 followed by a decrease in 2009-2011. As presented in Figure 6.19 in Section 6.3.6, one of the reasons for the low proportion of innovators in 2009-11 could be explained by the financial crisis Korea suffered at the end of 2008. Although there was a sharp increase in real GDP growth rate until the second quarter of 2010 after the economic shock, the knock-on effects in the later years, 2009, 2010 and 2011 could explain the decline.

Furthermore, as Symeonidis (1996) and Alsharkas (2014) argue, firm size has a positive correlation with innovation and therefore, as discussed in Section 6.3.6 in detail, the other reason for the low proportion of innovators in 2009-2011 could be found from the sample size.

Table 6.22 shows that the proportion of the sample firms for *firms with 10 to 49, 50-99, and 100-299 employees* selected from the population, are similar in the 2008, 2010 and 2012 surveys. Almost three to four times the smaller sample size for *firms with over 500 employees*, however, was included in the 2012 survey.

As the discussion in Section 6.3.6 suggested, the inclusion of a dramatically smaller large firm size category, made the percentage of smaller firm size category much larger compared to the 2008 and 2010 survey. Based on the discussion that larger firms are more likely to innovate than smaller firms, this could be a reason for the fall in the number of innovators in 2009-2011.

9.3 Policy Implication

Throughout this paper, systems variables of innovation have turned out to be effective on innovation in Korea. The particular innovation activities that are consistently influencing innovation is R&D, cooperation and access to innovation fund. Internal R&D and external R&D positively influences product innovation and process innovation respectively. Among the innovative firms the larger the firms the higher the proportion of firms that carried out R&D, which is consistent with the proportion of innovators by firm size. Public policy to encourage smaller size firms to perform innovation activities, would, therefore, appear to be required.

Although Korea demonstrates the highest R&D activities among OECD countries, only 20% of the R&D expenditure was funded by the government (OECD, 2012). There is relatively high government sector expenditure on R&D. Considering more than 70% of R&D is carried out by firms, 14% by research institutes and 10% by universities, increasing the public R&D should encourage better outputs of research publications and universities (Databank.worldbank.org$_b$, 2018).

Cooperation is found to be the element that constantly shows significance in all type of innovation through empirical analysis. The case study findings suggest that cooperation between firms and universities are common in R&D activities, especially in knowledge intensive industries, such as the games industry. Furthermore, cooperation between firms was more noticeable in the supply chain of traditional manufacturing industries in Korea, such as the footwear industry.

In many cases, cooperation between firms, and firm and university is stimulated by government policy measures and, therefore, increased levels of government measures including funding that does not involve much rent seeking behaviour will encourage cooperation in producing innovation.

Findings indicate that new to market product innovation is more likely to be positively affected by funding from government while loans are more likely to affect the production of new to firm product innovation. This suggests that firms will be encouraged to carry out more R&D activities for riskier, cutting edge innovation, if the provision of increased level of government funding is available.

The argument of Chang (1994) which stated that industrial policy played an important role in Korea is supported by the findings of this research. Although there is no guarantee that policies that worked before would work again, policy makers can adopt lessons from the past while they should also innovate to adapt these for new industry. It is clear the focus of government policy has to be shifted more towards basic research.

9.4 Limitations of the Research

There have been a number of limitations encountered during the research that need to be acknowledged. First of all, the answers to the questions relating to innovation activities and the innovation measures in the survey were mostly dichotomous. The advantage of categorical data is their clarity and simplicity. There are, however, a number of problems in using binary variables in statistical analysis. One of the problems is that it loses a certain amount of information and as a result there is reduced statistical power in detecting the relationship between dependent and independent variables.

This has been acknowledged by MacCallum *et al.* (2002) who argue that if a variable is dichotomised at the median, it loses power by the same amount as a third of the data is discarded. Moreover, Austin and Brunner (2004) warn that the positive output from a binary analysis can be a false positive. The extent of variation in outcomes can be seriously underestimated and binary outcomes can hide non-linearity in the relationship between the independent and dependent variables.

The lack of variation in binary data makes finding the factors influencing innovation, including at regional level, difficult as well. The proportion of innovators and the proportion of innovators who carried out each innovation activity, therefore, were used to observe the innovation performance.

Moreover, the sampling issue and the economic crisis have been provided as two possible reasons for the fall in innovators between survey year 2010 and 2012 and it would be useful to research more on other reasons that can explain this phenomenon.

