Impact Analysis of Intellectual Property Infrastructure

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Abstract

As the value and role of intellectual property increases in our knowledge-based economy, countries around the world have exerted various efforts to secure, utilize, and protect their intellectual property. The present study diagnoses the level of IP infrastructure of major OECD countries and analyzes their characteristics and impact. According to the diagnosis, the US, Switzerland, and Germany form a leading group followed by the mid-level countries of Korea, Ireland, Australia, and France, with Spain and Italy in the bottom group. In contrast to Korea's competitiveness in S&T and R&D infrastructures, its competitiveness in IP infrastructure is lower than the OECD average. This is thought to be due to Korea's IP infrastructure being hastily formed under the influence of international pressures rather than having been gradually built up by internal needs. A TFP analysis of the impact of IP infrastructure on economic growth shows IP infrastructure positively influences economic growth. Though this analysis is limited due to inability to secure sufficient data and indicators, it is a useful guide for understanding the nature and key characteristics of IP infrastructure

Keywords
IP infrastructure, S&T infrastructure, R&D infrastructure, TFP

1. INTRODUCTION

Infrastructure can be defined as facilities that are the basis of economic activities or social capital such as roads, rivers, harbors or airports, that are keenly related to economic activities. The concept of infrastructure, previously considered as exclusively tangible assets, has expanded to cover intangible assets.

The level of advancement in science and technology infrastructure often decides the quality of in-

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novation activity, and accordingly Korea has made major investments in education and research facilities since the 1960s to build up such S&T infrastructure. From the 1980s and onwards, significant investment has been directed towards building innovation clusters or facilities under the consideration that S&T and R&D infrastructure form a key basis for supporting the country's innovation activities. This was possible because of policy support as well as the general perception that S&T and R&D are important elements towards the economic development of a society.

As Korea started its journey towards a knowledge-based economy in the 2000s, intellectual property (IP) emerged as an important element of infrastructure, and various laws and institutions were put in place that help create, utilize, and protect IP. Unlike the building of S&T or R&D infrastructure that is often led by internal needs or strategies, the building of IP infrastructure requires the enactment of essentially external, internationally standardized laws and regulations. IP infrastructure oriented from internal needs or strategies is limited, as the scope of IP infrastructure should be extensive enough to cover not only tangible but also intangible assets. Building an IP infrastructure involves particular issues and factors such as international relations and considerations as to how the boundaries between S&T and R&D infrastructures are blurring.

In this context, the present study aims to diagnose the current level of S&T, R&D, and IP infrastructures of major OECD countries, and analyze the relationships between these different infrastructure categories and their impact on growth. The primary motivation of conducting an analysis on the characteristics of these infrastructures and their impact is to diagnose the level of infrastructure that forms the basis of innovation, a key element for growth models, and identify policy needs by different growth stages and thereby present clear policy directions. Though certain indicators require the analysis of not only quantitative but also qualitative data, the present study exclusively focuses on publicly available quantitative data.

Despite their importance, studies approaching infrastructure from the perspective of innovation are not many, and studies on IP infrastructure in particular are few. Existing studies mainly involve S&T and R&D infrastructures from the perspective of knowledge creation instead of IP infrastructure. Nayak & Kumar (2008), WIPO (2011), IMD (2011), ECLAC (2005), Tassey (2008), Adams, et al. (2008), Crisafulli(1998), and Justman & Teubal (1995) have explored the field of S&T infrastructure. According to Daugeliene (2008), R&D infrastructure consists of the three elements of R&D funding, human resources, and a patent system. RDC (2010) presents a regional support framework for R&D infrastructure. Studies on IP infrastructure were mainly led by public institutions including international organizations, with the UN's Intellectual Property Organization (WIPO) notably defining the global intellectual property infrastructure as a knowledge-based structure that supports and links IP systems of different countries or regions. WIPO also identifies four key characteristics of global IP infrastructure: 1) the use of common IP standards and classification criteria, 2) sharing of IP information and resources, 3) the establishment of IP databases and global sharing of various digital IP information, and 4) creating automated business solutions that help modern IP offices function properly. In addition to these four criteria, legal systems and human resources directly involved in the creation of IP are also considered important elements. KIPO (2010) also analyzed the IP infrastructure in the framework of creating, utilizing, and protecting IP infrastructure. This study identifies five important elements of IP infrastructure: 1) the establishment and operation of a patent technology trading system, 2) preventing redundant investment and improving investment efficiency by sharing and jointly utilizing national R&D project information and S&T data that are otherwise separately managed by individual government ministries and organizations, 3) building infrastructure for technology transfer and laying the foundation for commercialization, 4) strengthening professionals through education and training, and 5) developing IP experts (e.g. patent lawyers, a corporate IP workforce, and researchers competitive enough to develop new patentable technologies) in a demand-oriented manner. This definition is more detailed than WIPO's while congruent with WIPO's scope and definition of IP infrastructure. Other major studies on IP infrastructure include those by Li (2009), Taplin (2009), JPO (2011), Harvard (2010), Office of the President (2010), Information Infrastructure Task Force (2007), and the European Commission (2011).

