The Effects of Intellectual Property Capability of Regions on R&D Performance of Individual Firms†

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Abstract

This research observes, through empirical analysis, the effects of the intellectual property capability of regions on the R&D performance of individual firms, which in detail refers to the firms' growth, profitability, innovativeness, and productivity in comparison with the industrial average. The Korean Institute of Intellectual Property's 2015 Intellectual Property Capability Assessment of Regions and Korea Investor's Service's Database on Firms' Financial Performance Index was used for the analysis.

The IP capability of regions were categorized into IP input, infrastructure, activity, and performance. The findings can be summarized as follows. First, a firm's (sales) growth rate was higher in regions with active IP and education services. Second, in terms of a firm's profitability, the industry's innovation (IP) system was found to be more influential than that of the region. Third, the ratio of R&D investment of firms to total sales was higher in regions with active IP input and excellent IP performance. However, IP performance was found to contribute to private R&D growth when both IP creation and commercialization were active. Fourth, the firm's Total Factor Productivity growth was found to be highly correlated with the region's IP system when the IP activities of both public and private sectors were active.

Despite these results, considering the 16 administrative areas of Korea, none of the areas were found to be active in both public and private sector IP activities, obtain a good score in both IP creation and IP services, or have an active IP service market. This leads us to believe that a thorough reconsideration of the IP systems of the various regions is necessary.

Keywords: national innovation system, regional innovation system, regional intellectual property system

1. Background and Purpose of Research

When we consider an innovation system, a firm's performance is influenced not only by the internal, but also by the external competence, which includes the relationship with the consumer; the network effect of business, education, and research institutes; the usefulness of the financial system; and government support and restrictions. This means that when a firm performs beyond the industry average, it is difficult to interpret this without considering the environment in which the firm exists, such as the nation, the industry, or the region. This statement is also valid in explaining the relationship between a regional firm's performance and the regional innovation system.

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The purpose of this study was to observe which internal and external competencies, and in particular which capabilities in the region's innovation system, are influential when a firm performs beyond the industry average. In considering a firm's internal competence, the study was focused on its intangible capital; for its external competence, the focus was on the region's innovation system. In particular, in relation to the innovation system, it was proposed that the scope be restricted to the region's intellectual property system, which was classified into the four categories of IP input, IP infrastructure, IP activities, and IP performance in order to perform the analysis. In other words, the objective of the study is to observe how individual categories of the region's IP system influence a firm's superior performance, measured from the perspective of growth, profitability, innovativeness, and productivity.

The study consists of the following sections. Chapter 2 summarizes the previous research in this area, and Chapter 3 explains the dataset and variables, and provides quantitative models. Chapters 4 and 5 provide the results of basic statistics and model estimation, respectively, while Chapter 6 concludes the study and suggests implications.

2. Previous Research on the Capability and Effects of a Region's Intellectual Property

2.1. Definition of a Regional Innovation System

Regions are being considered as the new unit of competition defining a nation's competitiveness (Scott and Storper, 2003). This means that the region is not only a physical, geographical space, but is also a social and institutional environment which promotes innovation (Kim and Choi, 2007). There are numerous definitions of the concept of a regional innovation system, but the consensus is that it can be defined using a model that combines the Systems of Innovation approach and the Innovative Environment approach. According to Cooke et al. (1997), a Regional Innovation System refers to the networks and institutions in which firms, research institutes, academies, regional governments, and financial institutions participate, interact and study under the institutional milieu of a region, in order to maximize the innovation potential of the regional economy. While Braczyk et al. (1998) and Asheim and Coenen (2004) define it as a system that triggers methodical interactive learning between the firm's production structure (knowledge utilization system) and the support infrastructures (knowledge creation system) of research institutes, universities, and technology transfer organizations, Evangelista et al. (2002) defines the system as the unique local network that creates, enhances, and diffuses new technologies through interactions between the public and the private sector. Jeong-hong Kim (2003) defines a regional innovation system as the policy through which the clusters of each region's strategic industry, innovative firms in the region, research institutes and universities, and other supporting agencies such as Regional Development Agencies establish interactive networks, and effectively cooperate to develop the region. Seok-jin Kim (2005) refers it to a cyclical process, in which the technology created through interactive study between the firms, research institutes, universities, residents, local governments, and other innovative subjects become industrial assets through the connection mechanism of regional finance, which in turn contributes to industrial development, and ultimately feeds back to the innovative subjects. There are minor differences in how the concept of the system can be defined, but the consensus on the regional innovation system is that it is an important factor that explains the networking

between the region's innovative subjects and supportive regional environments of which leads to the excellent performance of a firm.

2.2. Measurement of a Region's Intellectual Property Capability

Many previous studies have aimed to effectively measure a region's innovation system or capability. Fratesi (2004) suggested that the scale of a region's resources and R&D investment is a crucial factor in measuring the region's competence. Schiuma and Lerro (2008) categorized the knowledge-based elements which can be used to differentiate the innovative capabilities of regions: human capital, relational capital, structural capital, and social capital. Here, they emphasize that human capital is the know-how and competence the personnel in the region possess, which are important components of an innovative system that determines a region's competitive advantage, as they are important resources for sustainable innovation and can be increased by training and education. Relational capital is the index which represents the linkage between the region's knowledge capital, and includes not only the competence accumulated in the region, but also the connection with the subjects outside the region. Structural capital refers to the assets which promote the development, acquisition, management, and diffusion of knowledge in the region. This includes not only the innovation infrastructure of the region, but also the intellectual properties the stakeholders in the region possess. Lastly, social capital usually refers to the value, culture, and network identity of the region, or in other words the components of competence which were capitalized as the interactions between the innovative subjects accumulated.

