Classification of Regional Innovation Types and Region-based Innovation Policies

Seong-ho Han[1]* Gwang-min Yoo[2], Dong-gwan Kim[1]

Abstract

The focus of regional innovation policies is shifting from the central government to local governments. The central government demands that regions enforce autonomous and responsible regional innovation policies and that regional governments seek for innovation policies fit for regional characteristics.

However, the central government and local governments have not arrived yet at a conclusion on what innovation policies are appropriate for regional circumstances. In particular, even if each local government is trying to find regional innovation strategies that are based on the needs of a region, its innovation strategies turn out to be similar with those of other regions. This leads to a consequence that is inefficient not only at the national level, but also at the regional level. Existing researches on regional innovation types point out that there are remarkable differences in the types or characteristics of innovation among the regions of a nation. In addition they imply that there would be no expected innovation output in cases in which policies are enforced with ignoring such differences. This means that it is undesirable to enforce regional innovation policies under a single standard.

This research, given this problem, aims to find out the characteristics and differences in innovation types among the regions in Korea and suggests appropriate policy implications by classifying such characteristics and differences. Regions were classified in consideration of the various indicators that comprise the innovation suggested by existing related researches and illustrated policies based on such characteristics and differences. This study used recent data mainly from 2012, and as a methodology, clustering analysis based on multiple factor analysis was applied. Supplementary researches on dynamically analyzing stability in regional innovation types, establishing systematic indicators based on the regional innovation theory, and developing additional indicators are necessary in the future.

Keywords: Regional Innovation Policy, Regional Innovation Type, Region-based Innovation, Multiple Factor Analysis, Clustering Analysis

1. Introduction

The focus of regional innovation policies is shifting from the central government to local governments. The contents of the 3rd Basic Plans for Science and Technology (2013–2017) and the 4th Comprehensive Plans for the Advancement of Local Science and Technology (2013–2017) discussed in the National Science and Technology Council in July 2013 reflected such a shift. The Basic Plans for Science and Technology suggests, as a promotion strategy, to reinforce mid- and long-term creativity capabilities and, as its contents, promote industry–academia–research institute cooperation for the industrialization of regional specialized technology: cultivate and

1 Business Support Division, Incheon Technopark, Gaetbeol-ro, Yeonsu-ku, Incheon, South Korea
2 Planning and Audit Division, Incheon Technopark, Gaetbeol-ro, Yeonsu-ku, Incheon, South Korea
* Corresponding Author: shhan@itp.or.kr

induce the settlement of regional talent, expand regional R&D investment: and introduce block grant–type R&D business. The Comprehensive Plans for the Advancement of Local Science and Technology, which aims to strengthen the autonomy and responsibility of regions and improve capabilities in regionally specialized science and technology, suggests, as main tasks to realize such aims, to expand regional initiative R&D business infrastructures; strengthen regional capabilities to plan and manage R&D; cultivate local science and technology talent and create jobs for such talent; vitalize industry–academia–research institute cooperation, which reflects regional characteristics, and so on. Moreover, the 6th Industrial Technology Innovation Plan (2014–2018), which was discussed in the National Science and Technology Council in December 2013 suggested, as one of its eight core strategies, a policy for the advancement of the regional innovation system and announced its action plans, such as to improve the effectiveness of regional industry investment, convert an industrial complex into a creative innovation cluster, cultivate regional talent and create jobs in the region and improve the system to support a regional industry. Regional innovation policy has many names, such as regional specialization, regional customization, region-based innovation, regional characteristics, regional investment efficiency, and others, but their main characteristic is to plan and promote competitive policies based on the regional characteristics and led by local governments.

However, as the many names for regional innovation policy show, it is difficult to say that the innovation policy based on a region has been enforced, and there has been no concrete answer to the question as to what innovation policy is appropriate for a specific region. Even if it is in vogue to claim that differentiated and competitive innovation policies are enforced in a region, what actually happens is the promotion of similar industries in many cases. It seems that this is because there is no sufficient understanding to back up regional innovation policy. In connection with this, it is required to completely appreciate that national innovation policy is, after all, realized through regions and that regional innovation is not created in a uniform manner in all regions. That is, the objectives of the national innovation policy will be attained through the enforcement of a regional innovation policy that appropriately reflects the characteristics of a specific region. Moreover, it is required to understand the elements and characteristics of each region in relation to the innovation thereof.

This research performed a classification based on the innovative characteristics of each region as groundwork for the promotion of region-based innovation policy. In addition, this study drew a regional innovation pattern for 16 (13) metropolitan cities and provinces by applying multiple factor analysis and clustering analysis with key indicators.

2. Review of Literature

Researches on the classification of regional innovation were performed mainly in the European Union (EU) in the late 2000's. The classification with respect to 25 nations in the EU by Navarro (2008) was the first full-scale research on the classification of regional innovation. This research is different from existing researches in that it performed statistical analysis of more data unlike previous researches which relied on case studies or were based on limited data. Researches on the classification of regional innovation in this way may be deemed as a statistical classification approach with extensive data. In this section, we aim to establish an empirical direction thereof by examining policy implications, related indicator selection, and classification results with respect to the major outcomes of these research.[1]

The research of Navarro (2009) uses 21 indicators for classification. In particular, 10 indicators among them are socio-economic indicators. Gross domestic product (GDP) per capita and productivity indicators represent a level of market segmentation and knowledge accumulation, respectively. Employment rate and the sectoral employment structure show capabilities to convert R&D into innovation and regional growth. Population density and peripherality refer to the economies of agglomeration and accessibility to a center of knowledge and technology, respectively. In addition to socio-economic indicators, 4 population composition indicators related to education and human capital represent knowledge and technology absorption capacity. Lastly, 7 R&D expenditures and patent indicators are used to show knowledge generation. The research of Navarro classifies 186 regions of 25 nations in the EU into the following 7 classes stated below using the 21 indicators stated above: ① a traditional manufacturing region with unfavorable conditions, ② a region with low-level economic and technological performance, ③ a region with average-level economic and technological performance, ④ an advanced region that specializes in manufacturing, ⑤ an innovative region with high-level economic and technological performance, ⑥ a capital region that specializes in specific high value-added services, and ⑦ an innovative capital region that specializes in high value-added services.

Navarro (2009) improved his previous analysis and mainly analyzed Spain. Its indicator utilization was expanded with data from the technology innovation survey that was conducted. Concretely, Navarro selected 31 indicators by regional innovation –related 8 classes and classified 17 regions in Spain into the following 4 classes[2]: ① a capital region that specializes in knowledge services, ② a medium and state-of-the-art technology manufacturing region, ③ an intermediate- and low-technology region, and ④ an underdeveloped region that specializes in agriculture or tourism.

The study conducted by Wintjes & Hollanders (2010)[3] begins with an introduction of the following problems: innovative routes in Europe are diverse, regional innovation is not delivered solely by differences in capabilities, and there is no sole optimal regional innovation model that may be applicable to all regions. Wintjes & Hollanders featured to approach regional innovation with a framework that includes the absorption and diffusion other than the retention (accessibility) of knowledge and technology. Specifically, they selected their indicators from five categories, such as employment, human resources, activity, technology, and economy. Employment-related indicators include the employment rates of high-tech industries, knowledge-intensive industries, and the public sector. Human resources indicators include the ratio of those who are engaged in the field of science and technology to those who are highly educated. Activity-related indicators include the employment rates of females and those who are highly educated as well as long-term unemployment rate. Technology-related indicators include the R&D investment of the private and public

1 The policy implication of these classification researches is that the regional innovation is not delivered only in a region with superiority in a specific condition, technology, infrastructure, and so on, but delivered in each region in various forms in accordance with the characteristics that each region has. The classification by statistics is attempted to find policy alternatives in accordance with differences in the classification.

2 With respect to the 25 nations in the European Union, it added a region that specializes in agriculture to the existing 7 classifications, and thus, it suggested 8 classes. See Navarro (2009), p. 10.

3 This research developed SWOT analysis of each class by classifying 27 nations in EU into 10 classes through 13 indicators such as economy, knowledge / learning, society population, etc. in 2008

sectors as well as patent application rate. Economy-related indicators include gross fixed capital formation rate and the labor productivity of manufacturing and service industries. Wintjes & Hollanders classifies 253 regions in the EU into 7 classes using the 20 indicators stated above.