While most of the above studies were concerned with the characteristics of infrastructure itself or with national infrastructure strategies, the present study attempts to diagnose from an international perspective the different levels of infrastructure in major countries, measure the impact of infrastructure on growth, identify different policy needs, and thus present different strategic directions for different groups of countries. Section 2 of this study reviews the composition of infrastructure and introduces various indices for analysis. Section 3 presents the results of comparative analysis of infrastructures between countries. Section 4 concerns the characteristics of infrastructure and Section 5 analyzes the impact of infrastructure on growth.

2. INFRASTRUCTURE DESIGN

2.1. Composition of Infrastructure

Building S&T infrastructure means building systems such as communication networks, building hardware such as laboratories, securing easy and convenient access to these systems and linkages between them, and developing relevant laws and policies. Compared with S&T infrastructure, R&D infrastructure is oriented more towards industry, so it tends to be closely related to building the equipment and facilities required for technology development, commercialization, and otherwise utilization of relevant information. Table 1 shows the classification of S&T and R&D infrastructures into tangible and intangible assets as well as other relevant indicators.

IP infrastructure can be classified into global and local infrastructures. While global infrastructure is approached from the perspective of standardization for coordination purposes within international society, local infrastructure mainly involves building domestic IP infrastructure. The components of global infrastructure can be categorized again into classification systems, treaty accession, human resources, and legislation. Meanwhile, local infrastructure involves cultural awareness, professional, platform and pipeline. Here, "platform" refers to hardware that function as a basic framework for IP creation and utilization while "pipeline" means software forming flow and organic linkages between IP assets.

TABLE 1. Classification of Composite Infrastructure Index

Classification Level 1	Level 2	Level 3	Classification Level 1	Level 2	Level 3	Classification Level 1	Level 2	Level 3
S&T	Tangible	Research organization(basic)	R&D	Tangible	Research organization(basic)	IP	Global	Classification system
		Communication Networks			Communication networks			Treaty accession
		Investment			Investment			Human resources
								Legislation
	Intangible	Human resources		Intangible	Human resources		Local	Cultural awareness
		Knowledge			Compensation/incentives			Professional
		Support policy			Cooperation system			Platform
					Support policy			Pipeline
					Relevant laws			
					Innovation capability			

2.2. Composition of Indicators

The present study comes up with sub-indicators for the purposes of comprehensive scoring of infrastructure using publicly available evaluation data of S&T, R&D, and IP infrastructures.

Since the scope of the study is limited to OECD member countries, the index data used in this study are statistical data on S&T and R&D publicly released by the OECD. Additionally, for the purposes of collecting IP-related indicators, IP-related indicators have been selected from the national IP competitiveness indices released by the KIIP. Table 2 shows the existing data used for the purpose of building indicators for this study.

TABLE 2. Existing Data Used for Building Composite Index for the Present Study

Organization	Data
OECD	Main Science and Technology Indicators
WEF	The Global Competitiveness Report
IMD	IMD World Competitiveness Yearbook
IUS	Innovation Union Scoreboard
KISTEP(Korea)	S&T Capability Index
KIIP(Korea)	National IP Competitiveness Index

Based on the existing infrastructure evaluation indicators, the present study came up with a new composite infrastructure index as a quantitative measure to compare S&T, R&D, and IP infrastructures of OECD member countries. The details of the standardization of indicators, processing of values unknown at present, and method of placing weights and summing up can be summarized as follows.

2.2.1. Standardization of Indicators

To come up with a new composite index by compiling existing indicators, it was necessary to standardize respective indicators. Since the different indicators used different measurement units, if simply added up, the different measurement units could have distorted the composite index.

The Min-Max Method is adopted as a standardization tool in the present study. However, when standardizing absolute variables, the square root was calculated before the Min-Max method was applied.

2.2.2. Processing of Value Unknown at Present

The present study evaluates the level of national S&T, R&D, and IP infrastructure based on existing evaluation indicators of thirty-two OECD member countries. However, the data of certain countries in certain years were hard to obtain. When the data were not available, researchers used the data of the most proximate year.

2.2.3. Placing Weights to Calculate Composite Index

Once the standardization of individual indicators is done, the next step is to add up these values by placing weights. The present study adopted both AHP method and a direct weighting method. When placing weights, three different weight categories, upper, middle and lower, are calculated using AP method.

3. CALCULATION RESULS OF IP INFRASTRCUTURE COMPOSITE INDEX

3.1. IP Infrastructure Composite Index

I came up with an IP Infrastructure Composite Index by placing weights on existing middle-category indicators of global and local IP infrastructures. The perfect score for the IP Infrastructure Composite Index is 15.41. The highest score is that of the U.S. (14.1), followed by Switzerland (11.5), Germany (10.5), and Sweden (10.4). The lowest score was Hungary's 3.6. Countries in the bottom group included Chile (4.7), Slovenia (4.8) and Slovakia (4.9).