Looking at previous studies conducted in Korea, Sung-jong Kim (2006) utilized the region's innovation foundation, innovative activities, and the region's innovativeness in order to analyze the innovation potential of 16 Korean administrative areas. The innovation foundation consists of a region's industrial, research, and information foundation, while the innovation performance consists of the number of venture firms, innovation exhibitions, total software sales, total software exports, and number of IPs in the region. Jin-su Kim and Myeong-shin Choi (2007) compared the innovation capabilities of local administrations, categorizing the capabilities as level of knowledge, economic power, human resource, and infrastructure. For the level of knowledge, the number of patent applications was used, while fiscal self-sufficiency ratio, number of workers in manufacturing and service industry, and the number of registered vehicles were used for the economic power, and the population and aging index were used for human resource. For infrastructure, total road length, number of medical personnel, urban land use, and the number of cultural facilities were used. Dong-sook Heo's recent study (2014) demonstrated that a region's innovation system can be evaluated using the existing statistics under the categories of Innovation input and resource (R&D expenditure, number of researchers and research institutes, number of incubation centers, etc.), Innovation environment and infrastructure (internet usage ratio, financial status of local administration, IT budget, etc.), economic and industrial foundation (Gross Regional Domestic Product (GRDP) per capita, income level, etc.), innovation calculation and performance (patent application and registration, percentage of venture firms, number of workers in knowledge-based manufacturing and service industry, etc.), and innovation process and linkage (number of firms' innovative activities, etc.).

2.3. *Effect Assessment of Regional Intellectual Property System*

The effect of a region's intellectual property system on the firms in the region can be explained by the agglomeration effect in cluster theory. The agglomeration effect is the functional synergy deriving from large-sized enterprise management, vertical integration of value chain, or concentration of diverse industries, academies, and research institutes in a nearby area.

Numerous studies have used the agglomeration effect to provide explanations on the performance of a regional innovation system. According to Cooke and Morgan (1998), a region's innovation system is not only the preconditions of technological innovations of firms, but also the aggregated system of institutions, knowledge structures, production structures, demand and competition, and trust and collaboration. Anselin et al. (2000), Bathelt et al. (2004), and Jaffe (1989) all suggested that a region's innovative behaviors and knowledge creation were found to be more vigorous when there were comparably more universities and research institutes. Lim (2004) argued that the specialization and diversity indices of a region's high-tech industry have a significant impact on the number of patents. Feldman and Audretsch (1999) analyzed the specialization, diversity, and competence indices of American science-based manufacturing industry in each region, and found a correlation between an industry's structural characteristics and the region's IP creation.

This agglomeration effect is maximized when various subjects of innovation concentrated in an area interact to produce, distribute, and reproduce tacit knowledge. Marshall (1920) emphasized through his Industrial District approach that spatial agglomeration establishes a decent pool of specialists, which in turn effectively spread knowledge among personnel, and ultimately recreate new knowledge through interactions. Furthering his argument, it can be said that the agglomeration effect explains the reason why a firm's performance increases when many firms in the same industry become concentrated in the same area. Patel and Pavitt (1994) suggested that the subjects of innovation reside in spatial and cultural proximity in order for them to minimize the uncertainty and danger that accompany the process of innovation, and emphasized the importance of geographic adjacency as the basic resource of success in innovation activities. Jaffe (1989) and Anselin, et al. (1997) both demonstrated how networks of inventors are arising in large cities, based on patent citation information. Exchange of tacit knowledge leads to the elimination of uncertainty, resulting in the success of innovation activities, and this unofficial face-to-face contact is more likely to occur in large cities with dense populations. Putnam (2000) addressed the agglomerate effect from the perspective of social capital, which includes trust, norms, and networks. The underlying idea was that communication and cooperation between innovative subjects are crucial for the knowledge to be created, and that the cities with abundant social capital are ideal locations for the interaction. According to Stern (2000), the innovation capabilities of regions rely on how ideally the research personnel and facilities are arranged in universities and research institutes, how agglomerated they are, and how well they are utilized.

There have also been numerous empirical studies on how regional IP capabilities influence the performance of the economy, industry, and a firm's performance in the region. Jae-jin Chung & Chae-hong Lim (2006) conducted an empirical analysis of the effects of a region's

innovation capability on an innovation firm's location and performance, based on 27 national industry innovation complexes. The regional innovation capabilities were categorized into four categories of economy (financial self-sufficiency), welfare (number of hospitals and social welfare facilities), industry's spatial competence (potential innovation capabilities, number of communication firms and manufacturers), and administrative competence (number of processed licenses and registers), and the factors the firms take into consideration when relocating to specific industry complexes were analyzed, from the perspective of regional innovation systems. It was found that innovation firms preferred regions with higher financial self-sufficiency, a higher potential innovation capability index, and more communication firms and manufacturers, while the correlation between the firm's location and the number of hospitals was relatively weak. It was also discovered that the region's financial self-reliance and the number of processed licences have a positive impact on the productive capacity and job creation of firms in the region. Hee-yeon Lee (2010) demonstrated how the number of postgraduate students in the region, the percentage of large companies in the region, the location quotient of leading manufacturers and knowledge-based manufacturers, and the diversity index of knowledge-based manufacturers had a statistically significant effect on regions' knowledge creation (patent application) differentials. Hong-joo Kim (2006) conducted a periodic analysis on the effects of a region's industry and technology structure, human resources, and social proximity on patent creation. The results showed that while in the 1990s the total number of firms, IT specialization, and adjacent social connection were the decisive factors, in the early 2000s, the percentage of specialists in the workforce arose as an additional significant factor.

3. Data and Analysis Model

3.1. Data

Two datasets are mainly used in the study's analysis. For regional IP capability, the Korea Institute of Intellectual Property's "2015 Intellectual Property Capacity Assessment of Regions" was used. Korea Institute of Intellectual Property began to measure the IP capacities of 16 administrative areas in Korea in four categories of input, infrastructure, activity, and performance, and announced the composite scores. The four categories consist of 9 types and 20 items. The RIPC assessment item in the IP infrastructure category was excluded from the study, as the performance evaluation on institutions that support a certain ministry may distort the interpretation of the study's analysis. The firm's productivity item in the IP performance category was also ruled out, as it is already included in the analysis as a performance variable, and using the same value as one of the explanatory variables may result in causality issues.