The research by Ajmone Marsan & Maguire (2011) is the first to be conducted on OECD nations, whereas most of then-existing research on region innovation classification were conducted on the EU region. They pointed out that regional innovation policy will be appropriately enforced only by taking into account the differences and distinctiveness of the innovation system and innovative route of regions, and aimed at classification by innovation-related indicators collected from OECD member nations from the late 2000's. Concretely, Ajmone Marsan & Maguire selected 12 indicators[4] because of constraints on obtaining data in OECD nations. They classified 240 regions of OECD nations, including Korea, into three classes and eight subclasses, using such indicators.

ESPON (2013)[5] asserts that not all regions deliver innovation solely through the knowledge that they retain and that various types of innovation are generated because of differences in the learning process, human resources, knowledge intensity, and others. In particular, ESPON asserts that the economy of a region is not grown solely through the expansion of its R&D investment, but rather, it is frequently grown by the capabilities of businesses in the region to absorb external technologies. It points out the limitations of existing researches—they relied only on the knowledge generation of an official form or a combination of simple indicators, they ignored the role of external knowledge, and factors inherent to a region were not fully understood. Concretely, ESPON sets up innovation-related indicators by dividing them into knowledge, innovation, regional conditions for knowledge generation, regional conditions for innovation generation, regional conditions for obtaining external knowledge and innovation, and the flow of knowledge and innovation in a region. ESPON theoretically brought in three forms but drew actually five regional innovation classes, which are as follows.

First, a science-based area class is a region in which knowledge and innovation are briskly generated, and features to be high in R&D investment intensity, human resources in science, highly educated human resources, and capabilities to absorb external knowledge. Second, an applied science area class is a region that features a brisk generation of applied science, a high level of knowledge through the exchange of knowledge with regions with similar knowledge bases, a high R&D intensity, and internal conditions for knowledge generation and absorption. Third, a smart technological application area class is a region that features a high level of product innovation, a high level of capabilities to convert external knowledge on basic science and applied science into innovation, an unignorable level of science and highly educated human resources, and in particular, creativity and entrepreneurship. Fourth, a smart and creative diversification area class is a region that features a low level of regionally applied knowledge, some level of innovation capabilities within a region, a high level of regional competitiveness, and creativity and an enticing factor that is required to absorb external knowledge which can be converted according to regional conditions. Fifth, an imitative innovative area class features a low level of knowledge and low R&D intensity, entrepreneurship, and creativity, as well as high

4 GDP per capita, population density, unemployment rate, highly educated employment rate, gross R&D expenditures, private sector R&D, rate of patent application per population, rate of agricultural workers, rate of public sector workers, rate of manufacturing workers, high-tech manufacturing, knowledge service industry

5 European Spatial Planning Observation Network (ESPON) is a compilation of the final research outcomes of an innovation-related project that was implemented as a part of a program carried forward from 2007.

inducement and potential to innovation, which may use external innovation.

Pons (2014) pointed out that existing researches on the classification of regional innovation were mainly performed from a view of input and output as well as overlooked efficiency. Therefore, he developed his own arguments with gaps related to regional innovation from the view of efficiency. Pons argues that the efficiency of regional innovation should be found from the relationship among the subjects that comprise a region and that classes of regional innovation shall be sorted according to a degree of harmony or want of the relationship. Concretely, Pons refers to four gaps as follows.

First, a human resource gap is a limitation on the capabilities of the management in private businesses—in particular, in small- and medium-sized businesses with histories that are not long—and Pons suggests, as indicators related thereto, high-level education, global capabilities, professional capabilities, and ICT capability possession rate. Second, an openness and learning gap serves as a limitation on such factors to the outside, and Pons suggests, as indicators related thereto, connection with other businesses and innovation business rate. Third, a technology gap is a limitation on technological capabilities in private businesses, and Pons suggests, as indicators related thereto, the introduction of domestic and overseas technology, the participation of external technology experts, and R&D employment rate. Fourth, Pons suggests, as indicators related to a financial gap, venture capital and technology-based new business rate. It may be deemed that Pons uses indicators that focus on relationship among technology innovation subjects unlike existing researches on the classification of technology innovation. Pons classifies 17 regions in Spain into 4 clusters, such as manufacturing-focused integration cluster, service-focused integration cluster, intermediate integration cluster, and nonintegration cluster, using these indicators.

As stated above, this study examined the results[6] of major researches on the classification of regional innovation from the late 2000's until today. Existing researches showed various contents, such as research region, major interests in innovation, cluster naming, and others. This research aims to comprehensively apply[7] the major indicators used in existing researches on the classification of regional innovation and analyze them by sorting them into categories.

3. Data and Analysis Methods

3.1 Major Indicators and Data

Indicators used in this research are listed in Table 1, as shown below. This research generally used percentage values to reduce the effects caused by differences in regional absolute quantities among variables. Moreover, this research was based on values from 2012 and, if unavailable, used data from 2011. Analysis object regions in this research were 16 metropolitan cities and provinces, excluding Sejong-si. This research divided the selected indicators in innovation into six categories, such as a demographic economic field that represents the overall technological power of a region ; an employment and foothold field that represents a regional innovation base ; an activity field that represents investment and connection ; an output field that represents activity results ; and an industry specialization of a region.

6 In addition, this research referred to Na (2003), which used CIS data of Korea ; Francisco (2013), which analyzed 32 regions in Mexico; Petruchenya (2013), which analyzed 83 regions in Russia; and Yoon (2014), which analyzed China.

7 It is desirable to establish a theoretical framework and then select related indicators. However, the theory on regional innovation has not been systematically established, and most researches generally select indicators by focusing on specific fields. This research also designated the establishment of a theoretical framework as a later task and chose an approach to variously include innovation-related indicators. With regard to this matter, please refer to Aimone Marsan & Maguire (2011), p. 11.

Table 1. Regional Innovation Indicators for Korea

Categories	Indicators	Unit	Data Source	Remarks
Demographic economy	Population density	Person/km^2	Ministry of Security and Public Administration, Resident Registration Population; Ministry of Land, Infrastructure, and Transport, Cadastral Statistical Annual Report	
	Gross regional product	%	Statistics Korea, Regional Income Statistics	Comparison with total added value
	Regional export	%	Korea Customs Service, Export and Import Statistics	Comparison with total export
	Regional import	%	Korea Customs Service, Export and Import Statistics	Comparison with total import
Employment	Employees in high-tech manufacturing	Person	Ministry of Employment and Labor, Labor Condition in Businesses	Subcategories 20–21, 26–31 (2011)
	Employees in the knowledge service industry	Person	Ministry of Employment and Labor, Labor Condition in Businesses	Finance・insurance, real estate lease, specialized science and technology service (2011)
	Highly educated employees in technology	Person	Statistics Korea, Economically Active Population Census	Graduate from college or above (end of December in 2012)
	Employees with master's and doctorate degree	Person	Korea Education Development Institute, Education Statistics	Degree recipient in August 2012 or February 2013
	Researchers	Person	Ministry of Science, ICT, and Future Planning, R&D Activity Census	Per 1,000 persons
Foothold	Universities	%	Korea Education Development Institute, Education Statistics	Comparison with total number of universities
	Public research institute	%	Ministry of Science, ICT, and Future Planning, R&D Activity Census	Comparison with total number of public research institutes
	Business research institute	%	Ministry of Science, ICT, and Future Planning, R&D Activity Census	Comparison with the number of businesses
	Venture business rate	%	Venture personnel, Venture Statistics System	Comparison with the number of businesses
	Patent per business	%	Statistics Korea, Business Activity Census	Comparison with the number of businesses to be surveyed
	e-System introduction rate	%	Statistics Korea, Business Activity Census	Comparison with the number of businesses to be surveyed
	Inno-Biz business rate	%	Inno-Biz, Inno-Biz Statistics	Comparison with the number of businesses
	Foreigner-invested business	%	Ministry of Trade, Industry and Energy, Information on Foreigner-Invested Business	Comparison with the number of businesses
	Newly established corporation rate	%	National Tax Service, Small and Medium Business Administration	Comparison with the number of businesses
	Large business	%	Maeil Business Newspaper, 1,000 Large Businesses in 2012	Comparison with the number of 1,000 Large businesses
	Public officials	%	Statistics Korea, e-Nation Indicators	Quota standard
Activity	University R&D	%	Ministry of Science, ICT, and Future Planning, R&D Activity Census	Comparison with total R&D