With an IP Infrastructure Composite Index score of 7.1, Korea ranked 18th among thirty-two OECD member countries. When compared with the OECD average (7.9) and the average of the top five countries (11.4), Korea's score was lower by 0.8 and 4.3 respectively than its counterparties. This means Korea is around 62.1% level of the average of the top five OECD countries.

TABLE 3. Groups with Different IP Infrastructure Levels

High-Level Group	Medium-Level Group	Low-Level Group
United States, Switzerland, Germany, Sweden, Canada, Denmark, Netherlands, United Kingdom, Norway, Japan	Ireland, Australia, France, Luxembourg, Belgium, Finland, Austria, Korea, Poland, Czech, Portugal, Iceland	Spain, Italy, New Zealand, Turkey, Mexico, Greece, Slovak, Slovenia, Chile, Hungary

TABLE 4. P Infrastructure Composite Index and Ranking by Country

Country	IP Infrastructure Composite Index (15.41)	Ranking	Country	IP Infrastructure Composite Index (15.41)	Ranking
Australia	9.1	12	Luxembourg	9.0	14
Austria	8.3	17	Mexico	5.3	27
Belgium	8.7	15	Netherlands	10.0	7
Canada	10.3	5	New Zealand	5.5	25
Chile	4.7	31	Norway	9.8	9
Czech Republic	6.8	19	Poland	6.3	22
Denmark	10.2	6	Portugal	6.6	20
Finland	8.6	16	Slovak Republic	4.9	29
France	9.0	13	Slovenia	4.8	30
Germany	10.5	3	Spain	5.8	23
Greece	5.2	28	Sweden	10.4	4
Hungary	3.6	32	Switzerland	11.5	2
Iceland	6.5	21	Turkey	5.3	26
Ireland	9.4	11	United Kingdom	9.9	8
Italy	5.8	24	United States	14.1	1
Japan	9.5	10	average	7.9	
Korea	7.1	18			

TABLE 5. Korea's Relative Position Among OECD Member Countries

	Average of top five OECD countries	OECD average	Korea (Score)	Korea (Ranking)
IP Infrastructure Composite Index	11.4 (100.0%)	7.9 (69.4%)	7.1 (62.1%)	18

Note: Figures in the parenthesis represent the percentage relative to the average of the top five OECD countries that were taken as a baseline of 100%.

3.1.1. Global IP Infrastructure

In terms of the level of classification systems, treaty accession, human resources, and legislation, the key components of global IP infrastructure indicators, Korea's classification system and treaty accession were relatively higher but its human resources and legislation levels were still lower than its counterparties. Korea's legislation level in particular was far lower than the OECD average.

In terms of the level of classification systems, Korea scored at 1.93, 0.30 higher than the OECD average and the same as the average of the top five OECD countries. This implies that Korea as a WTO member state has internationalized its IP regulation compliance with TRIPs provisions. Korea's score in legislation was 0.27, lower by 0.82 than the OECD average (1.09) and lower by 1.52 than the average of the top five countries (1.79), meaning Korea remains only at the 15.0% level of the top five OECD countries. This can be interpreted as a consequence of weak enforcement of IP protection or regulations. In human resources, Korea scored 1.20, higher by 0.28 than the OECD average (0.92), but lower by 0.42 than the average of the top five OECD countries. This places Korea at 73.6% level of the top five OECD countries.

FIGURE 1. Comparison of Sub-level Indicators of the Global IP Infrastructure Index

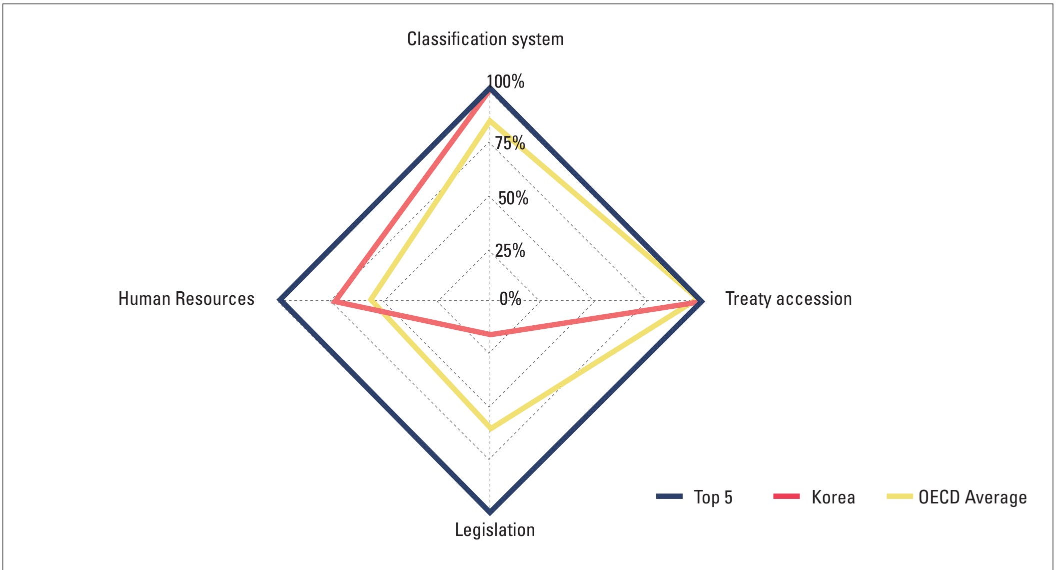


TABLE 6. Comparison of Sub-level Indicators of the Global IP Infrastructure Index

