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A Study on the Effect of Regional Innovation System on Regional Competitiveness of Local Government: Focused on the Technological and Economic Effects

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Abstract

Background/Objectives: The purpose of this study is to examine how the regional innovation system centered on R&D strengthens the science and technology capacity of the region and how it contributes to the economic effects of regional development.

Methods/Statistical analysis: For this, this study tried to measure the efficiency by using DEA model. The input utilized the foundation of innovation. The knowledge base used the technology development-related activities and the organization that creates, spreads, and utilizes the knowledge, and the indirect base utilized the costs invested for the purpose of creating, spreading, and utilizing knowledge. The calculation used papers and patents as variables of scientific and technological performance, and GRDP, company life, and financial independence as economic performance variables.

Findings: When regional MPI was compared by period, the productivity growth tended to decrease. Overall, the impact of TECI was found to have affected MPI reduction, and between 2017 and 2018, the TCI fell significantly and MPI decreased. When looking at each region, Jeju Island had the highest productivity due to technological innovation, while Sejong showed the lowest productivity index. Because this is a time when Sejong is a new city and infrastructure investment is expanding. In addition, the effect on each efficiency was analyzed. As a result, the number of study organizations had a negative effect on the efficiency, but the other variables had no significant effect.

Improvements/Applications: This study is meaningful in that it has an empirical approach to the contribution of regional achievements from an innovation perspective and provides implications for measuring the efficiency of future R&D inputs.

Keywords: *Regional Innovation System, Local Government, Data Envelopment Analysis, Economic effect, Scientific and technological effect.*

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1. Introduction

With globalization and the transition to the knowledge-based era, regional competitiveness rather than national level competitiveness is emphasized. Against this backdrop, attempts have been made to integrate the concept of the National Innovation System (NIS) into the local economy. This is defined as the Regional Innovation System (RIS). The regional innovation system is a concept that integration at the local scale is an appropriate method for innovation-based learning economies, as well as optimal for the creation and diffusion of knowledge[1]. Accordingly, each country is making efforts to improve local competitiveness by establishing its own regional

innovation system. The paradigm of the new economic system is to create new growth engines and solve job problems to overcome the economic recession, while shifting national competitiveness from national strategy to regional level [2].

Regional innovation systems are a complex of institutions and policies that influence innovation at the local level. Emphasis is placed on the interaction, learning and institutional building of innovations in the region. In other words, the regional innovation system refers to a system in which appropriate conditions are formed to reinforce the regional economy's ability to innovate and learn in the process of interaction between the innovation agents[3]. Innovators in various regions, such as local governments, regional universities, local enterprises, and research institutes, create new innovations and promote regional development through mutual cooperation and learning in various areas such as new research and development, new product production, administrative system reform, and cultural activities.

In this discussion, researchers present their interactions or learning views in a specific environment. However, in detail, the concept of regional innovation is slightly different. In terms of their definition of regional innovation system, OECD(1999) defines regionally as relations formed by actors interacting in the production, expansion and utilization of new economically useful technologies and knowledge. The focus is on the diffusion and utilization of skills and knowledge[4]. The EC(2002) defined the regional innovation system as cooperation and exchanges between companies and various institutions in order to meet the special needs of the regional core industries through the development of knowledge and technology diffusion. They argued that universities, education and training institutions, research institutes, technology transfer agencies, associations, and financial institutions are the means to establish regional innovation systems[5]. Lundvall's (1992) research shows that innovation is a result of the repetitive learning that appears in the process of systematic research and cooperation involving scientists, innovation intermediaries, and users of innovation, and local innovation as an infrastructure of the national innovation system. Emphasis was placed on regional innovation systems as infrastructure of national innovation systems[6]. Cooke's (2002) study also defined a network of companies and institutions that promote commercialization by using products, processes, and knowledge, and is held by companies, research institutes, universities, innovation support organizations, banks, government departments, and chambers of commerce. It means to systematically learn the characteristics of innovation[7].

The concept of Korea regional innovation was first applied in the mid-1990s[8]. Since then, the National Balanced Development Act of the Participatory Government was enacted in 2004, and the regional innovation policy was implemented. Based on this, the framework for regional development strategy was established, such as the operation of the special accounting system and the establishment of the National Balanced Development Committee. Afterwards, while maintaining the basic framework, the government changed the direction and strategy of regional development policies. The characteristic of local innovation in Korea is that it promotes projects centered on science and technology. For the endogenous development of regional innovation system, we provide science and technology infrastructure such as continuous increase of local R & D budget, expansion of regional technology innovation base, and regional innovation resources. Through this, we want to increase innovation performance.