Another limitation to be acknowledged is that this thesis could not include an analysis of interactions among the innovation measures and innovation activities themselves since there are too many possible interactions. Although rough information regarding the interrelatedness of innovation measures and innovation activities among themselves can be obtained from the correlation matrix presented prior to each statistical analysis, the examination of interactions between the innovation activities and the innovation measures themselves have not been carried out in this thesis.

An example of these interactions is that process innovation can contribute to the production of product innovation while organisational innovation can be associated with process innovation or, sometimes, marketing innovation may contribute to further product innovation. An example of interactions in innovation activities can be found in R&D activities dependent on gaining access to innovation funds or, on obtaining an opportunity to participate in government R&D projects, when a firm does not have sufficient funding for innovation or does not have an adequate level of human capital.

Although these further analyses would have contributed to making this thesis more comprehensive, the analyses carried out in identifying the factors shaping innovation performance at firm and regional level have provided evidence on the research questions raised at the beginning of this thesis.

9.5 Areas for Further Research

The analyses carried out in this thesis only covered the period between 2005 and 2011 and a study of how national and regional systems of innovation can be applied to different stages of economic development has not been possible. It would therefore be useful to carry out a study with further data covering a larger time span that includes different stages of economic development.

Furthermore, this thesis dealt with the manufacturing sector only and it would be useful to carry out the same analysis for the service sector using the Korea Innovation Survey. Atuathene-Gima (1996) has provided some evidence to suggest that the determinants of innovation for manufacturing firms and service sector firms are different in the case of Australia. It would, therefore, be interesting to carry out a comparative analysis of the manufacturing and service sectors in Korea. Astudy by Seo *et al.* (2016)[65] carried out a comparative analysis on the innovation patterns in manufacturing and services using the Korea Innovation Survey for 2012 but only for radical and incremental innovation. Future research could extend that work to include a wider range of innovation measures, over a longer time period.

[65] According to the authors, their study is arguably the very first attempt to compare the innovation pattern differences between manufacturing and service firms at a country level in Korea.

A1-5

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APPENDIX

Korea Innovation Survey Questionnaire

Innovation Survey 2012: Manufacturing

1. GENERAL INFORMATION ABOUT THE ENTERPRISE

1-1 Your enterprise type as of December 2011

❙Enterprise type	1. Independent company	2. Domestic affiliated company	3. Foreign affiliated company	*6*
❙Legal type	1. large enterprise	2. medium sized enterprise	3. small enterprise	*7*
❙appointment (choose all relevant)	1. venture enterprise	2. INNO-BIZ	3. N/A	*8*
❙Listed or not	1. An exchange listed enterprise	2. KOSDAQ listed enterprise	3. N/A	*9*

1-2 What was the sales/exports amount for the three years 2009 to 2011? Choose from the box below.

① less than a billion ② more than a billion but less than 5 billion ③ more than 5 billion but less than 10 billion ④ more than 10 billion but less than 50 billion ⑤ more than 50 billion but less than 100 billion ⑥ more than 100 billion but less than 500 billion ⑦ more than 500 billion

	2009	2010	2011
Sales amount	*10*	*11*	*12*
Export amount	*13*	*14*	*15*

1-3 What was your target market for the three years 2009 to 2011? Choose all relevant.

16-20

1. Korea 2. Asia 3. Europe 4. USA 5. Other: (__________*21-22*)

1-4 How do you carry out your R&D?

23

1. Operate a research institute 2. In-house research department
3. Temporary operation when necessary 4. Do not perform R&D

1-5 How many employees did you have during the three years 2009 to 2011.

	2009 (male+female)	2010 (male+female)	2011 male+female	2011 female
■no. of regular employees	*24-28*	*44-48*	*64-68*	*B6-10*
■no. of postgraduate degree holders	*29-33*	*49-53*	*69-73*	*11-15*
■no. of dedicated researchers	*34-38*	*54-58*	*74-78*	*16-20*
■no. of researchers engaged in other jobs as well as research	*39-43*	*59-63*	*79-83*	*21-25*

1-6 Do you have labour unions? Choose 'yes' if any of your businesses has one.

26

1. Yes 2. No

※ What is innovation?