	Classification system	Treaty accession	Legislation	Human resources
Korea	1.93	1.93	0.27	1.20
Top five countries	1.93	1.93	1.80	1.63
OECD average	1.63	1.93	1.09	0.92
Korea vs. Top five countries	0.00	0.00	-1.52	-0.42
Korea vs. OECD average	0.30	0.00	-0.82	0.28

3.1.2. Local IP Infrastructure

The Local IP Infrastructure Index is composed of culture awareness, professional, platform, and pipeline. Korea's performance was relatively lower than its counterparties in all of these four elements.

Korea scored 0.58 in cultural awareness, 0.37 lower than 0.95, the OECD average. Korea was lower by 1.10 than the average of the top five OECD countries, placing it at the level of 34.5% of the top five countries. In terms of professionals, Korea's score was 0.20, higher than the OECD average (0.17) by 0.03, but lower than the average of the top five countries by 0.50, placing Korea at 28.6% of the top five. For platform, Korea's score is 0.07, 0.03 lower than the OECD average (0.10) and 0.55 lower than the average of the top five. This means Korea remains at only 12.7% level of the top five OECD countries in platform. Lastly, for pipeline, Korea scores 0.86, lower by 0.23 than the OECD average (1.09) and lower by 0.91 than the average of the top five OECD countries, placing Korea at 48.6% level of the top five.

FIGURE 2. Comparison of Sub-level Indicators of the Local IP Infrastructure Index

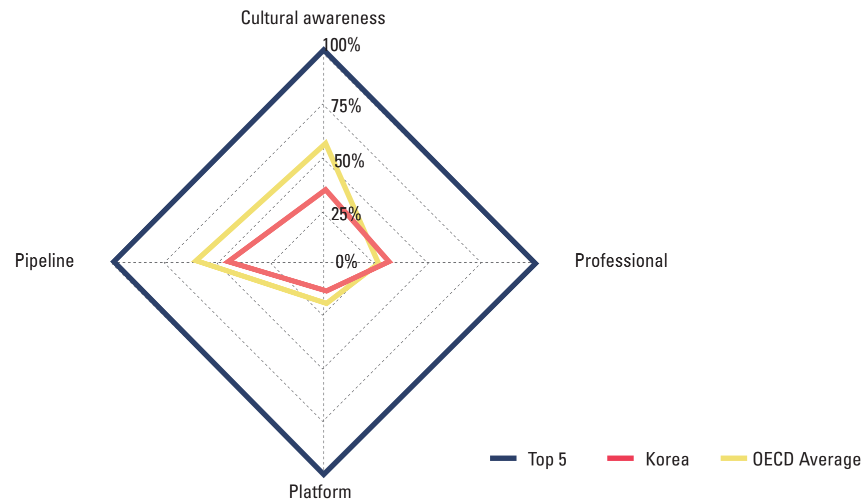


TABLE 7. Comparison of Sub-level Indicators of the Local IP Infrastructure Index

	Cultural awareness	Professional	Platform	Pipeline
Korea	0.58	0.20	0.07	0.86
Top five countries	1.68	0.70	0.55	1.77
OECD average	0.95	0.17	0.10	1.09
Korea vs. Top five countries	-1.10	-0.50	-0.48	-0.91
Korea vs. OECD average	-0.37	0.03	-0.03	-0.23

4. INFRASTRUCTURE CROSS-ANALYSIS

Figure 3 shows the results of a cross-analysis of the IP infrastructure index and the S&T infrastructure index. The red vertical line in the figure represents the average of the S&T infrastructure index

(20.5) while the red horizontal line represents the average of the IP infrastructure (7.9). Based on these two lines, countries in the 1st quadrant are those whose S&T and IP infrastructures both are above the OECD average. Countries in the 2nd quadrant are those whose S&T infrastructure is around the OECD average but IP infrastructure is higher than the OECD average. Those in the 3rd quadrant are countries whose S&T and IP infrastructures are lower than the average. Lastly, those in the 4th quadrant are countries whose S&T infrastructure is above the OECD average but IP infrastructure is lower than the OECD average.

As indicated in the figure, Korea is the only country whose S&T infrastructure is higher than the OECD average but IP infrastructure is lower than the OECD average.

The green diagonal line in the figure is a trend line of simple regression placing S&T infrastructure as an independent variable and IP infrastructure as a dependent variable. If a country is below the trend line, it means its IP infrastructure level is lower relative to its S&T infrastructure level. If a country is located above the trend line, its IP infrastructure is higher relative to its S&T infrastructure. Since Korea is located under this trend line, Korea's IP infrastructure can be said to be lower than countries that have S&T infrastructure level at the same level. As the figure shows, when compared to Belgium, Australia, Ireland, and Norway, nations with S&T infrastructure levels as high as Korea's, Korea lags behind in terms of IP infrastructure level.