IP input indices fall into one of the two categories of IP stock and financial investment, and are used to assess the essential input factors of regions in order to achieve IP creation. IP infrastructure indices consist of local administrations and services, and are used to assess the basis of a region's IP activities. IP activity indices are divided into the public and the private sector, and each are again segmented into the size of R&D organizations, and IP management and university-industry cooperation performance. IP performance indices are categorized into IP creation performance and economic performance. The detailed items of each index are explained in Table 1.

Table 1. IP capability indices for regions

Category	Type	Item	Sub-item
Input	IP Stock	IP Size	- Patent rights/design rights/trademark per 10,000 people - Region's territorial asset trademark
		IP Quality	- Patent's qualitative assessment grades, trademark registration & renewal rate
	Financial Investment	IP Investment	- IP budget amount, percentage of local gov't investment on IP budget
		R&D Investment	- Public sector R&D budget, private sector R&D budget
Infrastructure	Local Gov't & Institutions	IP-related Organizations & Institutions	- Presence of IP organization and IP specialist - Administrative efficiency of IP organizations, number of IP-related ordinances
		SME Supporting Organizations	- Personnel expertise, RIPC budget and activity - Technoparks, Creative Economy Centers personnel and budget management
	Service	IP Specialists	- IP service personnel, number of patent agents
		Education	- Credits in university and postgraduate courses, invention classes
Activity	Public Sector	R&D Organizations	- No. of R&D organizations/researchers per 10,000 people - Average number of researchers per R&D organization
		IP Management & University-industrial Cooperation	- Ratio of Technology Licensing Organizations, IP organizations and regulations
	Private Sector	R&D Organizations	- Number of R&D organizations/researchers per 10,000 people - Average number of researchers per R&D organization
		IP Management	- Ratio of firms with patented technology - IP organizations and regulations, technology valuation, IP financing
Performance	IP Creation	Quantitative Performance	- Number of patent/design/trademark applications per 10,000 people - Territorial asset trademark applications per 10,000 people
		Qualitative Performance	- Percentage of annual PCT applications among total applications - Applied patent's scope of protection and ratio of joint application
		Activity Performance	- Percentage of patent applied firms
	Economic Performance	IP Transfer Performance	- Technology transfer, national R&D engineering fee
		IP Commercialization Performance	- Commercialization of national and firm's R&D performance

Source: Korea Institute of Intellectual Property (2015), Intellectual Property Capacity Assessment of Regions, Amended

In order to measure a firm's performance and internal competence, the financial data of 24,990 firms were collected from Korea Investor's Service. Since the KIIP's Intellectual Property Capacity Assessment of Regions first commenced in 2014, Korea Investor's Services financial data from 2013 to 2015 was used.

Firm performance was measured in four categories: growth, profitability, innovativeness, and productivity. In order to measure the performance created by the intangible assets and innovative capabilities of the firm, the industry average performance was calculated from Korean Standard Industrial Classification's Division 2, and deducted from the performance of individual firms. The result was named "excess performance," and served as the basis for analysis.

Table 2. Excess performance indices of individual firms

Category	Indices
Growth	- Sales Growth: Compound Annual Growth Rate (CAGR) between 2013 and 2015, industry average deducted - Employment Growth: CAGR between 2013 and 2015, industry average deducted
Profitability	- Rate of Operating Profit: Operating income to sales in 2015, industry average deducted - ROA: Net profit to gross asset in 2015, industry average deducted
Innovativeness	- R&D Concentration: R&D Investment to sales in 2015, industry average deducted - R&D Expenditure Growth: CAGR between 2013 and 2015, industry average deducted
Productivity	- Total Factor Productivity Growth: CAGR between 2013 and 2015, industry average deducted - Labor Productivity: Sales per employee in 2015, industry average deducted

Table 3. Indices of internal competence of intellectual property

	Definition	Indices
Expenditure on Human Capital	- Employees' expertise, experience, skills, problem solving, leadership, entrepreneurship, business management know-how, innovativeness, etc.	- Personnel expenses, severance pay - Training expenses
Expenditure on Structural Capital	- Infrastructure, organizational process and structure, and information systems to support the personnel - Innovation, IP (Industrial Property, trade secrets, know-how) etc.	- R&D expenses - Welfare benefits, book and printing budget
Expenditure on Customer Capital	- Brand, relationship with clients and suppliers, industrial network, distribution channels, etc.	- PR expenses, sales promotion expenses - Export expenses, overseas marketing expenses

Source: Korea Institute of Intellectual Property (2015), Intellectual Property Capacity Assessment of Regions

A firm's internal IP competence is accumulated in the form of human capital, structural capital, and customer capital. However, it was impossible to identify the accumulative amount of capital due to the restrictions in the firms' financial dataset, and thus the expenditures on human, structural, and customer capital were used as proxy variables. For instance, the sum of firms' expenditure on personnel, severance, training, and education was used as the proxy variable, as it is highly correlated with human capital. For structural capital, the sum of R&D and welfare expenditure was used as the proxy variable, while for customer capital the sum of PR, promotion, exporting, and overseas marketing expenditures were used.

3.2. Basic Statistics

The composite scores of IP input, IP infrastructure, IP activity, and IP performance for 16 Korean administrative areas are as follows.

Table 4. IP input, infrastructure, activity, and performance scores of regions

Region	IP Input	IP Infrastructure	IP Activity	IP Performance
Seoul	49.7	39.9	57.7	42.4
Busan	25.6	44.3	28.2	26.9
Daegu	30.2	27.3	19.6	26.0
Incheon	24.2	26.2	41.6	35.9
Gwangju	17.7	26.4	30.8	33.7
Daejeon	64.4	56.9	78.9	41.6
Ulsan	37.5	24.6	37.5	31.8
Gyeonggi	48.5	21.7	63.8	57.0
Gangwon	16.8	26.8	21.0	37.1
Chungbuk	23.1	43.4	41.0	37.9
Chungnam	30.3	29.1	51.2	41.0
Jeonbuk	13.9	32.8	29.1	40.8
Jeonnam	15.7	28.4	24.6	27.3
Gyeongbuk	28.8	27.1	33.3	23.8
Gyeongnam	20.2	24.3	28.6	26.0
Jeju	11.4	40.1	7.2	30.9
Mean	28.6	32.5	37.1	35.0

Source: Korea Institute of Intellectual Property (2015), Intellectual Property Capacity Assessment of Regions

First, for IP input, Daejeon was ranked the highest with 64, followed by Seoul and Gyeonggi. Since Daeduck Research Complex and other public research institutes are located in Daejeon, the city's cumulative number of patents is high and the government R&D investment is active. This is also the case for Seoul and Gyeonggi, as many venture firms and corporate research institutes are located in this area, and private sector R&D investments are active.