- Innovation is the market introduction of a new or significantly improved good or process, marketing or organisational method such as business process/work organisation/external relations. The minimum requirement for certain activities to be innovative, they have to be new or significantly improved and also they have to be executed. In case of products, they actually have to be released to the market. For new process, organisational and marketing methods, they have to be actually applied to the business operation.

2. PRODUCT INNOVATION

Product innovation is the market introduction of a new or significantly improved good compare to the existing good in terms of its capabilities, user friendliness, components or sub-systems and as a result he sales increase has been brought about.

- Completely new product: Product produced based on new knowledge/technology, or creating a method to create new usage out of the existing technology, or significant change in technical specification, user friendliness, other functional character.
- Significantly improved product: product that has been significantly improved compared to the existing product in quality or in usage.

ex) new product innovation: film camera ➐ introduction of digital camera, MP3 etc.

improved product innovation: introducing ABS brake/GPS to motor cars, clothes made of breathing textiles **[caution]**

1. New model or change of design is not product innovation if the technical functionality is similar to the existing one.
2. Product innovation (new or improved) must be new to your enterprise, but they do not need to be new to your market. In case of multinational enterprise, only consider the ones developed within the country.
3. Regardless when they are developed, they should have been commercialised during the three years 2009 to 2011.

2-1 During the three years 2009 to 2011, did your enterprise introduce：

	yes	no	
■Completely new goods	1	2	*27*
■Significantly improved goods	1	2	*28*

※ If the answers are all 'no' please go to Section 3

※ If the answer to 2-1 is 'yes' please provide detailed description of the cases

2-2 Who developed these product innovations? (choose all relevant)

33-35

1. your enterprise by itself
2. Your enterprise together with other enterprises or institutions
3. Other enterprises or institutions

2-3 Were any of your product innovations during the three years 2009 to 2011:

	yes	no	
■ (new to your market) your enterprise introduced a new or significantly improved product onto your market before your competitors	1	2	*36*
■ (Only new to your firm) Your enterprise introduced a new or significantly improved product that was already available from your competitors in your market	1	2	*37*

2-4 Putting the total turnover as 100%, please give the percentage of the turnover contributed by the following innovation:

■ New to market product during the last three years	*38*	*39*	*40*	%
■ New to your firm during the last three years	*41*	*42*	*43*	%
■ Other products (including the existing products)	*44*	*45*	*46*	%

= total turnover in 2011☐☐☐%

■ **'Other product'** means unchanged or only marginally modified products that were on sale.

2-5 Were any of your product innovations during the last three years 2009 to 2011:

	yes	no	Don't know	
■ A first in Korea	1	2	3	*47*
■ A world first	1	2	3	*48*

3. PROCESS INNOVATION

What is process Innovation?

A process innovation is the implementation of a new or significantly improved production process and distribution method, and contributed to the reduction of production/logistics costs enhancing the quality of the products.

Ex.) new production methods (ERP, just-in-time etc.), introduction of an automated production equipment, introduction of RFID in products delivery, adaptation of IT skills to enhance the efficiency of procurement, accounting, and maintenance

[Caution]

1. Improvement of process, computerisation of office work, management innovation such as an expansion of the existing line, purchasing wrapping machine etc. are not included.
2. It has to be new to your company regardless if other companies have already introduced it.
3. Regardless of the timing of the development, only consider the process innovations introduced during 2009 to 2011.

3-1 During the three years 2009 to 2011, did your enterprise introduce following process innovation to the actual running of your enterprise?

	yes	no	
■ New or significantly improved methods of manufacturing goods	1	2	*49*
■ New or significantly improved logistics, delivery or distribution methods (raw materials/finished products)	1	2	*50*
■ New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing.	1	2	*51*

※ If 'no' to all options, please go to section 4

※ If 'yes' to question 3-1, please provide detailed case of the innovation.

3-2 Who developed these process innovations during the three years 2009 to 2011? (choose all relevant)

56-58

1. Your enterprise by itself
2. Your enterprise together with other enterprises or institutions
3. Other enterprises or institutions

3-3 Were there following process innovation during the three years 2009 to 2011?

	yes	no	don't know	
■ new to Korea	1	2	3	*59*
■ new to the world	1	2	3	*60*

4. Ongoing or abandoned innovation activities (process and product innovations)

- 'Innovation activity' means every scientific, technical, and organisational activities to perform 'innovation'.

  - Include the purchase of external knowledge, technology, machine, equipment for innovation. It also includes R&D activity even when it is not related to a product/process innovation.