Categories	Indicators	Unit	Data Source	Remarks
	Public R&D	%	Ministry of Science, ICT, and Future Planning, R&D Activity Census	Comparison with total R&D
	Business R&D	%	Ministry of Science, ICT, and Future Planning, R&D Activity Census	Comparison with total R&D
	Importance of external R&D	%	Statistics Korea, Business Activity Census	Comparison with the number of businesses to be surveyed
	Importance of strategic technical cooperation	%	Statistics Korea, Business Activity Census	Comparison with the number of businesses to be surveyed
	Technology transfer	%	Korea Intellectual Property Office	Rate in comparison with total number
Output	Patent application	Case/1,000 persons	Korea Intellectual Property Office, Intellectual Property Right Statistical Annual Report	
	Patent registration	Case/1,000 persons	Korea Intellectual Property Office, Intellectual Property Right Statistical Annual Report	
	Product innovation introduction in manufacturing	%	STEPI, Technology Innovation Survey	Comparison with business to be surveyed in 2009–2011
	Product innovation introduction in the service industry	%	STEPI, Technology Innovation Survey	Comparison with business to be surveyed in 2009–2011
	Process innovation introduction in manufacturing	%	STEPI, Technology Innovation Survey	Comparison with business to be surveyed in 2009–2011
	Process innovation introduction in the service industry	%	STEPI, Technology Innovation Survey	Comparison with business to be surveyed in 2009–2011
	Labor productivity in manufacturing	Million won/1,000 persons	Statistics Korea, Regional Income Statistics; Statistics Korea, Economically Active Population Census	
	Labor productivity in service	Million won/1,000 persons	Statistics Korea, Regional Income Statistics; Statistics Korea, Economically Active Population Census	
	Science paper publication	Paper/1,000 persons	Ministry of Science, ICT, and Future Planning	2011
Specialization	Rate of added value in manufacturing	%	Statistics Korea; Regional Income Statistics	Comparison with total added value
	Rate of added value in service	%	Statistics Korea, Regional Income Statistics	Comparison with total added value
	Rate of added value in agriculture and fisheries	%	Statistics Korea, Regional Income Statistics	Comparison with total added value

First, this research selected, as demographic economic indicators, regional density, overall technology condition, and population density by region, which acts for global activity, GRDP (Gross Regional Domestic Product), and export/import. Then, as employment indicators that represent a regional innovation base, in consideration of potential innovation personnel, the importance of employees in a high-tech manufacturing sector[8]; the importance of employees in knowledge service, such as finance, insurance, real estate leases, specialized science and technology service, and others; and the importance of master's or doctorate graduates and researchers in a region were selected. Moreover, as foothold indicators, university, public research institute, business research institute, patent per business, e-system introduction, Inno-Biz business, foreigner-invested business, newly established corporation, large business, and public officials were selected.[9] These indicators may manifest the innovation subject of a region, a business that retains technological capabilities in a region, and a national support base. As indicators to show activity, this research selected the importance of R&D investment of academia, the public sector, and a business sector in comparison with regional total R&D. As explained above, Pons (2014) pointed out the connection among innovation subjects as a core factor for regional innovation. In this research, technology transfer, the contracting-out of technology, and strategic technology cooperation were included to represent the connection among innovation subjects.[10] This research selected, as output indicators, patent application and registration, the importance of product and process innovation,[11] and labor productivity and scientific paper publication rates. Lastly, as indicators to represent the specialization of a region, added-value rates by industry, such as manufacturing, service industry, agriculture and fisheries, and others were selected.

3.2 Analysis Methods

Clustering analysis was applied to classify regional technology innovation. Among various methods for clustering analysis, hierarchical clustering analysis and K-means clustering analysis are the most typical methods. Hierarchical clustering analysis, which groups adjacent clusters, ultimately represents clusters through a dendrogram, whereas K-means clustering analysis defines an arbitrary number of clusters in advance, computes distances, and divides clusters toward the most distant one. In general, K-means clustering analysis is used for large-volume data, whereas hierarchical clustering analysis is used for small-scale data. This research intends to draw the number of clusters by performing hierarchical clustering analysis and then consolidating such results by performing K-means clustering analysis on the number of clusters stated above[12]. Because the

8 High-tech manufacturing represents in subcategory : chemical substance and chemical product manufacturer (20); medical substance and medicine manufacturer (21); electronic part, computer image and sound, and communication equipment manufacturer (26); medical precision optical instrument and watch manufacturer (27); electrical equipment manufacturer (28); other machineries and equipment manufacturer (29); automobile and trailer manufacturer (30); and other transportation equipment manufacturer (31).

9 In computing the regional rate, the number of business in a denominator was based on the "Economic Survey" of 2010. In computing other rates, the number of businesses that were subject to be surveyed would be denominators.

10 A connection indicator among innovation subjects in Aimone Marsan (2011), which analyzed OECD nations, is highly important but difficult to obtain. Aimone Marsan stated that existing researches have used joint inventions (patents) or joint researches.

11 Various indicators for innovation activity and output may be drawn from a technology innovation survey. This research used the product and process innovation of manufacturing and service industry only. Refer to Na (2003) and Siller et al. (2014) for major researches on the form, class, and division of regional technological innovation with technological innovation survey.

12 The most desirable method to define the number of clusters is to apply the Ward method and then consolidate the results by reiterating K-means clustering analysis on such results. Refer to Hollanders et al. (2012), p. 26.

selected indicators (variables) are closely interrelated, it is not desirable to perform clustering analysis on all indicators (variables) simultaneously. Thus, this research performed clustering analysis after going through principal component analysis (PCA) to contract variables. PCA selects major factors in an order of their explanation power for the total variation of all variables. This research may variously examine the relationship among regions, variables, and major factors through PCA at a preclustering analysis phase.

This research selected extensive indicators related to the regional innovation classes and classified these indicators into various fields related to regional innovation. In this case, this research intends to apply multiple factor analysis (MFA) rather than directly apply PCA, which may display characteristics among categorized groups. Because MFA may be deemed as a generalized PCA, its principle is to perform PCA on each group and then perform overall PCA by assigning a weighted value on each group. Thus, it is possible to analyze all objects and understand the relationship among objects, groups, variables, and major factors through PCA. This research used the FactoMineR Package prepared in R program for MFA application.[13]

4. Analysis Results

4.1 Multiple Factor Analysis (MFA)

MFA, as a kind of PCA, is used to reduce the number of related variables. Table 2, as shown below, represents the explanation power of the two major components in PCA and MFA by category, as suggested above.[14] Even if the 1st Major Component in PCA and MFA by category show the biggest explanation powers, there are differences in the explanation powers of the 1st Major Component and the 2nd Major Component in each category. Thus, it is important to analyze with MFA, which is represented with weighted values for each category, rather than to analyze with PCA.

Table 2. Eigenvalues of PCA and MFA by Category

	Category1 PCA (Demographic Economy)		Category2 PCA (Employment)		Category3 PCA (Foothold)		Category4 PCA (Activity)		Category5 PCA (Output)		MFA	
	Eigen value	%	Eigen value	%	Eigen value	%	Eigen value	%	Eigen value	%	Eigen value	%
1st Major Component	2.4213	60.53	3.2151	64.302	6.6036	60.03	2.7413	45.68	2.8533	31.70	4.1114	40.25
2nd Major Component	0.9648	24.12	0.9104	18.20	1.7198	15.63	1.1656	19.42	2.2760	25.28	1.4763	14.45

Table 3 shows the correlation between each variable and the 1st Major Component. The 1st Major Component, which accounts for 40.25% of all variable changes shows, especially high correlation with the number of public research institutes, the number of science paper publications, public R&D, and the number of technology transfer. The 2nd Major Component, which accounts for 14.45% of

13 Refer to Pagés (2004), Husson et al. (2010), Husson et al. (2011), Nakayama (2014), Josse et al. (2014), and others.
14 Industry specialization is used as an auxiliary variable of PCA and does not affect major component determination.

all variable changes, shows especially high correlation with highly educated employee in technology, the number of researchers, the number of researchers for businesses, the number of patent registrations, etc. Figure 1 and Table 3 illustrate these correlations. To sum, it is represented that most indicators have positive correlation with the 1st Major Component.