Daejeon was also ranked the highest in IP infrastructure indices, followed by Chungbuk and Busan. Since the core indices of IP infrastructure are the presence and size of IP organizations in local governments, the administrative efficiency of local administrations, and small and medium-sized enterprise support activities, Daejeon, where these public services are concentrated, was able to get a good score on this as well.

For IP activity, Daejeon was also ranked the highest, with Gyeonggi and Seoul in second and third place, respectively. This is because the number of researchers in public and private sector research institutes is the core index of IP activity score.

For IP performance, Gyeonggi was ranked first, while Daejeon was in the middle of the table. Judging by the results, it can be assumed that the reason why Daejeon's IP performance score is low, despite the fact that IP performance is influenced by the number of patent applications, is that the city lacks technology transfer and commercialization performance, as the city's IP system is focused more on public research institutes.

Then, the human, structural, and customer capital were measured, based on the firms' investment on enhancement of internal competence. The results are as follows.

Table 5. Firm's internal competence of Intellectual Property (Percentage of expenditure on sales, %)

Regions	Expenditure on Human Capital	Expenditure on Structural Capital	Expenditure on Customer Capital
Seoul	11.64	0.66	3.31
Busan	6.80	0.36	1.38
Daegu	7.11	0.69	1.58
Incheon	6.28	0.74	1.72
Gwangju	6.50	0.60	1.61
Daejeon	9.98	1.97	2.27
Ulsan	5.94	0.48	1.12
Gyeonggi	7.20	1.11	1.82
Gangwon	9.51	1.00	3.34
Chungbuk	6.19	0.87	2.10
Chungnam	5.80	0.75	1.86
Jeonbuk	5.22	0.88	1.68
Jeonnam	4.92	0.43	1.31
Gyeongbuk	5.23	0.50	1.49
Gyeongnam	5.34	0.44	1.43
Jeju	11.31	0.67	3.01
Mean	8.04	0.77	2.17

The firms were found to spend 8.04% of total sales on human capital. In Seoul and Jeju, the numbers go up to more than 10%. In Seoul, where high wage personnel are abundant and a diverse educational infrastructure is in place, employee education and training are active. In contrast, Jeju's economy is less focused on manufacturing and more in the service industry, which accounts for the high personnel expenses.

Structural capital refers to the ratio of R&D investment to total sales, and the national average was a mere 0.77%. Daejeon was ranked the highest at 1.97%, followed by Gyeonggi's 1.11%, where the infrastructure for venture firms is well established in towns like Pangyo. However, even the highly ranked areas only invest a small amount in this type of capital.

Firms were found to spend 2.17% of total sales on customer capital, which include promotion and PR expenses. Seoul, Gangwon and Jeju were on the top of the table, with their spending on customer capital exceeding 3% of total sales.

The study measured the excess performance in terms of a firm's growth, profitability, innovativeness, and productivity, as a firm's performance indices. The absolute performance indices, without deducting the industry average, are as follows.

Table 6. Firm performance in regions

Regions	Growth		Profitability		Innovativeness		Productivity	
	Sales Growth (%)	Employment Growth (%)	Rate of Operating Profit (%)	Net Income Ratio (%)	R&D Intensity (%)	R&D Growth (%)	TFP Growth (%)	Labor Productivity Growth (%)
Seoul	0.81	-2.86	1.61	3.98	0.25	-21.88	-0.78	-0.40
Busan	-0.40	1.51	2.13	2.94	0.18	-21.86	-1.08	-0.56
Daegu	-1.60	-0.88	2.27	3.83	0.40	10.10	-1.41	-0.66
Incheon	0.84	-2.38	1.76	2.92	0.49	15.29	-0.77	-0.27
Gwangju	11.21	-0.43	2.57	4.76	0.17	-10.97	0.11	-0.16
Daejeon	-6.55	-0.22	0.95	5.25	1.28	-16.17	-1.13	-0.68
Ulsan	0.63	-0.21	1.76	3.81	0.23	-37.94	-0.70	-0.31
Gyeonggi	-0.45	-0.61	1.46	2.31	0.73	-9.24	-0.75	-0.34
Gangwon	4.34	-3.01	-0.34	-0.73	0.37	4.59	-0.09	-0.07
Chungbuk	4.75	0.53	2.18	2.19	0.59	25.29	-0.39	-0.20
Chungnam	-0.68	-3.18	1.99	2.42	0.45	-5.25	-0.66	-0.39
Jeonbuk	3.88	1.30	0.54	1.01	0.30	28.98	-0.63	-0.41
Jeonnam	5.99	2.42	1.53	4.47	0.20	-23.86	-0.42	-0.16
Gyeongbuk	-3.87	-3.09	0.37	1.33	0.36	-1.87	-1.02	-0.50
Gyeongnam	-1.46	0.59	0.55	0.96	0.25	-0.88	-1.02	-0.59
Jeju	10.82	-4.28	0.78	1.25	0.13	-31.49	-0.54	0.01
Mean	0.35	-1.30	1.50	2.86	0.42	-10.48	-0.79	-0.39

The national average sales growth of Korean firms was only 0.35%, and employment decreased by 1.3% in 2015. In terms of profitability, the average ratio of operating profits to sales was 1.5%, while the average net profit ratio was 2.8%. In terms of innovativeness, the average ratio of R&D investment to total sales was only 0.42%, which was down by 10.4%. On productivity, the total factor productivity and labor productivity are both decreasing. All 8 indices show the slow growth of the Korean economy overall.