  - Include abandoned or ongoing activities

4-1 During the past three years 2009 to 2011, did your enterprise have any innovation activities that did not result in a product or process innovation because the activities were:

	yes	no	
■ Abandoned or suspended before completion	1	2	*61*
■ still ongoing as of December 2011	1	2	*62*

※ If your enterprise had no 'product' or 'process' innovations or 'innovation activity' during the three years 2009 to 2011 (no to all options in questions 2-1, 3-1, 4-1), go to section 8. Otherwise, carry on to the next question.

5. Innovation activities and expenditures for process and product innovations

5-1 During the three years 2009 to 2011, did your enterprise engage in the following innovation activities:

		yes	No
In-house R&D	Creative work undertaken within your enterprise to increase the stock of knowledge for developing new and improved products and processes	1	2 *63*
	(↳ **If yes,**) did your enterprise perform R&D during the three years 2009 to 2011? 1. Continuously (your enterprise has permanent R&D staff in-house) 2.Occasionally (as needed only) *64*		
Collective R&D	Same purpose as in-house R&D, but performed collaboratively with other enterprise or organisation	1	2 *65*
External R&D	Same purpose as in-house R&D, but performed by other enterprise or organisations (public or private research organisations) and purchased by your enterprise	1	2 *66*
Acquisition of machinery, equipment and software	Acquisition of advanced machinery, equipment (including computer hardware) or software to produce new or significantly improved products and processes	1	2 *67*
Acquisition of external knowledge	Purchase or licensing of patents, non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations for the development of new or significantly improved product and processes	1	2 *68*
Training for innovative activities	Internal or external training for your personnel specifically for the development and/or introduction of new or significantly improved products and processes	1	2 *69*
Market introduction of innovations	Activities for the market introduction of your new or significantly improved goods or services, including market research and launch advertising	1	2 *70*
Design	Activities to design, improve or change the shape or appearance of new or significantly improved goods or services	1	2 *71*
Other	Other activities to implement new or significantly improved products and processes such as feasibility studies, testing, routine software development, tooling up, industrial engineering, etc.	1	2 *72*

5-2 What was the total amount of expenditure for innovation activities during the three years 2009 to 2011 and please provide the percentage of expenditure for each of the following innovation activities.

Total amount of expenditure	*73*	*74*	*75*	*76*	*77*	*78*	Million won
■ Amount spent in In-house R&D			*C6*		*7*	*8*	%

■ Amount spent in External R&D activities	9	10	11	%
■ Acquisition of machinery, equipment, and software (Exclude expenditures on equipment for R&D)	12	13	14	%
■ Acquisition of external knowledge and technology (Exclude expenditures on equipment for R&D	15	16	17	%

= Total percentage ☐ ☐ ☐ %

5-3 How did your enterprise source the fund for innovation activities during the three years 2009 to 2011?

18-197

1. Company's own fund
2. Fund from Subsidiary or affiliated company
3. Government fund
4. Bank loan
5. Stock issue
6. Corporate bond
7. No expenditure
8. Other( )

6. Sources of information and co-operation for product and process innovation

6-1 During the three years 2009 to 2011, did your enterprise use the following sources in innovation activities and how important were they?

	usage		importance		
Information source	No(1)	Yes(2)	high	medium	low
■ Within your enterprise or enterprise group	☐	☐20	1	2	3 30
■ Suppliers of equipment, materials, components, or software	☐	☐21	1	2	3 31
■ Clients or customers	☐	☐22	1	2	3 32
■ Competitors or other enterprises in your sector	☐	☐23	1	2	3 33
■ Private consulting company/R&D institutes	☐	☐24	1	2	3 34
■ Universities or other higher education institutions	☐	☐25	1	2	3 35
■ Government or public R&D organisation	☐	☐26	1	2	3 36
■ Conference, trade fairs, exhibitions	☐	☐27	1	2	3 37
■ Scientific journals and trade/technical publications	☐	☐28	1	2	3 38
■ Professional and industry associations	☐	☐29	1	2	3 39

6-2 During the three years 2009 to 2011, did your enterprise co-operate on any of your innovation activities (product and process innovation) with other enterprises or institutions?