Table 3. Correlation between Variables and Major Components

Variable Name		The 1st Major Component	The 2nd Major Component
g3_2	Number of Public Research Institutes	0.955116	−0.23337
g5_9	Number of Science Paper Publications	0.947726	−0.25451
g4_2	Public R&D	0.934907	−0.3079
g4_6	Number of Technology Transfers	0.932169	−0.06204
g3_8	Foreigner Invested Business	0.902996	−0.36587
g3_10	Number of Big Companies	0.898247	−0.4146
g2_2	Employees in Knowledge Service	0.875782	0.238022
g3_1	Number of Universities	0.853631	−0.22175
g1_2	Gross Regional Product	0.834052	−0.28404
g1_1	Population Density	0.827235	−0.30999
g3_4	Venture Business Rate	0.787151	−0.06119
g3_11	Number of Public Officials	0.742781	−0.35327
g3_7	Inno-Biz Business Rate	0.708267	−0.00911
g5_2	Patent Registration	0.699187	0.551482
g2_4	Number of Master’s or Doctorate Graduates	0.692461	0.227441
g2_5	Number of Researchers	0.683144	0.605039
g5_1	Patent Application	0.682644	0.506498
g4_1	University R&D	0.660473	0.539317
g1_4	Regional Import	0.647782	−0.63105
g5_8	Labor Productivity in Service	0.602909	−0.64459
g4_3	Business R&D	0.579179	0.128476
g3_5	Patent per Business	0.572372	0.182604
g2_3	Highly Educated Employees in Technology	0.548385	0.652557
g2_1	Employees in High-tech Manufacturing	0.504307	−0.12036
SER	Service Added-Value Rate	0.454946	0.153213
g3_3	Number of Business Research Institute	0.418295	0.608228
g5_3	Product Innovation Introduction in Manufacturing	0.292501	0.421323
g3_9	Newly Established Corporation Rate	0.290814	0.45435
g1_3	Regional Export	0.202298	−0.01896
g4_5	Importance of Strategic Technology Cooperation	0.155493	−0.03091
g4_4	Importance of External R&D	0.148361	0.147468
g3_6	e-System Introduction Rate	0.123148	−0.00563
g5_4	Product Innovation Introduction in the Service Industry	0.083875	0.496373
g5_6	Process Innovation Introduction in the Service Industry	−0.07742	0.37426
g5_5	Process Innovation Introduction in Manufacturing	−0.28282	−0.27215
g5_7	Labor Productivity in Manufacturing	−0.30948	−0.3186
IND	Manufacturing Added-Value Rate	−0.34724	−0.07754
AGR	Agriculture and Fisheries Added-Value Rate	−0.46785	−0.3345

Note: Listed in a descending order of positive correlation with the 1st Major Component.

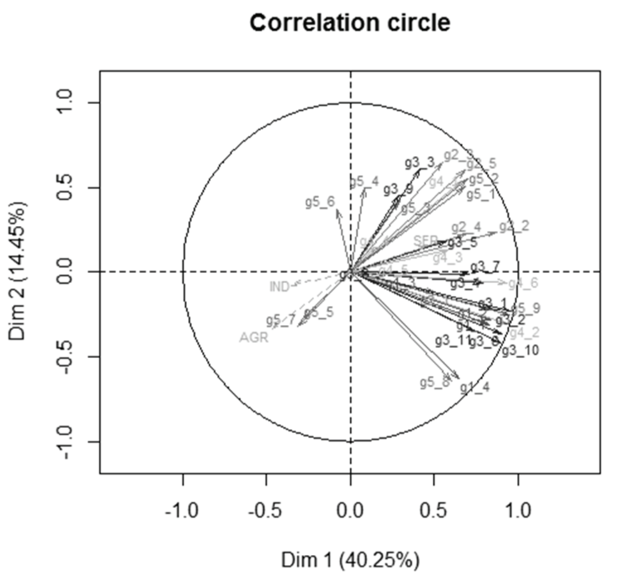

Figure 1. Correlation Diagram between Variable and Major Component

Table 4. Correlation between Variables and Major Components

	1st Major Component	2nd Major Component
Seoul	6.382	−2.244
Busan	−0.412	−0.298
Daegu	−0.671	0.522
Incheon	−0.518	0.611
Gwangju	−0.423	0.995
Daejeon	2.179	3.317
Ulsan	−1.439	−0.855
Gyeonggi	2.825	0.949
Gangwon	−1.156	−0.444
Chungbuk	−0.787	0.551
Chungnam	−0.438	−0.124
Jeonbuk	−0.976	0.271
Jeonnam	−1.362	−1.599
Gyeongbuk	−0.731	−0.546
Gyeongnam	−0.672	−0.261
Jeju	−1.800	−0.845

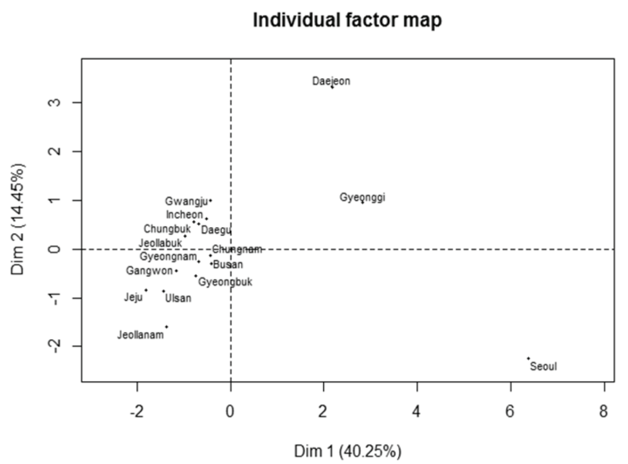

Figure 2. Distribution Diagram of Major Component Score of Region

Table 4 expresses the size of major components of each region with the 1st Major Component score and the 2nd Major Component score by region. Figure 2 illustrates such scores with the first component as the horizontal axis and the second component as the vertical axis. First of all, with respect to the 1st Major Component, which has the highest explanation power, Seoul is in the far right, Gyeonggi and Daejeon are in the middle, and the remaining regions are in the left in the respective group. Viewed in connection with Table 3, Seoul stands out with the number of public research institutes, the number of science paper publications, public R&D, and the number of technology transfers—all of which have high correlation with the 1st Major Component.

Daejeon stands out with the number of researchers, the number of researchers in businesses, and the number of patent registrations—all of which have high correlation with the 2nd Major Component. Table 5 and Figure 3 additionally show values by category for Seoul, Gyeonggi, and Daejeon where the 1st Major Component score is high. In case of Seoul, the value for population is large and the value for employment is small. Gyeonggi shows a relatively large value for activity and a small value for demographic economy, whereas Daejeon shows a large value for employment and negative vales for foothold and demographic economy.