On the regional scale, Gwangju, Jeonbuk, and Jeonnam were regions with comparably higher growth in terms of sales and employment. These regions also showed comparably brisk statistics in terms of profitability. Although Daejeon was ranked the highest in terms of innovation factor input, infrastructure, and activity, the firms' average sales and employment was showing a decline. Considering that the region's R&D investment growth is rapidly declining despite its comparably higher ratio of R&D intensity to total sales, the high R&D intensity is considered to have been influenced by the decrease in total sales, rather than the increase in R&D expenditure. In terms of productivity, all regions except for Gwangju are experiencing a decline. The decline in productivity all over the country, despite the general decline in employment and investment in facilities, is caused by the structural abyss of slow growth.

3.3. Analysis Model

Excess performance, which is derived by taking the 8 indices of a firm's performance, as suggested in Table 1, and subtracting the industry average, was used as the dependent variable, while the three internal innovation capabilities (human, structural, and customer capital), and four categories of regional innovation systems (IP input, IP infrastructure, IP activity, IP performance) were used as the independent variable. The quantitative model which assesses the effect of region j's IP system on the performance of firm i which is located in region j is then established as follows:

$$Firm's\ Performance_{ij} - Industry\ average_j = \phi control\ variables_{ij} + \alpha \cdot Internal competence_{ij} + \beta \cdot regional competence_j + \epsilon_{ij}$$

The control variables included to rule out the effect of scale and political support are firm age, gross assets, and whether or not the firm is considered a small and medium-sized enterprise.

The four categories of regional capabilities were used in the analysis for the study, along with 8 items in order to analyze the results in different dimensions. Each of the variables are natural logarithms of composite scores for each capabilities. In order to check the error deriving from interrelationship between explanatory variables in quantitative models using the least squares method, the correlativities between 8 independent variables on a region's innovative capabilities, 3 independent variables on a firm's internal competence, and 2 control variables excluding the dummy variable, were calculated. The correlations between variables were low.

4. Results of Analysis

4.1. Growth

Table 7 shows the effect of a region's IP capability on a firms' sales and employment growth.

Among the internal competencies of firms, expenditure on structural capital was found to contribute to the firms' sales and employment growth. This reflects the fact that expenditures on R&D have bigger effects on a firm's growth than spending on human or customer capital, because unlike other types of capital, investment in R&D expenditures is accompanied by investments in facilities, which leads to the employment of professionals, and ultimately results in short-term sales growth due to the promotion of new facilities.

Table 7. Effects of regions' IP capability on growth

Independent Variables		Model I (Based on IP capability categories)				Model II (Based on IP capability types)			
		Sales Growth		Employment Growth		Sales Growth		Employment Growth	
		Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation
Control Variable	Firm Age	-0.070***	0.011	-0.027***	0.009	-0.070***	0.011	-0.027***	0.009
	Gross Assets	-0.055***	0.010	-0.034***	0.008	-0.055***	0.010	-0.035***	0.008
	Small and Medium Enterprises	-0.038*	0.022	0.011	0.017	-0.038*	0.022	0.011	0.017
Firm's Competence	Human Capital	0.015	0.011	0.010	0.008	0.012	0.011	0.011	0.008
	Customer Capital	-0.006	0.005	-0.001	0.004	-0.006	0.005	0.000	0.004
	Structural Capital	0.008**	0.004	0.010***	0.003	0.008**	0.004	0.010***	0.003
Regional Competence	IP Input	-0.055	0.035	0.005	0.027				
	IP Stock					-0.054	0.044	-0.023	0.034
	Financial Investment					-0.018	0.022	0.012	0.017
	IP Infrastructure	0.088***	0.028	0.031	0.022				
	Local Gov't					-0.017	0.027	0.034	0.021
	Service					0.085**	0.039	0.055*	0.030
	IP Activity	0.044	0.047	-0.018	0.036				
	Public Sector					0.012	0.045	-0.044	0.035
	Private Sector					0.024	0.028	0.020	0.022
	IP Performance	0.041	0.047	0.022	0.036				
	IP Creation					0.037	0.028	-0.004	0.022
	Econnomic Performance					0.093	0.058	0.044	0.045
Constant Variable		0.899***	0.287	0.499**	0.228	0.805**	0.370	0.342	0.292
Industry Dummy Variables		Included		Included		Included		Included	
No. of Observations		6,216		5,384		6,216		5,384	
R^2		0.029		0.023		0.031		0.024	

1) Asterisks ***,**,* each refer to 1%, 5%, 10% significance level, respectively.

2) The upper and bottom 2.5th percentile dependent variables are excluded as outliers.

Among regional IP capabilities, the firms' sales growth was bigger in regions with higher IP infrastructure scores. For a 1% increase in IP infrastructure scores, the sales growth rate compared to the industry average increased by 0.08%p.

To identify this mechanism in greater detail, the regional innovation capabilities were further segmented into the units of types (see Table 1), and were used as independent variables (Model II of Table 7). The results showed that the statistics related to the specialists in the private sector, such as the density and activity of IP service-related workers or patent agents, or the excellence of relevant education infrastructures, were influential on the firm's sales growth or job creation, rather than the local government's competence. Since the IP-related personnel mainly contribute to the commercialization process, rather than the R&D phase, the analytic results of Model II are in accordance with the expectation.

However, these IP-related personnel tend to reside in large cities, due to agglomeration effects. If the service-concentrated large cities act as hub cities which diffuse benefits to other nearby cities, the shortage of IP-related personnel in rural administrative areas is not a cause for concern. However, as seen in Table 5, while Seoul scored 70 on IP service, Busan scored 32, and other large cities such as Daegu, Incheon, Gwangju, Daejeon, and Ulsan scored 19, 16, 27, 33, and 15, respectively. Incheon is adjacent to Seoul, and is less likely to be able to supply IP service personnel. However, Daegu and Ulsan, which are cities far away from Seoul, do suffer from a shortage in personnel, and cannot function as hub cities of IP services. Therefore, the roles of metropolitan cities as hub cities of IP service markets must be reevaluated in consideration of local universities.