As the regional innovation system is a process of creating, spreading and utilizing knowledge in a certain region, the regional innovation system affects scientific and technological achievements

and economic performance. The groups that make up the regional innovation system will have scientific and technological achievements in the process of creating knowledge, and will have secondary economic outcomes in the process of spreading and utilizing them. In the case of the creation of scientific and technological achievements, most scholars agree with these achievements as the achievements of the members of the regional innovation system in the process of R & D or knowledge sharing. On the other hand, there is some disagreement with respect to economic performance. According to the theory of classical economics, the cost of constructing regional innovation system or developing technology is approaching that it is ineffective or low due to the conflicting utility of technology. Sustainable economic growth is an important factor, and capital and labor are faced with the law of diminishing marginal production, which is achieved through innovation by introducing new technologies for sustainable economic growth.

In this study, as emphasized in the theory of new growth, the core factor of innovation is how much innovation capacity is in the region in the production, diffusion, and utilization of knowledge. In addition, innovation is a process for regional economic actors for regional economic development, and this ability to innovate varies from region to region[9-11]. In order to analyze regional performance based on this innovation theory, the foundation for creating and disseminating regional knowledge should be comprehensively accessed. Therefore, the linkage between the regional innovation system and the achievements indicates that members of the innovation system formed in the region can create scientific and technological achievements through the production and diffusion of knowledge, and economic results in the process of utilizing and spreading the knowledge again.

Relevant previous studies also analyzed the impact between regional innovation system and performance, and found that the establishment of regional innovation system affects performance. Therefore, this study also assumes that regional innovation system can play a big role in science and technology and economic performance, and finally can lead to sustainable development. In other words, previous studies are to solve the question of whether the establishment of regional innovation system affects the scientific and economic performance. The direction is to identify the impacts and to build the optimal regional innovation system.

There are many components of a regional innovation system that influence performance. The components of the regional innovation system show a lot of differences among researchers studying the regional innovation system. The definition of the regional innovation system, the theoretical approach, the direction of policy-making, and the introduction of foreign cases have similar opinions, but they argue that there can be as many components as the components of the regional innovation system. It should also be noted that different researchers have different views on the distinctions between regional innovation systems and clusters. Although the conceptual distinction between clusters and regional innovation systems is still controversial, the academic community accepts the concept of regional innovation systems as a higher concept of clusters, and the logic that the concept of regional innovation systems may be more comprehensive than clusters.

In this study, it is concluded that the empirical approach to the effect of regional innovation system has not yet been attempted due to such conceptual differences. This study, agrees with the logic that the regional innovation system is the upper concept of the cluster, and therefore, we will try to empirically analyze the logic that the regional innovation system is the upper concept of the cluster.

In this sense, the regional innovation system is largely formed of institutions, incentives, and foundations, and the contents of each are as follows[12]. Firstly, the system refers to laws and regulations at the national or regional level that provides a framework for economic activity. In other words, institutions include not only formal legislation that can be considered tangible, but also intangible, such as social norms and customs, and other elements that can affect economic activities. Therefore, it covers social capital in a broad sense. Such a system provides an environment in which regional innovation systems operate, which is an important factor in understanding the innovation environment and process of a region[13]. Next, incentives in the regional innovation system include various financial-related elements and physical facilities that play a decisive role in business activities. Financial elements include not only banks and stock markets that provide capital to existing firms, but also venture capital that provide capital to start-ups with high risk but high expected returns. In particular, venture capital has already been proven to be crucial in the innovation process of high technology. In addition, physical facilities refer to physical facility structures that support the communication and diffusion of people and information, such as roads, ports, and communication systems[14-16]. Finally, the foundation in the regional innovation system includes the knowledge base and the social indirect base. The knowledge base is not only an economic entity that directly participates in the production of knowledge, such as a university or research institute, but it also includes high-quality human resources capable of conducting research. Social indirect infrastructure, on the other hand, is a major factor for creating the actual knowledge base as the scale of investment in R & D.

This study intends to conduct research based on the foundation of regional innovation system. Considering that the two key functions of the regional innovation system are the production and diffusion of knowledge, the importance of infrastructure in the regional innovation system cannot be overemphasized. Accordingly, this study intends to promote the knowledge-based and business indirect-based perspectives as the main elements of regional innovation.