FIGURE 3. Cross Analysis of IP Infrastructure Index and S&T Infrastructure Index

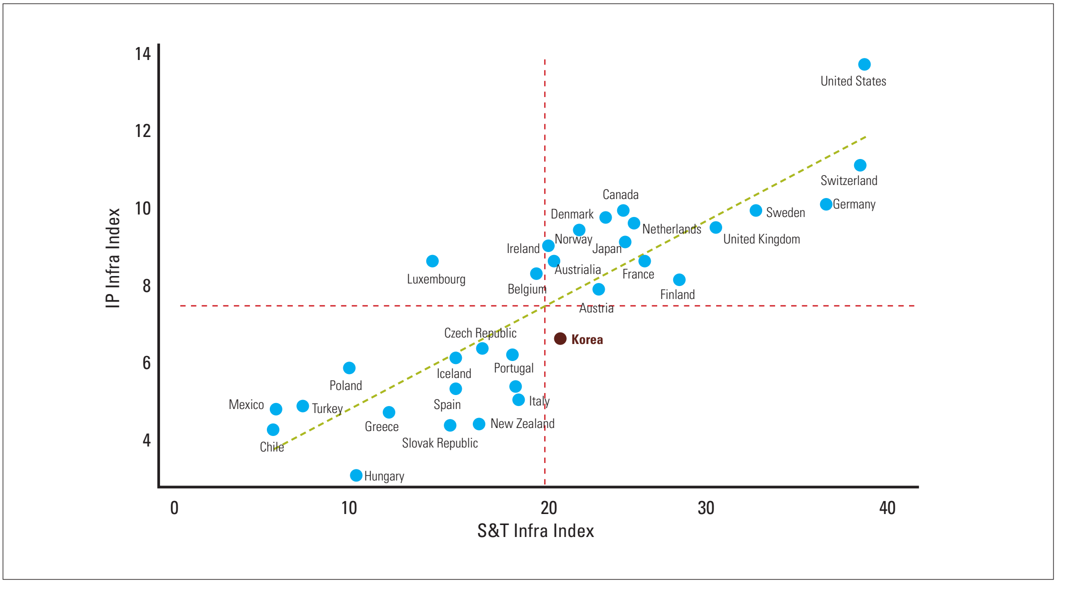
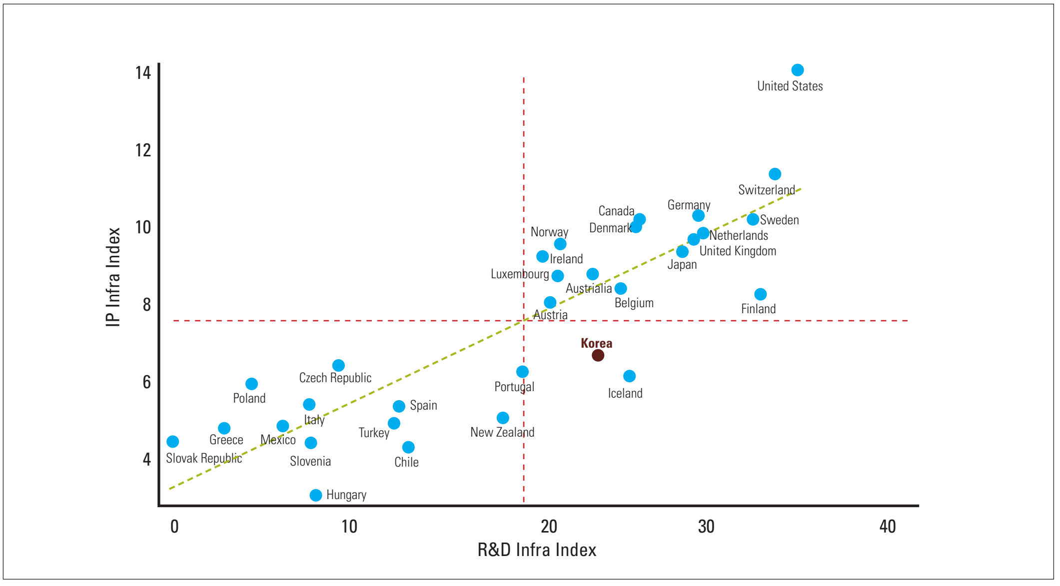


Figure 4 is the results of a cross-analysis between the IP infrastructure index and R&D infrastructure index. The red vertical line is the average (15.0) of the R&D infrastructure index while the red horizontal line is the average (7.9) of the IP infrastructure index.

This figure also shows a similar trend as the previous figure on the S&T infrastructure index. As illustrated in the figure, Korea along with Iceland belongs to a group with R&D infrastructure above the OECD average but IP infrastructure lower than the OECD average. This implies that Korea's IP infrastructure level is lower relative to its R&D infrastructure level. Again, the green diagonal line here is a trend line of simple regression taking R&D infrastructure as an independent variable while taking IP infrastructure as a dependent variable. When assuming the same R&D infrastructure level, countries marked below the trend line have relatively lower IP infrastructure while those above the trend line have higher IP infrastructure relative to their R&D infrastructure.