Table 5. Major Component Score of Region

		1st Major Component	2nd Major Component
Seoul	Demographic economy (g1)	7.722	−6.876
	Employment (g2)	4.577	2.417
	Foothold (g3)	6.476	−3.059
	Activity (g4)	6.480	−0.800
	Output (g5)	6.656	−2.900
Gyeonggi	Demographic economy (g1)	1.246	−0.381
	Employment (g2)	1.380	2.072
	Foothold (g3)	4.892	−0.510
	Activity (g4)	5.032	0.413
	Output (g5)	1.578	3.152
Daejeon	Demographic economy (g1)	−0.463	0.804
	Employment (g2)	5.136	5.461
	Foothold (g3)	−0.238	1.315
	Activity (g4)	2.263	2.779
	Output (g5)	4.197	6.227

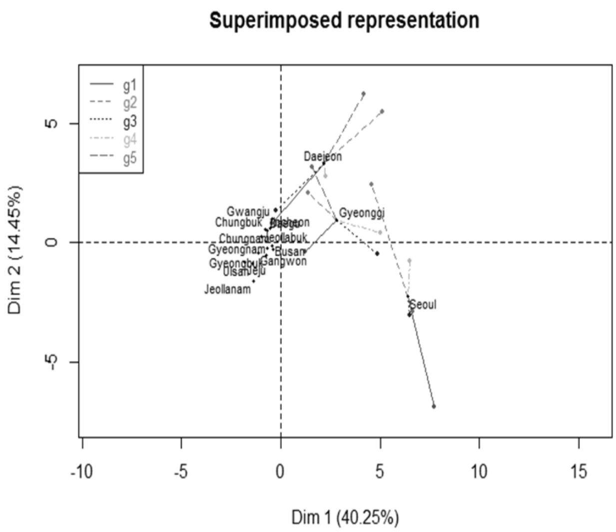

Figure 3. Major Component Score by Category of Region

This research uses the RV coefficient to evaluate the degree of linear correlation among categories that is composed of various indicators. If the value of RV coefficient is in the range of 0 to 1, as it is close to 1, there is a strong linear correlation among variables in categories, whereas as it is close to 0, there is a weak linear correlation among them. The Lg coefficient—a coefficient to supplement the RV coefficient—is used to measure similarity of structure among variables in two categories. As the value of the Lg coefficient is large, there is a high similarity among them, whereas as its value is close to 0, there is no similarity among them. Because the Lg coefficient for itself is related to the explanation power of the selected major components, a high Lg coefficient value means that the selected major components will prove sufficient for explanation. A relatively low Lg coefficient value means that an additional major component variable is needed.[15]

Viewed from the RV coefficient in Table 6 shown below, the values of foothold category (g3) and demographical economy category (g1) as well as the foothold category (g3) and activity category (g4) are 0.720 and 0.789, respectively, which represent high degrees of linear correlation. However, the values of employment category (g2) and demographical economy category (g1) as well as the employment category (g2) and the foothold category (g3) are 0.363 and 0.399, respectively, which represent low degrees of linear correlation. Similar correlations are found with the Lg coefficient. On the other hand, because the Lg coefficient for itself shows low values in demographical economy, employment, and foothold categories comparing to values in activity and output categories, additional explanation variables are needed for the former categories.

Table 6. RV Coefficients and Lg Coefficients of Variables among Categories

RV	g1	g2	g3	g4	g5	sup	MFA	Lg	g1	g2	g3	g4	g5	sup	MFA
g1	1.000							g1	1.194						
g2	0.363	1.000						g2	0.418	1.110					
g3	0.720	0.399	1.000					g3	0.831	0.444	1.115				
g4	0.609	0.601	0.789	1.000				g4	0.785	0.747	0.983	1.392			
g5	0.534	0.663	0.475	0.575	1.000			g5	0.860	1.029	0.739	1.000	2.170		
sup	0.227	0.532	0.213	0.283	0.335	1.000		sup	0.280	0.630	0.253	0.376	0.555	1.266	
MFA	0.786	0.747	0.818	0.874	0.827	0.391	1.000	MFA	0.994	0.911	1.000	1.194	1.410	0.509	1.340

Table 7 and Figure 4 represent the level of contribution of five categories to major components. Even if the value of the 1st Major Component is bigger than the value of the 2nd Major Component in all categories, there are minor differences in categories. The value of the activity category is the biggest in the 1st Major Component, while the value of the output category is the biggest and the value of the activity category is the smallest in the 2nd Major Component.

15 In this research, five major components that explain more than 80% of gross changes were selected through MFA. With respect to explanation on RV and Lg coefficients, refer to Pagés (2004).

Table 7. Level of Contribution of Categories to Major Components

	1st Major Component	2nd Major Component
Demographic economy (g1)	0.760	0.238
Employment (g2)	0.705	0.285
Foothold (g3)	0.839	0.174
Activity (g4)	0.934	0.156
Output (g5)	0.873	0.624

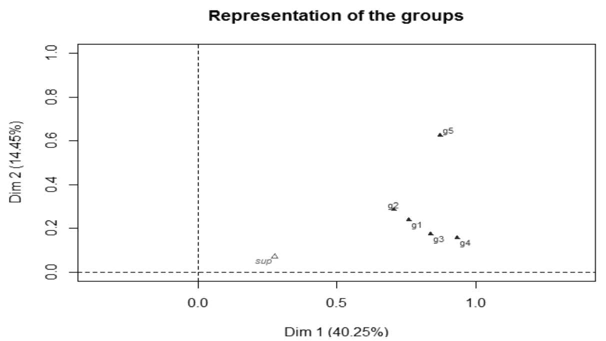

Figure 4. Distribution of Level of Contribution of Categories to Major Components

4.2 Clustering Analysis I: 16 Metropolitan Cities and Provinces

This research has examined major characteristics with regard to the variables selected through MFA. With this, clustering will be performed on the basis of MFA. This research drew seven clusters, which were shown in Table 8 and Figure 5, through computing a Euclidean distance of the sum of square increment (Ward's method) and K-means consolidating hierarchical classification and its result.16

Table 8. Distance among Clusters within a Cluster

		Distance from the Center	Closest Euclidean Distance
1st Cluster	Jeju	0.000	2.681
2nd Cluster	Jeonnam	1.117	2.389
	Ulsan	1.165	3.091
	Gyeongbuk	1.249	1.828
	Chungnam	1.369	2.260
3rd Cluster	Jeonbuk	0.427	2.230
	Chungbuk	0.673	1.953
	Incheon	0.716	2.041
	Gangwon	0.746	1.884
	Daegu	0.856	2.535
	Gyeongnam	0.987	1.580
	Busan	1.155	2.359
4th Cluster	Gwangju	0.000	2.499
5th Cluster	Daejeon	0.000	5.166
6th Cluster	Gyeonggi	0.000	4.905
7th Cluster	Seoul	0.000	6.430

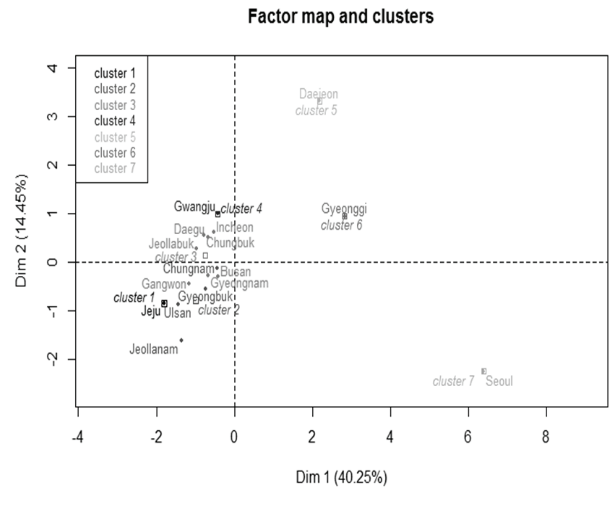

Figure 5. Cluster Distribution

16 This research performed clustering analysis based on the scores of each region for the five major components drawn through MFA. The number of clusters to be distinguished depends on how many major components are used. Because MFA showed that five major components explained more than 80% of a whole, this research decided to use such five major components and consolidated the cluster distinction through the K-means method after hierarchical clustering analysis was performed. In cases in which the number of major components is decided as 2, they will be divided into four clusters, such as Seoul, Gyeonggi, and Daejeon, and remaining areas.

Table 9 shows the average values of relevant indicators (variables) of each cluster and a value in bold means an indicator with meaningful differences from other clusters. The v.test in the far right of such table is used to verify the meaningfulness of differences for the average value of the relevant values. In cases in which the value of v.test is bigger than 1.96 or smaller than -1.96, p value will be smaller than 0.05 and the value will be deemed as statistically meaningful. Variables by cluster with these meaningful differences are as follows: In the 1st Cluster (Jeju), the e-system introduction rate of the foothold category and the product innovation introduction rate in the service industry of the output category were remarkably low and the rate of agriculture and fisheries was high. In the 2nd Cluster, the importance of the regional export of the demographic economy category, the labor productivity in manufacturing of the output category, and the added-value rate in manufacturing of the specialization category were high, whereas the added-value rate in the service industry was low, and the employees in high-tech industry and the highly educated employees in technology of the employment category were weak. In the 3rd Cluster, there were no indicators with remarkably high or low values. In the 4th Cluster (Gwangju), the external R&D of the activity category was high. In the 5th Cluster (Daejeon), four out of five variables of the employment category, excluding the rate of employees in high-tech, were remarkably high and the university R&D rate of the activity category and the rate of patent application and registration of the output category were also high. In the 6th Cluster (Gyeonggi), the number of venture businesses, the business patent, the rate of Inno-Biz, and the number of public officials of the foothold cluster and the business R&D and the number of technology transfers of the activity category were high. In the 7th Cluster (Seoul), there were many variables with meaningful differences in employment, foothold, activity, and output category, including the gross regional product of the demographic economy category.