40

1. yes 2. no ➜ if 'no' go to Section 7-1

6-3 Please indicate the type of innovation co-operation partner by location. (tick all that apply)

Type of co-operation partner	Relevancy		Domestic					Over Seas
	No (1)	Yes (2)	Capital	Choongchung (incl. Gangwon)	Cholla (incl. Jeju)	Daegu/ Kyungbook	Busan/ Kyungnam	
■Other enterprises within your enterprise group	☐	☐*41*	1	2	3	4	5	6 *48*
■Suppliers of equipment, materials, components, or software	☐	☐*42*	1	2	3	4	5	6 *49*
■Clients or customers	☐	☐*43*	1	2	3	4	5	6 *50*
■Competitors or other enterprises in your sector	☐	☐*44*	1	2	3	4	5	6 *51*
■Consultants or private R&D institutes	☐	☐*45*	1	2	3	4	5	6 *52*
■universities or other higher education institutions	☐	☐*46*	1	2	3	4	5	6 *53*
■Government or public research institutes	☐	☐*47*	1	2	3	4	5	6 *54*

6-4 Which type of co-operation partner did you find the most valuable for your enterprise's innovation activities? Choose one from the following co-operation partner.

55

1. Other enterprises within your enterprise group
2. Suppliers of equipment, materials, components, or software
3. Clients or customers
4. Competitors or other enterprises in your sector
5. Consultants or private R&D institutes
6. universities or other higher education institutions
7. Government or public research institutes

7. Objectives for your product and process innovations during 2009 to 2011

7-1 What was the main purpose of your activities to develop product or process innovations during 2009 to 2011? How important were the following objectives? (If your enterprise had several projects for product and process innovations, make an overall evaluation)

	Relevance		Importance		
	No (1)	Yes (2)	high	medium	Low
Increase range of goods or services	☐	☐56	1	2	3 66
Replace outdated products or processes	☐	☐57	1	2	3 67
Enter new markets or increase market share	☐	☐58	1	2	3 68
Improve quality of goods or services	☐	☐59	1	2	3 69
Improve flexibility for producing goods or services	☐	☐60	1	2	3 70
Increase capacity for producing goods or services	☐	☐61	1	2	3 71
Reduce labour costs per unit output	☐	☐62	1	2	3 72
Reduce material and energy costs per unit output	☐	☐63	1	2	3 73
Reduce environmental impacts	☐	☐64	1	2	3 74
Improve health or safety of your employees	☐	☐65	1	2	3 75

7-2 How effective were the product and process innovation performed during three years 2009 to 2011? (If your enterprise had several projects for product and process innovations, make an overall evaluation)

	Relevance		Effectiveness		
	No (1)	Yes (2)	high	medium	low
Increased range of goods or services	☐	☐D6	1	2	3 16
Improved out of date product/process	☐	☐7	1	2	3 17
Entered new markets or increase market share	☐	☐8	1	2	3 18
Improve quality of products	☐	☐9	1	2	3 19
Improved flexibility of production	☐	☐10	1	2	3 20
Increased production capacity	☐	☐11	1	2	3 21
Reduced production costs per unit of labour	☐	☐12	1	2	3 22
Reduced production costs per unit of materials and energy	☐	☐13	1	2	3 23
Reduced environmental impacts	☐	☐14	1	2	3 24

Improved working conditions on health and safety	☐	☐15	1	2	3 25

7-3 Please evaluate the usage of protection of product/process innovation during the three years 2009 to 2011 and the importance of them.

	Usage		Importance		
	No(1)	Yes(2)	high	medium	Low
Patent	☐	☐26	1	2	3 33
Utility model right	☐	☐27	1	2	3 34
Design right	☐	☐28	1	2	3 35
Trademark right	☐	☐29	1	2	3 36
Company secret	☐	☐30	1	2	3 37
Complicated planning method	☐	☐31	1	2	3 38
Occupying the market before the competitors	☐	☐32	1	2	3 39

8. Factors hampering product and process innovation activities

8-1 During the three years 2009 to 2011, how important were the following factors in preventing your enterprise from innovating or in hampering your product and process innovation activities? Please evaluate the importance of each item.