Against this backdrop, this study identifies how the regional innovation system centered on R & D reinforces regional science and technology capabilities and how it contributes to economic effects such as commercialization, establishment of businesses, business growth, and sales, which are closely related to regional development. In other words, investment and construction directions for R & D and R & D infrastructure for establishing regional innovation systems differ from region to region, and the results are different due to these characteristics. In order to achieve the purpose of this study, this study attempts to analyze the efficiency between regional innovation system construction and scientific and technological and economic performances using DEA, and proposes regional innovation system characterization strategies and guidelines. In other words, the purpose of this study is to suggest the direction of efficient R & D activities by identifying the optimum efficiency of R & D and R & D infrastructure construction activities for the establishment of regional innovation systems for scientific and technological and economic performance.

2. Materials and Methods

2.1 Research Model

This study attempted to approach the regional innovation system in terms of production factors for regional economic growth rather than using the abstract concept of existing studies. Existing regional innovation studies have referred to the regional innovation system as a system that creates new knowledge or technology through innovation activities among economic actors, and

spreads the knowledge and technology created by forming a network. They can be distinguished and produce results in the process of spreading. In other words, it starts with the assumption that the regional innovation system can clearly estimate the effects. It also uses the assumption that the elements of the regional innovation system for regional growth can be used independently. Even though the local innovation system is integrated into the system, it is assumed that some factors can be separated and used.

In addition, this study will focus on the foundation of regional innovation system. Previously, the regional innovation system was composed of infrastructure, institutions, and incentives. Among these, considering that the two core functions of the regional innovation system are the production and diffusion of knowledge, the importance of infrastructure in the regional innovation system can be emphasized. Accordingly, this study intends to promote the research with the knowledge-based and business indirect perspective as the main elements of regional innovation.

Existing previous studies are to solve the question of whether the establishment of the regional innovation system affects the scientific and economic performance, but this study is the most effective in influencing the regional innovation system on the scientific and technical and economic performance. In this regard, there is a direction to find out the impact of the development and to build an optimal regional innovation system.

For the analysis, this study divided the regional innovation system into a knowledge base and an indirect base, where the knowledge base used technology development-related activities[17] and organizations that create, spread, and utilize knowledge[6,18]. Also, the indirect base utilized the costs that the knowledge-based organization puts in order to create, spread and use knowledge.

In addition, the achievements were divided into scientific and technological achievements, and economic outcomes. First, the scientific and technological achievements are based on the results of the basic research characteristics derived through the regional innovation system of local governments and tangible and intangible technological outcomes affecting local industries. Next, economic performance was intended to utilize the results generated by local companies through regional innovation system of local governments and the results realized at the local economic level.

2.2 Research Method

This study compares and analyzes the DEA methodology based on linear programming of management science to derive regional innovation and economic performance according to R & D activities of local governments.

DEA is a linear planning model for measuring the relative efficiency of decision making units (DMUs)[19]. In addition to the efficiency calculation, this method is highly applicable in that multiple input factors and output factors can be considered simultaneously in the analysis. In other words, DEA calculates the efficiency index based on a large number of input and output factors, and measures the efficiency by relatively evaluating the inefficient DMU based on the most efficient DMU among the DMUs to be compared.

In this study, regional innovation and economic performance will be assessed based on the relative efficiency analyzed through multiple inputs and outputs. While performance has been primarily considered to achieve a competitive advantage, in recent years, the concept of efficiency, which achieves higher performance through relatively few inputs, is also important.

Relative efficiencies can be used as a way of solving the limitations that are not appropriate for comparative evaluation of performance and extent

when presenting absolute figures used as the main method in previous studies. In addition, the results of the DEA provide implications for establishing an inefficient regional innovation system in that it derives areas that perform activities efficiently and induces benchmarking of regional innovation systems based on best practice areas.

This study uses the DEA methodology to analyze the relative efficiency between regions and, broadly, between regions. Here, efficiency refers to the relative efficiency composed by the comparative group, and relative efficiency refers to the efficiency through comparison with the entity having the optimal efficiency, not comparing and analyzing the difference considering the ratio of input and output which are absolute figures. It is to measure and calculate the weight for the regional innovation system.

2.3 Research Variable

For the measurement of performance variables, the scientific and technological achievements utilize the performance indicators of papers and patents, which are outputs in the output area, in a quantitative approach. Papers, which are generally scientific publications, provide a lot of insight into the organization's knowledge[20]. Because they are appropriate as performance indicators in the early stages of R & D projects[21]. Patents are a variable that is widely measured as a result of R & D[22]. Patents derived from R & D measure performance in terms of innovation activities, namely application and commercialization, for new product development or efficient process development[20].