4.2. Profitability

Table 8 shows the effects of a region's IP capability on the firm's ratio of operating profit to sales and net profit.

Of the internal competencies of firms, increased expenditure on customer capital was found to contribute to an increase in a firm's profitability. This means that investing in market encounters, which include efforts to enhance the relationship with customers and marketing, leads to an actual increase in profitability of the firm.

However, among the IP capabilities of regions, none were found to enhance the profitability of firms.

Similar results were found using Model II, which indicates that industry effects such as the performance and the competition of the industry are what influences the firm's profitability, not the regional effects.

4.3. Innovativeness

Table 9 shows the effects of a region's IP capability on the firm's R&D investment to total sales, and the R&D investment growth.

First, of the internal competencies of firms, the growth of expenditure on structural capital was found to contribute to the firm's improvement in innovativeness. However, this correlativity is presumed to have been due to the fact that the variable on structural capital is based on the R&D investment statistics of 2013, while the performance variable is based on the statistics of 2015. In general, firms that continuously invest in R&D tend to maintain the same level or increase investment over the previous year.

In contrast, a firm's ratio of R&D investment to total sales was higher in regions with higher IP input and IP performance.

Table 8. Effects of regions' IP capability on profitability

Independent Variables		Model I (Based on IP capability categories)				Model II (Based on IP capability types)			
		Operating Profit to Sales Ratio		Net Profit Ratio		Operating Profit to Sales Ratio		Net Profit Ratio	
		Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation
Control Variable	Firm Age	0.431	0.379	1.214***	0.326	0.431	0.379	1.201***	0.327
	Gross Assets	-0.116	0.332	-1.412***	0.288	-0.159	0.332	-1.437***	0.289
	Small and Medium Enterprises	0.873	0.734	1.466**	0.640	0.843	0.734	1.452**	0.640
Firm's Competence	Human Capital	0.389	0.353	0.928***	0.305	0.495	0.355	0.964***	0.307
	Customer Capital	0.522***	0.181	0.668***	0.157	0.536***	0.181	0.679***	0.157
	Structural Capital	0.217*	0.122	0.319***	0.107	0.203*	0.122	0.317***	0.107
Regional Competence	IP Input	-2.052*	1.177	-0.026	1.013				
	IP Stock					-0.387	1.471	-0.953	1.281
	Financial Investment					-0.688	0.751	0.373	0.653
	IP Infrastructure	-0.560	0.954	0.736	0.833				
	Local Gov't					0.876	0.913	0.385	0.802
	Service					-1.724	1.307	0.194	1.138
	IP Activity	2.283	1.587	-0.407	1.360				
	Public Sector					1.897	1.525	0.395	1.338
	Private Sector					1.245	0.957	0.292	0.829
	IP Performance	0.305	1.585	1.021	1.375				
	IP Creation					-0.621	0.955	0.215	0.835
	Econ. Performance					-0.462	1.957	0.007	1.692
Constant Variable		-17.910	9.528	-6.697	8.272	-19.201	12.345	-4.790	10.660
Industry Dummy Variables		Included		Included		Included		Included	
No. of Observations		6,243		6,331		6,243		6,331	
R^2		0.014		0.021		0.016		0.022	

1) Asterisks ***,**,* each refer to 1%, 5%, 10% significance level, respectively.

2) The upper and bottom 2.5th percentile dependent variables are excluded as outliers.

Table 9. Effects of regions' IP capability on innovativeness

Independent Variables		Model I (Based on IP capability categories)				Model II (Based on IP capability types)			
		R&D Investment to Total Sales		R&D Growth		R&D Investment to Total Sales		R&D Growth	
		Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation
Control Variable	Firm Age	-0.144***	0.039	0.046*	0.024	-0.1378**	0.039	0.046*	0.024
	Gross Assets	-0.252***	0.035	-0.038*	0.021	-0.264***	0.034	-0.043*	0.021
	Small and Medium Enterprises	0.274***	0.074	0.085*	0.045	0.264***	0.073	0.082*	0.045
Firm's Competence	Human Capital	-0.099***	0.036	0.039*	0.022	-0.066*	0.036	0.046**	0.022
	Customer Capital	-0.050***	0.019	0.023**	0.012	-0.045**	0.019	0.024**	0.012
	Structural Capital	0.457***	0.013	0.009	0.010	0.452***	0.013	0.008	0.010
Regional Competence	IP Input	0.352***	0.119	-0.003	0.070				
	IP Stock					0.483***	0.146	-0.044	0.089
	Financial Investment					0.349***	0.076	0.039	0.046
	IP Infrastructure	0.143	0.097	-0.081	0.059				
	Local Gov't					0.444***	0.095	0.021	0.057
	Service					-0.490***	0.132	-0.156*	0.080
	IP Activity	0.032	0.164	0.062	0.097				
	Public Sector					0.461***	0.156	0.148	0.095
	Private Sector					-0.171*	0.101	0.060	0.060
	IP Performance	0.446***	0.163	-0.007	0.097				
	IP Creation					-0.105	0.096	-0.040	0.058
	Econ. Performance					-0.228	0.195	-0.149	0.117
Constant Variable		-0.972	0.988	-2.286	0.812	-0.504	1.252	0.777	-0.360
Industry Dummy Variables		Included		Included		Included		Included	
No. of Observations		4,212		4,294		4.212		4,294	
R^2		0.268		0.008		0.286		0.012	

1) Asterisks ***,**,* each refer to 1%, 5%, 10% significance level, respectively.

2) The upper and bottom 2.5th percentile dependent variables are excluded as outliers.