As Korea located below the trend line, its IP infrastructure level is assumed to be lower than its peers with similar R&D infrastructure levels. Therefore, compared to Belgium and France that have R&D infrastructure levels as high as Korea, Korea's IP infrastructure level is far lower.

FIGURE 4. Cross Analysis of IP Infrastructure Index and R&D Infrastructure Index



5. IMPACT OF IP INFRASTRUCTURE ON THE GROWTH OF TOTAL FACTOR PRODUCTIVITY (TFP)

5.1. Basic Model

In general, social infrastructure is known to have a positive external effect. In terms of IP, countries better equipped with IP infrastructure tend to better secure and utilize property rights as an outcome of technology development. It is therefore likely that better IP infrastructure contributes to the enhancement of overall productivity or efficiency of the society.

This section will review whether IP infrastructure positively impacts TFP growth. To understand this aspect of the role of IP infrastructure, the present study uses the data compiled in the process of analyzing indicators.

5.1.1. Variables for Analysis

The data was largely divided into two categories. The first data are variables related to production function. To calculate TFP using production function, we need factors such as labor (L), capital (K), total production volume (Y), and labor's share in income (α). All the variables data related to these factors were from UN and WDI data. For total production volume, actual GDPs were used. For labor, total labor force (TLF) was taken. Actual capital stock was calculated using PIM (Perpetual Inventory Method). In PIM, the initial value of capital was calculated using $K_0=I_0 l(\delta_0+ri_0^-)$ while the subsequent values were estimated using $K_t=(1-\delta_t)K_{t-1}+I_t$ taking investment and capital stock of previous cycle into consideration. Labor's share in income (α) was calculated by dividing compensation of employment by total values added.

The second set of data is infrastructure index data. Among infrastructure indicators, IP infrastructure index was adopted as a core index while the S&T infrastructure index and R&D infrastructure index were used as controlling variables. In case of infrastructure index, the previous section used only the most recent data, but in this section, for panel analysis purpose, data of all available years of all the concerned countries were used. Since it was impossible to obtain data for all years, linear interpolation and extrapolation were conducted to fill in the values unknown at present.

Data were collected and processed in the above-mentioned manner from 2000 to 2011 for all thirty-two OECD member countries, producing a total of 384 samples.

5.1.2. Composition of TFP

TFP was calculated using the growth rate of actual value added, the growth rate of actual capital stock, the growth rate of labor input, and labor's share in income. The annual TFP growth rate was calculated based on the growth accounting method. The production function of the total economy was assumed as a Cobb-Douglas function as the following.

$$Y_{it}= F(L_{it},K_{it},A_{it})= A_{it}L_{it}^{\alpha_{it}}K_{it}^{1-\alpha_{it}} \quad (1)$$

Here, *i* represents country, and t represents time. So, α_{it} is labor's share in income of country *i* in year *t*.

Y_{it} is the production volume of country *i* in year *t*. It is the outcome of employing labor, L_{it}, and capital stock, K_{it}. A_{it} refers to the TFP of country *i* in year *t* that cannot be explained only with such input as L_{it} and K_{it}. TFP is often understood as the efficiency level of technology progress and production structure.

Eq. (1) can be converted into Eq. (2) using a log linear model. If Eq. (2) is again split into year ***t*** and year ***t-***1 , then its relation to the TFP growth rate ($\Delta \ln A_{it}$) can be calculated as in Eq. (3). Here, Δln in front of the each variable means growth rate of each variable.

$$\ln Y_{it} = \alpha_{it} \cdot \ln L_{it} + (1-\alpha_{it}) \cdot \ln K_{it} + \ln A_{it} \quad (2)$$

$$\Delta \ln A_{it} = \Delta \ln Y_{it} - [\alpha_{it} \cdot \ln L_{i} - \alpha_{it-1} \cdot \Delta \ln L_{it-1}] - [(1-\alpha_{it}) \cdot \Delta \ln K_{it} - (1-\alpha_{it-1}) \cdot \Delta \ln K_{it-1}] \quad (3)$$

As I did in calculating labor's share in income, if the average of two consecutive years is used, in other words, $\bar{\alpha}_{it} = \frac{\alpha_{it} + \alpha_{it-1}}{2}$, Eq. (3) can be converted into Eq. (4). Using Eq. (4), the TFP growth rate of country i in year t can be calculated. Since this is a growth rate variable, it is possible to come up with annual data during the period of 2000~2011.

$$\Delta \ln A_{it} = \Delta \ln Y_{it} - \bar{\alpha}_{it} \cdot \Delta \ln L_{it} - (1-\bar{\alpha}_{it}) \cdot \Delta \ln K_{it} \quad (4)$$

5.1.3. Model

The present study analyzes the impact of the IP infrastructure on the TFP growth rate through a panel analysis. For dependent variables, TFP growth rate by industry is used.

$$\Delta \ln A_{it} = \beta_o + \beta_1 IP_{it} + e_{it} \quad (5)$$

$\Delta \ln A_{it}$ represents the TFP growth rate of country *i* in the year *t* and IP_{it} means IP infrastructure index of country *i* in year *t*.Lastly, e_{it} represents the error term. After estimating the regression function, if the estimated coefficient β_1 has statically significant positive value, it can be interpreted that IP infrastructure positively impacts the TFP growth rate.