Next, for the measurement of economic performance Variables, regional production (GRDP), life expectancy, and financial incentives were used in this study. In general, GRDP is a value-added statistic in terms of production, and is mainly used for judging economic performance in that it can comprehensively understand the regional economic structure and economic growth. The life expectancy of means that as economic growth grows, new companies are created and the length of time that existing companies can continue to operate economically is increasing. (`75 : 30 years → `95 : 22 years→ `15 : 15 years). Fiscal self-sufficiency is a budget that can be used autonomously by local governments. In this study, it is expected that the economic efficiency of the local government will increase due to the effect of the industrial revitalization and population influx through the regional innovation system, which will result in high fiscal independence. To this end, we will use secondary data that are being investigated by domestic government agencies. The analytical data is to utilize the data of R & D activities of the last five years, regional innovation buildings, and regional indicators to derive R & D activities and results by region.

The main research databases are R&D activity survey and the national R&D project survey and R&D project performance survey and the local R&D factual survey by Korea Institute of Science and Technology Planning and Evaluation, technological innovation survey by Science & Technology Policy Institute, Local Finance 365 (the Local Finance Integrated Public Open System) by Korea Local Information Research and Development Institute, new corporate trends by the Ministry of Small and Medium-sized Venture Business, national business survey and corporate survival statistics by National Statistical Office and population number and GRDP by the National Balanced Development Commission. As related surveys are officially approved by the National Statistical Office, the reliability of relevant surveys can be used to estimate the reliable results.

3. Results and Discussion

In this study, MPI and related indices were derived in order to see the trend of annual output.

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Table 1. Average Productivity Index by Period

Time series	TECI	TCI	PECI	SECI	MPI
T2	0.9624	1.0012	0.9959	0.9663	0.9635
T3	0.9801	1.0634	1.0133	0.9672	1.0422
T4	0.9633	1.0148	0.9954	0.9678	0.9776
T5	1.0371	0.8831	1.0414	0.9959	0.9158
Geometric mean	0.9853	0.9883	1.0113	0.9742	0.9737

Table 1. shows the change in average productivity over time. At this time, since each productivity index value means a change rate, the average value of productivity change was derived using the geometric mean. Period 1 is 2014-2015, period 2 is 2015-2016, period 3 is 2016-2017, period 4 is 2017-2018.

<Table 1> shows that when the MPI is compared by period, the increase and decrease trend tends to decrease. In 2015-2016, the MPI increased 4.2%, the most among the five-year periods, but the decrease increased to 2.2% and 8.2% in 2016-2017 and 2017-2018, respectively. Overall, the MPI of the DMUs decreased by 2.6%, because TECI (0.9853) affected more than TCI (0.9883). Nevertheless, the big decrease in 2017 ~ 2018 showed the effect of TCI. This is due to a 3.7% increase in TECI and a 11.7% decrease in TCI, affecting the MPI decline.

In other words, the overall MPI appears to have declined due to a decline in input technology and production efficiency.

Figure 1 shows the average productivity index by region in a graph. Overall, the regions with the highest productivity index for five years were Jeonbuk, Jeonnam, Jeju, and Incheon

Table 2 shows the average productivity index by country for detailed analysis. Table 2 shows the comparison of productivity in each region by using geometric mean for productivity change. Looking at this, Jeju Island, which has the highest productivity increase, seems to have improved productivity by TCI (1.0184), that is, technological innovation. On the other hand, the region with the lowest productivity index is Sejong, which shows a decrease of 18.1%.