Table 9. Average Value of Variables by Cluster

Indicators		1st Cluster	2nd Cluster	3rd Cluster	4th Cluster	5th Cluster	6th Cluster	7th Cluster	v. test
Demographic economy	Population density	−0.48	−0.46	−0.17	0.15	0.13	−0.27	3.52	3.639
	Gross regional product	−0.82	−0.11	−0.34	−0.64	−0.62	**2.37**	**2.56**	2.449 2.645
	Regional export	−1.06	**0.91**	−0.42	−0.98	1.64	−1.02	0.75	2.103
	Regional import	−0.56	0.27	−0.30	−0.56	−0.56	−0.56	3.30	
Employment	Employees in high-tech manufacturing	1.80	**-1.01**	−0.02	−0.22	0.28	0.30	**2.02**	−2.339 2.087
	Employees in the knowledge service industry	−1.24	−0.61	−0.26	0.34	**1.96**	0.65	**2.49**	2.028 2.576
	Highly educated employees in technology	−0.33	**−1.04**	−0.12	1.18	**2.22**	1.30	0.62	−2.397 2.295
	Employees with master's or doctorate degree	−0.70	−0.50	−0.24	0.89	**1.99**	−0.85	**2.35**	2.054 2.425
	Researchers	−0.75	−0.31	−0.41	−0.36	**2.97**	1.31	0.89	3.065
Foothold	University	−1.00	−0.03	−0.43	−0.18	−0.08	1.75	**2.66**	2.749
	Public research institute	−0.68	−0.43	−0.27	−0.52	0.40	1.04	**3.39**	3.495

Indicators		1st Cluster	2nd Cluster	3rd Cluster	4th Cluster	5th Cluster	6th Cluster	7th Cluster	v. test
	Business research institute	－1.51	－0.22	0.00	－0.71	1.47	1.70	－0.08	
	Venture business rate	－0.73	－0.42	－0.23	－0.49	－0.33	**2.99**	1.88	3.090
	Patent per business	－0.88	－0.31	－0.11	－0.71	0.15	**2.39**	1.05	2.471
	e-System introduction rate	**－2.32**	0.40	0.15	－0.08	－0.67	0.23	0.20	－2.395
	Inno-Biz business rate	－0.71	－0.38	－0.22	－0.49	－0.41	**3.26**	1.45	3.361
	Foreigner-invested business	－0.43	－0.38	－0.26	－0.40	－0.41	1.13	**3.45**	3.560
	Newly established corporation rate	0.19	－0.56	－0.11	0.95	1.22	0.22	0.41	
	Large business	－0.50	－0.26	－0.29	－0.43	－0.37	0.81	**3.57**	3.684
	Public officials	－1.03	－0.11	－0.19	－0.88	－0.88	**2.18**	**2.36**	2.250 2.436
Activity	University R&D	－0.51	－0.40	－0.35	－0.47	**3.37**	0.53	1.12	3.480
	Public R&D	－0.57	－0.37	－0.30	－0.25	0.09	0.74	**3.55**	3.665
	Business R&D	－0.46	-0.26	－0.33	－0.40	－0.11	**3.61**	0.66	3.731
	Importance of external R&D	－0.75	－0.53	0.03	**2.66**	0.12	－0.55	0.41	2.749
	Importance of strategic technical cooperation	－1.84	0.53	－0.25	0.78	－0.52	0.81	0.38	
	Technology transfer	－0.69	－0.43	－0.37	－0.27	0.27	**2.40**	**2.59**	2.480 2.676
Output	Patent application	－0.94	－0.08	－0.47	－0.47	**3.03**	0.77	1.20	3.129
	Patent registration	－0.89	－0.24	－0.40	－0.37	**3.10**	0.75	1.18	3.205
	Product innovation and introduction in manufacturing	－1.75	－0.72	0.36	0.86	－0.01	1.01	0.25	
	Product innovation and introduction in the service industry	**－2.07**	－0.57	0.35	1.86	－0.17	0.74	－0.55	－2.136
	Process innovation and introduction in manufacturing	0.69	0.53	0.03	－1.23	－0.76	－0.78	－0.23	
	Process innovation and introduction in the service industry	0.50	－0.50	0.34	－1.21	1.30	－0.21	－0.81	
	Labor productivity in manufacturing	－0.96	**1.50**	－0.43	－0.37	－0.63	－0.14	－0.84	3.452
	Labor productivity in service	0.24	0.06	－0.25	－0.96	－0.36	－0.75	**3.35**	3.460
	Science paper publication	－0.55	－0.40	－0.31	－0.19	0.41	0.56	**3.56**	3.680
Specialization	Rate of added value in manufacturing	－1.51	**1.25**	－0.18	－0.22	－0.84	0.24	－1.37	2.883
	Rate of added value in service	0.91	**-1.31**	0.20	0.40	1.04	－0.10	1.57	－3.017
	Rate of added value in agriculture and fisheries	**2.77**	0.21	－0.08	－0.76	－0.84	－0.64	－0.83	2.865

Note: A value that is in bold and is underlined is a statistically meaningful value. The v.test value means a meaningful value. In cases in which there are two values, an above value is for a front numerical value and a below value is for a rear numerical value.

Through the examination of the characteristic indicators stated above, the seven clusters may be characterized as follows:

- Cluster that constructs a foundation for comprehensive innovation: Seoul
- Cluster that is a center for entrepreneur and business innovation activities: Gyeonggi
- Cluster that uses an external innovation activity: Gwangju
- Cluster that constructs a foundation for average innovation: Jeollabuk-do, Chungcheongbuk-do, Incheon, Gangwon, Daegu, Gyeongnam, and Busan
- Cluster with manufacturing specialized innovation and weak human resources: Jeollanam-do, Ulsan, Gyeongsangbuk-do, and Chungcheongnam-do
- Cluster with specialization in agriculture and fisheries and weak activities and output: Jeju

4.3 Clustering Analysis II: 13 Metropolitan Cities and Provinces

This research performed MFA and the clustering analysis based on MFA on 16 metropolitan cities and provinces. Because Seoul, Gyeonggi, and Daejeon were heavily influential on all regional innovation variables, this analysis excluded such 3 regions and performed the clustering analysis on 13 metropolitan cities and provinces. This section will briefly explain MFA for 13 metropolitan cities and provinces here and present the result of the clustering analysis.

If the explanation rates of the 1st Major Component and 2nd Major Component in PCA and MFA by category in Table 10 are compared with those in Table 2, it would seem that the explanation powers of the Category 2 (employment) and the Category 3 (foothold) in PCA and the 1st Major Component in MFA drop greatly.

Table 10. Eigenvalues of PCA and MFA by Category

	Category 1 PCA (Demographic Economy)		Category 2 PCA (Employment)		Category 3 PCA (Foothold)		Category 4 PCA (Activity)		Category 5 PCA (Output)		MFA	
	Eigen value	%	Eigen value	%	Eigen value	%	Eigen value	%	Eigen value	%	Eigen value	%
1st Major Component	2.2984	57.46	1.9384	38.76	4.9160	44.69	2.6615	44.35	3.2008	35.56	3.1920	27.46
2nd Major Component	0.9627	24.06	1.8164	36.32	2.9241	26.58	1.5010	25.01	1.9719	21.91	2.7704	23.83

Table 11 represents the relation of variables among categories and, in general, shows values with low relation in comparison with Table 6. With respect to the RV coefficient, the relation between the foothold category and the activity category is similarly high (0.631), whereas the relation between the foothold category and the population category is not high (0.434), and the relation between the employment category and the output category is high (0.601). Here, the values of demographic economy and foothold are low but the value of employment category is the highest. In addition, the value of activity category is low, whereas the values of demographic economy, employment, and foothold category are also low as shown in Table 6. On the other hand, Table 12 and Figure 6 represent the level of contribution of 13 metropolitan cities and provinces to the major components and their contribution to the 1st major contribution is relatively low while the contribution of the output category is also particularly low.