When Model II was used for the analysis, a firm's R&D investment was higher in regions with IP stocks of higher quality, and with stronger financial investment from the central government. In terms of IP infrastructure, regions with a solid structure and vigorous activities contributed to the firm's R&D performance. In contrast, the ratio of a firm's R&D investment to total sales was lower in regions with active IP services. This is basically due to the increase in total sales, rather than the decline in R&D investment, as shown in Table 7. The sales growth is likely to be high in regions with active IP service infrastructures in the private sector, and this speed of growth may exceed the growth of R&D investment, thus decreasing the ratio of R&D investment to total sales. In terms of IP activity, the firm's investment in R&D was strengthened in regions with more abundant research personnel and vigorous industry, education, and research collaboration in the public sector. However, this correlation was not found to be statistically significant in the private sector.

Table 9 shows that a firm's R&D investment tended to strengthen in regions with excellent IP performance, as reflected in a higher number of patent applications and vigorous technology transfer and commercialization. However, such correlation is not found when using Model II, and this means that IP creation and economic performance should take place in parallel, in order for the IP performance to contribute to the firm's R&D investment. Regions without IP commercialization, or without a decent stock of IP will not be able to link their strength toward firms' actual investment on R&D, failing to establish a successful virtuous mechanism.

4.4. Productivity

Table 10 shows the effects of a region's IP capability on firms' total factor productivity and labor productivity growth.

First, the productivity of firms was lower in regions with more IP input, while the productivity of firms in regions with vigorous IP activities was comparably higher.

Under the analysis using Model II, financial investment was found to be correlated to a firm's productivity. However, it would be hasty to jump to the conclusion that bigger financial investment from governments for local administrations leads to a decline in productivity for firms. Rather, the central government invests more in regions with low GRDP and low productivity, as the composite score for financial investment is calculated based on the percentage of government financing on GRDP. This causality issue derives from the limits of the quantitative models and datasets used in this study.

Critically, the significance of the IP activity found using Model I disappeared when Model II was used, a similar result to the innovativeness analysis shown in Table 9. This means that the IP activities of both the public and private sector should seek synergy through interactions in order to enhance the productivity of firms in the region. A great example of this assumption is the low productivity of Daejeon, despite strong public sector activities, and of Seoul and Gyeonggi, despite strong private sector activities, as the asymmetric status of public and private sector activities cannot work in synergy to benefit the productivity of firms in the region.

Table 10. Effects of regions' IP capability on productivity

Independent Variables		Model I (Based on IP capability categories)				Model II (Based on IP capability types)			
		TFP Growth		Labor Productivity		TFP Growth		Labor Productivity	
		Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation	Estimated Coefficient	Standard Deviation
Control Variable	Firm Age	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.001
	Gross Assets	0.001	0.001	-0.001**	0.000	0.001	0.001	-0.001**	0.000
	Small and Medium Enterprises	-0.001	0.002	-0.001	0.001	-0.001	0.002	-0.001	0.001
Firm's Competence	Human Capital	0.000	0.001	0.001	0.001	0.000	0.001	0.001	0.001
	Customer Capital	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Structural Capital	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Regional Competence	IP Input	-0.010***	0.003	-0.004**	0.002				
	IP Stock					0.000	0.003	0.000	0.002
	Financial Investment					-0.005***	0.002	-0.002**	0.001
	IP Infrastructure	0.002	0.002	0.001	0.001				
	Local Gov't					-0.003	0.002	-0.001	0.001
	Service					0.005*	0.003	0.001	0.002
	IP Activity	0.008**	0.003	0.003	0.002				
	Public Sector					-0.001	0.003	0.002	0.002
	Private Sector					0.002	0.002	0.000	0.001
	IP Performance	0.003	0.003	0.001	0.002				
	IP Creation					0.002	0.002	0.001	0.001
	Econ. Performance					0.012***	0.004	0.003	0.003
Constant Variable		-0.056***	0.021	-0.008	0.014	-0.084***	0.027	-0.012	0.018
Industry Dummy Variables		Included		Included		Included		Included	
No. of Observations		5,382		5,396		5,382		5,396	
R^2		0.019		0.015		0.022		0.016	

1) Asterisks ***,**,* each refer to 1%, 5%, 10% significance level, respectively.

2) The upper and bottom 2.5th percentile dependent variables are excluded as outliers.

5. Conclusion and Implications

This study explains the correlation between firms' excess performance and the region's innovation system. A firm's high performance in comparison with the industry average was found to be highly related not only to the efforts of individual firms, but also to the capability of the industry's or the region's innovation system. The study aimed to focus specifically on the IP capability in explaining a firm's performance above the market average.

Table 11 summarizes the results of this research. A firm's investment in R&D is related with each and every aspect of a region's IP capability. If a region's IP input is high, its IP infrastructure is solid, it is active in IP activities, and achieves excellent IP performance, a firm in the region will strengthen its R&D investment, thereby creating a virtuous cycle. However, the IP service market and private R&D system were found to not contribute much during this process compared to their public counterparts. Moreover, in order for a region's IP performance to influence a firm's excess performance, the region's IP creation and commercialization must be simultaneously invigorated. The fact that the average R&D concentration rate among firms was below 1%, as shown in Table 2, indicates that the contributions of the public sector are insufficient to continuously attract an intensification of R&D investment from the private sector.

The invigoration of the IP service market and education services was found to contribute to firms' growth. This stresses the need for the current system, which focuses only on market opening, to be strengthened in order to contribute not only to the R&D phase, but also to an overall enhancement in the productivity and industrial structure of a firm. But by its nature, the IP service market is one of the aspects most influenced by the agglomeration effect, and thus it is inevitable for this market to be concentrated on Seoul and five other metropolitan cities. A thorough planning which would provide services to other regions, while metropolitan cities act as market hubs, is therefore required.

Table 2 shows the slow growth of Korean Firms' productivity. It can be seen that IP activities contribute to a firm's productivity only when the public and the private sector work in synergy. In Daejeon, where IP activities of the public sector are vigorous, the private sector IP activities were poor, while in regions with strong private IP activities such as Seoul and Gyeonggi, the public sector's IP activities were poor. If the government seeks to support regional IP systems in regard to market down, the effects of the support policy may not trickle down onto individual firms. These results stress the need to reconsider the effectiveness of government policies, and to select and concentrate public and private resources on a single definite goal.