All the variables representing IP infrastructure in the present study are values prior to year one because IP infrastructure often impacts the following year more significantly than the current year. The estimation is done at three different levels: 1) the entire IP infrastructure index, 2) Global IP Infrastructure Index and Local IP Infrastructure Index separately, and 3) composite level concurrently taking both variables into consideration as independent variables.

5.2. Results

5.2.1. Description of Data and Basic Statistics

Analysis was done with data from 2000 to 2011 of thirty-two OECD member countries. The sample was 384. Variables used in the estimation are summarized in Table 8. TFP refers to the TFP growth rate of individual countries using the same method that was described in the previous sections. IP, the sum of the Global IP Infrastructure Index and the Local IP Infrastructure Index, represents the level of intellectual property infrastructure of individual countries. IP_g is the Global IP Infrastructure Index and its full score is 7.71. Mean IP_g was 5.652 and standard deviation was 1.240. IP_l refers to the Local IP Infrastructure Index that has a full score of also 7.71. Mean IP_l was 2.347 and standard deviation was 1.304.

TABLE 8. Description of Data and Summary of Statistical Data

Variable	Description	Mean	Standard Deviation
TFP	TFP growth rate of individual OECD country in year t	0.002	0.025
IP	IP Infrastructure Index of individual OECD country in year t-1	8.000	2.290
IP_g	Global IP Infrastructure Index of individual OECD country in year t-1	5.652	1.240
IP_l	Local IP Infrastructure Index of individual OECD country in year t-1	2.347	1.304

Figure 5 shows the distribution of the growth rate of TFP, the dependent variable. Most TFP growth rates are in the range of -0.05 ~ 0.05. It shows a stable distribution with very few outliers. Figure 6 shows the degree of scattering of the TFP growth rate as the y-axis and IP infrastructure as the x-axis. The red dots in the figure compose the regression line as the result of simple regression analysis. The degree of scattering does not reveal any clear correlation, but the regression line shows a slightly positive correlation.

FIGURE 5. Distribution of TFP Growth Rates

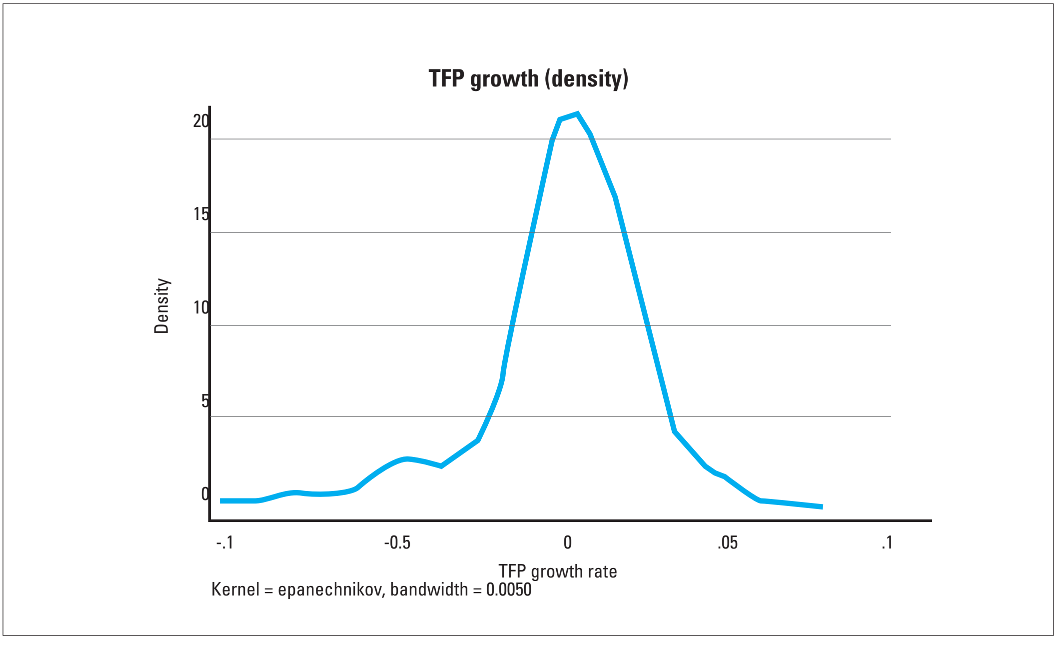
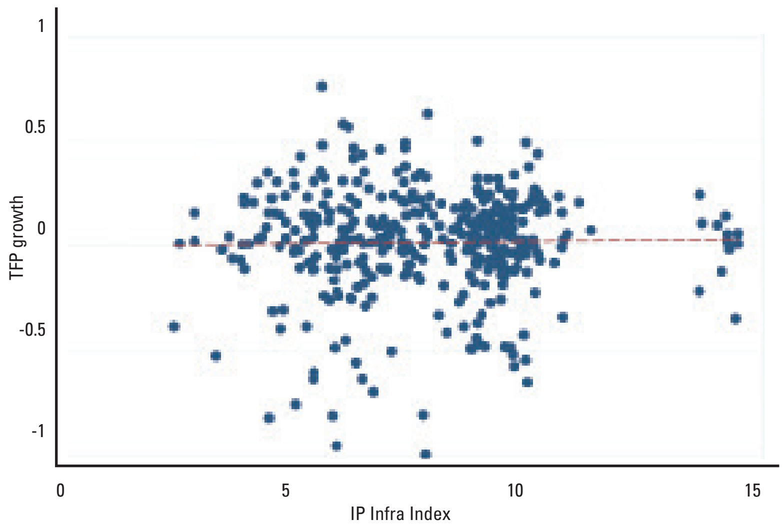