		Relevance		Importance		
		No(1)	Yes(2)	high	med	low
Cost factors	Lack of funds within your enterprise or group	☐	☐40	1	2	3 51
	Lack of finance from sources outside your enterprise	☐	☐41	1	2	3 52
	Excessive costs spent in innovation	☐	☐42	1	2	3 53
Capacity factors	Lack of qualified personnel	☐	☐43	1	2	3 54
	Lack of information on technology	☐	☐44	1	2	3 55
	Lack of information on markets	☐	☐45	1	2	3 56
	Difficulty in finding cooperation partners for innovation	☐	☐46	1	2	3 57

Market factors	▯ Market dominated by established enterprises	☐	☐47	1	2	3	58
	▯ Uncertain demand for innovative goods or services	☐	☐48	1	2	3	59
Reasons not to innovate	▯No need due to prior innovations by your enterprise	☐	☐49	1	2	3	60
	▯ No need because of no demand for innovations (incl. OEM)	☐	☐50	1	2	3	61

9. Organisational Innovation

What is Organisational Innovation?

An organisational innovation is a new organisational method in your enterprise's business practices including knowledge management, workplace organisation or external relations that has not been previously used by your enterprise. It has to be new to your enterprise and does not matter even if other companies are already using it.

ex) significant improvement in the methods of information gathering and knowledge share, trying to change the work organisational type to enhance work flexibility and efficiency, entering into new relationship with other companies though outsourcing

[Caution]

1. Organisational innovation must be the result of strategic decisions taken by management. Exclude mergers or acquisitions, even if for the first time.
2. Setting Business strategy itself is not an organisational innovation, but company or departmental change to apply this is included in an organisational innovation.
3. It has to be introduced during the three years 2009 to 2011.

9-1 During the three years 2009 to 2011, did your enterprise introduce:

	yes	no	
▯New business practices for organising procedures (i.e. supply chain management, 6-sigma, knowledge management, lean production, quality management etc)	1	2	62
▮New methods of organising work responsibility (i.e. team work, integration or de-integration of departments, education /training systems etc.)	1	2	63
▮New methods of organising external relations with other organisations (alliance, partnership, outsourcing etc.)	1	2	64

※ If no to all options, go to section 10.

※ If yes to all Q.9-1, please provide detailed case of the innovations. *65-68*

9-2 How important were each of the following objectives for your enterprise's organisational innovations introduced during the threee years 2009 to 2011? Please evaluate the importance for each object. (If your enterprise introduced several organisational innovations, make an overall evaluation)

	Relevance		Importance		
	No (1)	Yes (2)	high	med	low
? Reduce time to respond to customer or supplier needs	☐	☐*69*	1	2	3 *74*
? Improve ability to develop new products or processes	☐	☐*70*	1	2	3 *75*
? Improve quality of your goods or services	☐	☐*71*	1	2	3 *76*
? Reduce costs per unit output	☐	☐*72*	1	2	3 *77*
?Improve communication or information sharing within your enterprise or with other enterprises or institutions	☐	☐*73*	1	2	3 *78*

10. Marketing innovation

What is Marketing Innovation?

Introduction of significant change compare to existing methods in sales and marketing such as product design, product packaging, product promotion, product display to enhance the attractiveness of product and consumer awareness.

Ex) when the product design is much changed, when open an internet site or carry out target advertisement, when sales strategy is made to suit new export market, when prices are differentiated according to age groups and time.

[Caution]

1. Introducing new advertisement through existing marketing company or media is not marketing innovation.
2. Advertisement using new media or technology such as mobile phones are included in the marketing innovation.
3. Only when it is significantly different from the existing methods of your enterprise. It does not matter if other companies are already using them.
4. Changes due to normal or seasonal factors are excluded.

10-1 During the three years 2009 to 2011, did your enterprise introduce:

	yes	no	
⑴Significant changes to the aesthetic design or packaging of a good (exclude changes that alter the product's functionality or user characteristics – these are product innovations)	1	2	E6
⑵New media or techniques for product promotion (i.e. the first time use of a new advertising media, a new brand image)	1	2	7
⑶New sales strategies such as new methods for product placement or sales channels	1	2	8
⑷ New methods of pricing goods (i.e. discount systems, etc)	1	2	9

※ If no to all, go to Section 11

※ If yes to any of Q. 10-1, please provide detailed innovation cases (ex. Advertisement using smart phone application) *10-13*

10-2 How important were the following objectives for your enterprise's marketing innovation during the three years 2009 to 2011. Please evaluate the importance of each objective. (If your enterprise introduced several marketing innovations, make an overall evaluation)

	Relevance		Importance			
	No(1)	Yes(2)	high	medium	Low	
⑴ Increase or maintain market share	☐	☐*14*	1	2	3	*17*
⑵ Introduce products to new customer groups	☐	☐*15*	1	2	3	*18*
⑶ Introduce products to new geographic markets	☐	☐*16*	1	2	3	*19*

11. Government support system/Patent etc

11-1 During three years 2009 to 2011, did your enterprise use any of the following government support systems? If yes, how important were they?