Table 11. Effects of region's IP capability on a firm's overall performance

	Growth	Profitability	Innovativeness	Productivity
IP Input			Contribution (Gov't financing, IP registration, etc.)	
IP Infrastructure	Partial Contribution (IP service market & education service)		Partial Contribution (Competence of local administrations)	
IP Activity			Partial Contribution (Public sector activities)	Conditional Contribution (Under the precondition of synergy between the public and private sector)
IP Performance			Conditional Contribution (Under the precondition of both IP creation and commercialization)	

However, it is still too early to overtrust the findings of this study, as there exist methodological and data restrictions in empirically assessing a region's innovation capacity in linkage with the performance of individual firms. Including detailed indices of regional IP capabilities as explanatory variables for multilateral interpretation may cause errors in interrelationship of variables. Also, in the methodological sense, this study considers the regional variables and firm variables as explanatory variables at an equal level, but these variables are in fact hierarchical data, as firms are located in a specific region. This calls for the need to apply a Multi-level model in the analysis, but due to certain restrictions the study utilized the least squares model. The empirical results of this study, which focused on the one-way effect of the regional IP capability on a firm's excess performance, neglected the mutual influence between the two variables, and therefore restricts us from extending the interpretation beyond statistic significance.

In further studies, it is necessary to enhance the methodology of the study, to modify the analysis model through reconstruction of the IP capacity indices, to collect the specialist's thoughts on the results, and to calibrate and systemize the mechanism related to how the IP capabilities influence a firm's performance.

References

Anselin, L., Varga, A. and Acs, Z. (1997) "Local Geographic Spillovers between University Research and High Technology Innovations", Journal of Urban Economics, Vol. 42, pp. 422-448.

Anselin, L., Varga, A. and Acs, Z. (2000) "Geographical Spillovers and University Research: a Spatial Econometric Perspective", Growth and Change, Vol. 31, pp. 501-515.

Bathelt, H., Malmberg, A. and Maskell, P. (2004) "Clusters and Knowledge: Local Buzz, Global Pipelines and the Process of Knowledge Creation", Progress in Human Geography, Vol. 28, pp. 31-56.

Braczyk, H., Cooke, P. and Heidenreich, M. (1998) "Regional Innovation Systems", Routledge, UCL Press.

Cooke, P., Gomez, M. and Etxebarria, G. (1997), "Regional innovation systems: institutional and organisational dimensions", Research Policy, Vol. 26, pp. 475-491.

Cooke, P. and Morgan, K. (1998), "The associational economy: firms, regions, and innovation". Oxford: Oxford University Press.

Evangelista R., Iammarino, S., Mastrostefano, V. and Silvani, A. (2002) "Looking for regional systems of innovation: evidence from the Italian innovation survey," Regional Studies, Vol. 36, pp. 173-186.

Feldman, M. P. and Audretsch, D. (1999), "Innovation in cities: science-based diversity, specialization and localized competition", European Economic Review Vol. 43, pp. 409-429.

Fratesi, U. (2004) "Regional Economies, "Innovation and Competitiveness in A system Dynamics representation", QUADERNI DI RICERCA (Universita Politechnica delle Marche, Dipartimento di Economia), pp. 204-210.

Jaffe, A. (1989), "Real Effects of Academic Research", American Economic Review, Vol. 79, pp. 957-970.

Lim, U. (2004) " Knowledge spillovers, agglomeration economics, and the geography of innovative activity; a spatial econometric analysis", The Review of Regional Studies, Vol. 34(1), pp. 11-36.

Marshall, A. (1919) "Industry and Trade", Macmillan.

Patel, P. and Pavitt, K. (1994) "National innovation system: When they are important, and how they might be measured and compared", Economics of Innovation and New technology.

Putnam, R. (2000). Bowling Alone: The collapse and Revival of community. Touchstone Books.

Schiuma, G. and Lerro, A. (2008) "Knowledge-based capital based in building regional innovation capacity", Journal of Knowledge Management, Vol. 12(5), pp. 121-136.

Scott, A. and Storper, M. (2003) "Regions, Globalization, Development," Regional Studies, Vol. 37(6-7), pp. 579-593.

Stern, S., Michael, E., Poter, J. and Furman, L. (2000) "The determinants of national innovative capacity", National Bureau of economic research, pp. 1-56.

Kim, Seok-jin (2005) "Regional Innovation and the Tasks of Regional Finance", Daegu Bank Economic Review, pp.50-73.

Kim, Seong-jong, Ko, Seok-chan, Ko, Kim, Hak-min (2006) "Analysis on Regional Innovation Potential for the

Establishment of Regional Innovation System", Korea Academia-Industrial Cooperation Society, Vol. 7. pp. 80-88.

Kim, Jeong-hong (2003) "An Empirical Analysis between Regional Innovative Capabilities and Regional Industrial Performances in Korea", The Korean Economic Association, pp. 99-121.

Kim, Jin-su, Choi, Myeong-shin (2007) "An Empirical Investigation of the Upper and the Lower Local Governments Innovation Capability in Korea“, Financial Knowledge Research, Vol. 5(2), pp. 29-57.

Kim, Hong-joo (2006) "Determinants of Regional Knowledge Production Based on Korean Patent Data", Korean Journal of Regional Science Vol. 22(3), pp. 95-115.

Lee, Hee-yeon (2010) “The Spatial Clustering of Knowledge Production Activities and Its Determinants of Regional Disparity based on Korean Patent Data”, Korea Intellectual Property Society, Vol. 5(1), pp. 115-149.

Jeong, Jae-jin, Lim, Chae-hong (2006) “Empirical Analysis on RIC (Regional Innovation Capacity) and LPIE (Location and Performance of Innovational Enterprises)”, Korea University Institute of Governmental Studies, Governmental Studies, pp. 171-201.

Heo, Dong-sook (2014) “The Influence of Innovative Capacity on Regional Economic Performance”, Journal of the Korean Geography Society, Vol. 49(6), pp. 884-896.

Korea Institute of Intellectual Property (2014), Developing a Model for Measuring the Intellectual Property Capacity of Regions.