Table 11. RV Coefficients and Lg Coefficients of Variables among Categories

RV	g1	g2	g3	g4	g5	sup	MFA	Lg	g1	g2	g3	g4	g5	sup	MFA
g1	1.000							g1	1.242						
g2	0.496	1.000						g2	0.799	2.086					
g3	0.479	0.236	1.000					g3	0.642	0.410	1.447				
g4	0.434	0.391	0.631	1.000				g4	0.596	0.694	0.934	1.512			
g5	0.419	0.601	0.409	0.511	1.000			g5	0.627	1.167	0.661	0.844	1.802		
sup	0.664	0.596	0.265	0.307	0.454	1.000		sup	0.808	0.940	0.348	0.412	0.666	1.191	
MFA	0.733	0.747	0.712	0.779	0.795	0.608	1.000	MFA	1.224	1.616	1.283	1.435	1.598	0.994	2.242

Table 12. Level of Contribution of Categories to Major Components

	1st Major Component	2nd Major Component
Demographic economy (g1)	0.546	0.581
Employment (g2)	0.539	0.848
Foothold (g3)	0.792	0.147
Activity (g4)	0.799	0.396
Output (g5)	0.513	0.796

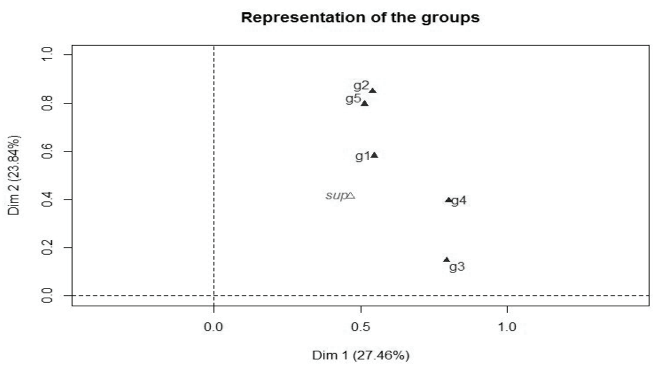

Figure 6. Distribution of Level of Contribution of Categories to Major Components

On the basis of MFA for the above 13 metropolitan cities and provinces, 4 clusters, which were shown in Table 13 and Figure 7 were derived through hierarchical clustering analysis and the K-means consolidation process.

Table 13. Distance among Clusters within a Cluster

		Distance from the Center	Closest Euclidean Distance
1st Cluster	Gangwon	1.525	2.703
	Jeonnam	2.409	4.352
	Jeju	2.421	5.034
2nd Cluster	Ulsan	0.000	4.278
3rd Cluster	Daegu	1.472	4.141
	Jeonbuk	1.591	2.705
	Incheon	2.146	3.289
	Busan	2.212	4.132
	Chungbuk	2.420	3.138
	Gwangju	2.716	5.400
4th Cluster	Gyeongbuk	0.642	3.767
	Gyeongnam	1.468	3.746
	Chungnam	1.595	3.968

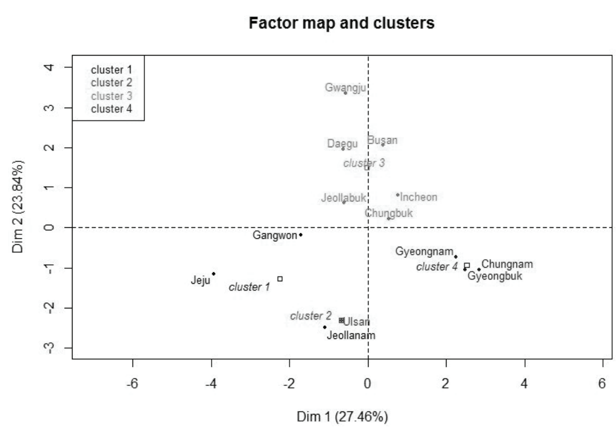

Figure 7. Cluster Distribution

Table 14 shows the average values of relevant indicators (variables) of each cluster.

Meaningful values in Table 14, which shows average values of relevant variables of four clusters, are as follows. The 1st Cluster is weak in the number of researchers, the foothold category, and the activity category but high in the service productivity and is specialized in the agriculture and fisheries. The 2nd Cluster (Ulsan) is remarkably high in the importance of the regional export but substantially low in the number of public research institutes. The 3rd Cluster shows high values in population density, highly educated employees in technology, and product innovation in manufacturing in comparison with those of the 13 metropolitan cities and provinces; however, its service productivity is low. The 4th Cluster shows high values in the gross regional product, the regional innovation foothold, the activity, and so on. In consideration of these characteristics, the four clusters may be named as follows:

- Cluster with regional innovation foothold and activity: Gyeongbuk, Gyeongnam, and Chungnam
- Cluster with highly educated employees in technology and manufacturing output foothold: Daegu, Jeonbuk, Incheon, Busan, Chungbuk, and Gwangju
- Cluster centered on export and with weak public research foothold: Ulsan
- Cluster specialized in agriculture and fisheries and with weak regional innovation foothold: Gangwon, Jeonnam, Jeju

Table 14. Average Value of Variables by Cluster

Indicators		1st Cluster	2nd Cluster	3rd Cluster	4th Cluster	v. test
Demographic Economy	Population density	−0.69	−0.09	**0.68**	−0.66	2.285
	Gross regional product	−0.81	0.14	−0.32	**1.40**	2.761
	Regional export	−0.48	**2.27**	−0.56	0.84	2.365
	Regional import	0.24	−0.61	−0.50	0.97	
Employment	Employees in high-tech manufacturing	0.69	−1.46	0.25	−0.69	
	Employees in the knowledge service industry	−0.91	0.80	0.56	−0.48	
	Highly educated employees in technology	−0.15	−1.07	**0.75**	−0.99	2.491
	Employees with master's or doctorate degree	−0.69	−1.19	0.52	0.04	
	Researchers	**−1.15**	0.05	0.12	0.90	−2.275
Foothold	University	−0.36	−1.25	−0.14	**1.05**	2.068
	Public research institute	−0.07	**−2.05**	0.12	0.51	−2.135
	Business research institute	**−1.18**	−0.35	0.30	0.69	−2.329
	Venture business rate	**−1.03**	−0.86	0.34	0.63	−2.035
	Patent per business	−0.54	0.25	0.32	−0.18	
	e-System introduction rate	**−1.19**	−0.20	0.03	**1.20**	−2.344 2.377

Indicators		1st Cluster	2nd Cluster	3rd Cluster	4th Cluster	v. test
	Inno-Biz business rate	**−1.03**	−1.04	0.24	0.91	−2.043
	Foreigner invested business	−0.53	−0.61	0.42	−0.11	
	Newly established corporation rate	**−1.01**	1.05	0.54	−0.42	−2.002
	Large business	**−1.07**	0.00	−0.11	**1.27**	−2.108 2.519
	Public officials	−0.08	−1.45	−0.26	**1.09**	2.147
Activity	University R&D	−0.78	−1.06	−0.07	**1.26**	2.491
	Public R&D	−0.67	−1.19	0.44	0.19	
	Business R&D	−0.96	−0.31	−0.14	**1.34**	2.656
	Importance of external R&D	−0.61	−0.59	0.44	−0.09	
	Importance of strategic technical cooperation	−0.29	1.82	0.01	−0.34	
	Technology transfer	−0.98	−1.84	0.27	**1.06**	2.093
Output	Patent application	**−1.17**	1.61	−0.06	0.76	−2.312
	Patent registration	**−1.05**	−0.23	0.09	0.95	−2.070
	Product innovation and introduction in manufacturing	−0.69	−1.76	**0.71**	−0.14	2.369
	Product innovation and introduction in the service industry	−0.96	−1.31	0.59	0.23	
	Process innovation and introduction in manufacturing	−0.21	1.62	−0.33	0.33	
	Process innovation and introduction in the service industry	−0.42	−0.62	0.06	0.52	
	Labor productivity in manufacturing	0.20	1.22	−0.55	0.48	
	Labor productivity in service	**1.06**	0.30	**−0.81**	0.46	2.090 −2.708
	Science paper publication	−0.97	−1.13	0.44	0.47	
Specialization	Rate of added value in manufacturing	−0.81	1.81	−0.34	0.88	
	Rate of added value in service	0.57	−1.68	0.46	−0.94	
	Rate of added value in agriculture and fisheries	**1.19**	−0.96	−0.45	0.03	2.347

Note: A value that is in bold and is underlined is a statistically meaningful value. The v.test value means a meaningful value. In cases in which there are two values, an above value is for a front numerical value and a below value is for a rear numerical value.