	Usage		Importance		
	No(1)	Yes(2)	high	medium	low
▯ Tax relief for technology development	☐	☐20	1	2	328
▯Support for technology development and funding	☐	☐21	1	2	3 29
▯ Participation in government R&D project	☐	☐22	1	2	3 30
▯ Technical support from the government	☐	☐23	1	2	3 31
▯ technology information	☐	☐24	1	2	3 32
▯ technicians and educational research	☐	☐25	1	2	3 33
▯ procurement by government or collective purchasing	☐	☐26	1	2	3 34
▯ Marketing (exhibition, export promotions etc.)	☐	☐27	1	2	3 35

11-2 Has your enterprise ever patented innovation or invention during the three years 2009 to 2011?

1. yes ☐	▎no. patents related to product innovation 37 | 38 | 39 | 40 ▎no. of patents related to process innovation 41 | 42 | 43 | 44 ▎no. of patents related to organisational/marketing innovation 45 | 46 | 47 | 48	☜ include only patented ones
2. no☐		

12. New Business

12-1 Has your enterprise attempted to search for new business during the three years 2009 to 2011? If yes, how were they attempted? (answer all)

1. Yes 50
   1. Employ specialists from within the country/abroad
   2. Dispatch internal employee to a relevant enterprise
   3. Understand the current trends in relevant sector (pay a study visit to a leading company etc.)
   4. attend relevant seminars or forums at home and abroad
   5. consultation with specialised organisation
   6. affiliate and technology agreement with related enterprise
   7. Merge/acquisition of related enterprise
   8. Other (51-52)
2. No -------❼ finish the survey 49

(if yes to Q. 12-1 please go to 12-2)

12-2 What was the achievement from the new business searches? If they were in process as of December 2011, please answer based on that. 53

1. No achievement
2. Setting up detailed new business strategy (model)
3. Decision on investment in new business
4. Produced sales from the new business
5. Other (54-55)

(Please answer Q.12-3 only if you answered yes to Q. 12-1)

12-3 Does your enterprise have a section devoted to new business searches? 56

If yes, how does it operate?

1. Yes 57
   1. Regular section
   2. Occasional section
2. No

(Please answer Q.12-4 only if you answered 'Regular section' in Q. 12-3)

What type of section is it? Please choose from the following. Please also provide number of employees and the size of the budget.

12-4

1. Type 58
   1. Management : HR/Admin
   2. Business: business planning/strategy, strategy planning
   3. Research: R&D/Research centre
   4. Other (59-60)
2. No. of Employees 61
   1. 1-4

2. 5-9
3. 10-19
4. Over 20

3. Budget size *62*
   1. No set budget
   2. Less than 1 billion
   3. More than 1 billion and less than 5 billion
   4. More than 5 billion and less than 10 billion
   5. More than 10 billion and less than 50billion
   6. More than 50 billion and less than 100billion
   7. over 100 billion (*63-64*)

♣ This is the end of the Survey. Please provide the following information for our purpose of data analysis.

General information about the enterprise	Name of your enterprise	*65-68*
	Business registration no.	*69* | *70* | *71* – *72* | *73* – *74* | *75* | *76* | *77* | *78*
	Address of the Enterprise	(county and city only) *79-80*
Information about the respondent	Department :	*f 6-7*
	Position :	*8-9*
	Name:	*10-13*
	Telephone :	*14* | *15* | *16* – *17* | *18* | *19* | *20* – *21* | *22* | *23* | *24*
	Fax no. :	*25* | *26* | *27* – *28* | *29* | *30* | *31* – *32* | *33* | *34* | *35*

♣ Thank you for completing the survey. Your responses are going to be used as primary data only to produce statistics. Thank you.

◈ **Interviewer**

List no.	36	37	38	39	40	Sample no.	41	42	43	44	–	46	47	48	ID	48-52

Name : 53-55
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- Changes in the company information

	Existing information	changes
Name of the company		56-59
Business nature	60-61	62-63
size	64	65
Location	66-67	68-69

Research Method: 1. Fax 2. Emil 3. Visit 70
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