FIGURE 6. TFP growth rate and IP Infrastructure Index



5.2.2. Estimation Results

Table 9 shows the estimation results using a fixed effect model. This shows the impact of IP infrastructure on the TFP growth rate. The most frequently used methods for panel analysis are fixed effect and stochastic effect models. The present study used the fixed model to interpret the estimation results.

Model (1), which shows the impact of IP infrastructure on the TFP growth rate, came up with statistically significant results at the 5% level, meaning IP infrastructure positively affects TFP growth rate.

To confirm whether the same positive correlation appears in global and local IP infrastructures, such as in Model (2) and Model (3), global IP infrastructure and local IP infrastructure were respectively taken as independent variables for estimation. The results show that global IP infrastructure had positive value at a statistically significant level of 1%, implying its positive correlation with the TFP growth rate. In the meantime, local IP infrastructure did not have statically significant impact on the TFP growth rate, meaning little impact on TFP.

Lastly, Model (4), a composite model of global and local IP infrastructure, shows that like in Model (2), global IP infrastructure exerts statically significant positive influence on TFP growth rate at the level of 1%, but local IP infrastructure does not seem to have any statically significant impact as it does with Model (3) though it showed minus value.

In summary, the IP infrastructure index has positive impact on TFP growth, which is the result of positive impact from the Global IP Infrastructure Index on the TFP growth rate. This means global IP infrastructure is more important than local IP infrastructure in enhancing a country's TFP. Therefore, the better a country is equipped with global IP infrastructure, the higher chance of it having enhanced IP competitiveness in the global market. It also means higher R&D productivity and efficiency since better global IP infrastructure helps accelerate a country's entry into the global market, ultimately contributing to economic growth.

TABLE 9. Estimation Results Based on Fixed-effect Model

	Model (1)	Model (2)	Model (3)	Model (4)
ip	0.005**			
	(2.064)			
ip_g		0.009***		0.011***
		(2.788)		(2.970)
ip_l			0.000	-0.006
			(0.038)	(-1.025)
Constant	-0.039*	-0.051***	0.002	-0.045**
	(-1.958)	(-2.675)	(0.122)	(-2.233)

t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

6. REMARKS

While IP has important value in itself, it is becoming more and more important due to its impact on the economy and industry. More and more attention is being paid to the issue of IP in addition to human resources and capital, the other key elements of economic growth. Nevertheless, recognition of IP infrastructure and investment in IP infrastructure has been limited. IP laws and regulations of less developed countries were adjusted to meet global standards under pressure from developed countries, but even in this process, only limited investment was made in domestic IP infrastructure.

As the present study suggests, global IP competence shows great variation among countries around the world. This difference will inevitably cause gaps between countries in their pursuit of IP competitiveness. Therefore, it is necessary to develop support policies and strategy tailored to the development level of IP infrastructure. Through consulting or other support, developed countries should help developing countries build their infrastructure, and this will help lay down a sound foundation for harmonious growth. Since infrastructure serves as the basis of growth in any given area, the IP infrastructure level needs to be established and maintained at a global level in order to develop a global IP growth model and to be able to mutually recognize the value of IP among different countries.

Since the 2000s, Korea has rapidly built up its IP competitiveness, but the country's IP infrastructure level is still immature relative to its S&T and R&D infrastructures. Among OECD countries, Korea's IP infrastructure competitiveness still remains low compared to its R&D investment or infrastructure assets. Volume-oriented growth without a build-up of infrastructure may act as a limitation in pursuing IP competitiveness. Therefore, a more fundamental approach towards building infrastructure is required. It is now time to expedite the enforcement of global regulations and the development of IP professionals.

Despite these important implications, the present study has certain limitations. One of the most conspicuous limitations is the limited composition of the indexes. Since this study borrows only publicly available data, qualitative indicators, another essential element of infrastructure, were excluded. For example, qualitative data such as data accessibility and convenience of screening procedures that can be obtained through surveys on individual countries (not from the officially available date pool) were not included in the present study. In the future, a survey-based analysis of qualitative data can be conducted as a follow-up of the current study.

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