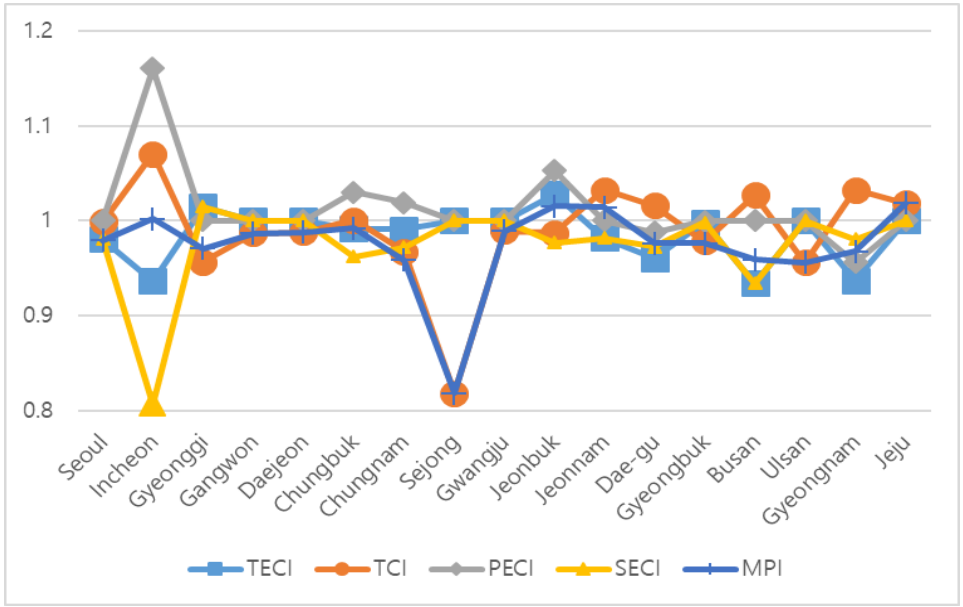

Figure 1. Regional Productivity Index

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It is not long since Sejong was designated as a local government, which is expected to occur.

The impact on productivity gains was found to be characteristic of each region. Incheon, Jeonnam, and Jeju show that technological innovation has a significant impact on productivity, while Jeonbuk has shown that technological efficiency has a significant impact on productivity.

The result of analyzing the factors affecting each efficiency is shown in Table 2. The results of the analysis in turn showed that the number of research organizations among negative factors affecting technology efficiency was negative and was statistically significant. In addition, the pure technology efficiency showed the same result as the number of research organizations had a negative effect. As the number of research organizations increased, technical efficiency and pure technology efficiency decreased

The reason for this is that in each region, investment for regional innovation is invested in a type of organization such as research organization rather than pure R & D investment, thereby increasing inefficiency. Of course, there can be a variety of causes of this effect. The presumed reason for this is that the expansion of the organization is being promoted in new regions such as Sejong City, while the effect is not immediately visible. For other reasons, local R & D investments are concentrated in creating specific research groups, and investment may be relatively weak in the technology development required by industry. However, further research is needed to elucidate clear reasons.

4. Conclusion

This study can be regarded as important in confirming the role and importance of the regional innovation system from the perspective of regional innovation and exploring the direction of constructing an effective regional innovation system.

First of all, the existing discussions on the regional innovation system have some differences of opinion on the definition and method, but most of them focus on the theoretical process and the logic of formation and legitimacy between the bodies of regional innovation. However, this study empirically approaches the effect of contributing to regional performance in an innovation perspective that meets the main attributes of regional innovation systems. Therefore, it can be shown that regional innovation systems have not only theoretical significance but also have very important attributes.

Existing studies have conceptually explained Korea's innovation capacity and focused on

Table 2: OLS, TOBIT analysis result

Division	CRS				VRS			
	Tobit		OLS		Tobit		OLS	
	B	t	B	t	B	t	B	t
R & D investment	0.0004	1.140	0.0046	1.420	0.0000	0.120	0.0054	1.210
Corporate R & D Investment	-0.0005	-1.900	-0.0041	-1.490	0.0000	-0.200	-0.0047	-1.220
Number of Research Organizations	-0.0001*	-2.020	-0.0002**	-2.530	0.0000*	-1.670	-0.0003***	-2.750
Number of researchers	0.0059	1.400	-0.0027	-0.260	0.0036	1.470	0.0137	0.690
Cons	0.7995	25.24	0.8723	14.40	0.9336	51.15	1.0585	12.86
Adj R	0.3285		0.3399		0.0222		0.2416	

identifying its impact on each effect. While past studies have analyzed regional differences, studies in recent years have conducted studies on how innovation capacity indicators can be transferred to regional scientific, technological and economic ripple effects. Existing studies have shown that increasing the capacity of members of the regional innovation system has a positive effect on scientific and economic and economic performance. However, it does not give any implications for the direction of the regional innovation system. In other words, it can mean expanding R & D investment and expanding R & D organization in establishing regional innovation system, but it does not provide information on how to build local innovation system within limited resources.

Therefore, in this study, based on the variables that make up the regional innovation system, it is possible to suggest the direction of effective regional innovation system by estimating the influence on the scientific and technological achievements and economic performance of the region and understanding its efficiency. In other words, the most significant point is that the items that make up the regional innovation system are found to be most effective.

Next, we verified the influence of innovation variables and R & D efficiency of our regional innovation system. Through this, we were able to confirm the contribution effect of the input of the regional innovation system. In other words, the factors influencing regional R & D were identified through the variables that make up the regional innovation system and the influence of regional innovation efficiency. Through this, we could confirm the difference in the impact characteristics of the region's R & D performance.

Lastly, the results of the regional innovation system can be found in terms of the research of the capitalist perspective of the classical school, as well as the study of the capital flow perspective of the traditional classical school.

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