5. Conclusions

There are only a few who deny the fact that innovation is an important factor for regional development; with this, the regional innovative policy shall be enforced on the basis of characteristics carried by the innovation-related resources of the relevant region. However, there are not enough studies to empirically approach the differences in the innovative types among regions. Thus, it is essential to disambiguate differences in the regional innovation types in order to create a paradigm shift in which the regional innovation policies shall be enforced with autonomy and responsibility to have substantial significance. To serve as a fundamental research for such a subject, this study attempted to classify the innovation types for 16 metropolitan cities and 13 cities and provinces, excluding Seoul, Gyeonggi, and Daejeon through multiple factor analysis and the clustering analysis. As a result, this research classified 7 clusters through the analysis of 16 metropolitan cities and provinces, and 4 clusters through the analysis of 13 metropolitan cities and provinces, excluding Seoul, Gyeonggi, and Daejeon.

Even if the result of clustering may become slightly different depending on the indicators or analysis methods to be used, this study can verify that there exists a clear typological difference in the innovation among regions through statistical methods. With this, most of the related literature also suggest a common awareness of problem and the conclusion that an identical method may not be applied to all regions for regional innovation policy. In addition, it can be inferred that the differences in the innovation types among regions shall be understood to draw such policy differences.[17]

According to the clustering analysis, the regions of Seoul, Gyeonggi, and Daejeon are separated from other regions in the innovation foothold, the activity, and the output. Above all, Seoul, as a cluster that constructs a foundation for comprehensive innovation, is a central region in that every aspect of the city comprises innovation, such as, population density, economic power, science and technology human resources, universities, public research institutes, foreigner-invested businesses, large companies, public R&D, technology transfer activity, labor productivity in service, business service, making the city one step ahead. Seoul shall focus on promoting technological innovation or nontechnological overall innovation as well as disseminating global level knowledge and constructing knowledge network. Also, Seoul shall expand and intensify a global innovation network on the basis of the demands of businesses located therein. In addition it may be a desirable policy objective to maximize the R&D investment profits rather than to expand R&D investment.

Gyeonggi, a cluster that is a center for entrepreneur and business innovation activities, is a region with a strong economic power, high rates in venture business, and a large number of patented businesses and innovation businesses. It is also highly involved in business R&D and technology transfer activity. In this region, human resources are equipped with a relatively high education level, and its number of businesses of middle standing, all of which aim for globalization, continues to increase. In this region,

17 For instance, Ajmone Marsan (2011) pointed out that, because there are various regional innovation types within one nation, it is undesirable to enforce a national innovation policy irrespective of these differences. Moreover, Ajmone Marsan pointed out that Korea is one of the nations that show a huge difference in regional innovation types. He classified regions in Korea into five clusters, such as a knowledge-intensive area (capital area), intermediate technology manufacturing and service area (Gyeongnam, Gyeongbuk), traditional manufacturing area (Jeolla-do), knowledge and technology hub (Chungcheong), and service and natural resources area (Jeju, Gangwon). Furthermore, Francisco (2013), which classified Mexico into five regional innovation clusters, pointed out that, because Mexico is a nation with nonhomogeneous regions, various types of policies based on these heterogeneity shall be developed to succeed in expanding the innovation.

universities, businesses, and administrations are well balanced in comparison with other regions. Thus, a strategy to enlarge knowledge and productivity with which the businesses may compete in the global market through the international network is important in this region. With this, the promotion of the diffusion of innovation connected with the existing traditional manufacturing field is considered necessary. For this, it will be required to diversify specialized areas in applied science rather than in basic science.

Daejeon, an output-centered cluster with human resources in high technology, is a basic science-centered region abundant with high-quality human resources, engineers, and university R&D-making it ahead in patent application and registration. In this region, R&D activity is brisk and joint researches of research institutes and the private sector take a relatively important factor. The objectives of innovation policy in this region are to reinforce R&D for business to commercialize and supply a genuine sharing system for knowledge and technology among public institute, university, and business. It is important to promote international connectivity and develop/transfer knowledge and technology for/to businesses inside or outside of the region, which may also be commercialized. The basic research supports the idea that creative innovation and creative commercialization will have a great significance in this region.

As shown in Table 15, the differences in the regional innovation types in 13 metropolitan cities and provinces, excluding Seoul, Gyeonggi, and Daejeon, are similar in cases of comparing the 16 regions except few region. The regions that show meaningful differences are as follows: the Gangwon region belongs to Cluster 3 in the Clustering Analysis I in which the clustering analysis is performed with Seoul, Gyeonggi, and Daejeon, whereas it belongs to Cluster 1 in the Clustering Analysis II in which such three regions are excluded from the clustering analysis. Gyeongbuk and Chungnam belong to Cluster 2 in the Clustering Analysis I, whereas they belong to Cluster 4 in the Clustering Analysis II. On the other hand, there are no changes in the positions for other regions.

Table 15. Differences in the Clustering Analysis of 13 Metropolitan Cities and Provinces

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Clustering analysis Ⅰ	Jeju	Jeonnam, Ulsan, Gyeongbuk, Chungnam	Jeonbuk, Chungbuk, Incheon, Gangwon, Daegu, Gyeongnam, Busan	Gwangju
Clustering analysis Ⅱ	Kangwon, Jeonnam, Jeju	Ulsan	Daegu, Jeonbuk, Incheon, Busan, Chungbuk, Gwangju	Gyeongbuk, Gyeongnam, Chungnam

In regions that belong to Cluster 1 are specialized in the agriculture and fisheries and the values of all factors that comprise the innovation are relatively low; however, the service industry, such as tourism, is developed, and the labor productivity in service is high. In these regions, the population density is relatively low and accessibility is hindered. These regions should then focus on improving the educational level of the human resources and the technology absorption capabilities. It is expected that the development of technology absorption capabilities rather than the expansion of R&D will greatly influence on these regions' economic growth.

The regions that belong to Cluster 2 are regions specialized in traditional manufacturing, as it is shown from the fact that the labor productivity in manufacturing for these regions is high. It seems desirable to establish strategies to develop internal capabilities linked with external powers, e.g., foreign investment in order for these regions to achieve sustainable development. These regions shall improve their competitiveness through innovation by absorption, adaptation, and diffusion of technology externally developed as well as their capabilities to improve external absorption.

Cluster 3 is a region with an average economy and level of technology. Even if these regions do not have markedly outstanding aspects, they do not have aspects falling far behind. The objectives of the innovation policy for these regions are to expand investment to improve the current innovation-related level and the direction of the innovation policy for these regions shall be to maximize the current capabilities by forming cooperative relations among the innovation subjects. The R&D investments shall be made to maximize their effects rather than to increase them. The preparation of a policy system is also required to systematically carry forward R&D investments.[18] Even if an approach based on basic R&D or the creative idea is important, it is more significant to focus on specialized fields using the existing industries. If necessary, the innovation relying on imitation may be a good alternative.

Because the Cluster 4 shows the most desirable innovation circumstances among 13 metropolitan cities and provinces and has some traditionally strong industrial fields, it is highly likely that the promotion of the regional innovation based on such circumstances and industries is feasible. The high rates of innovation introduction business in the manufacturing and service industry or the capabilities to appropriately use the external technology with high importance of external R&D and strategic technology cooperation prove its viability. The selection and promotion of major strategic fields is thus seen as desirable.

The contents of the policy direction shown above are drawn from the results of statistical analysis performed from the awareness of problem that there are obvious differences in the regional innovation types among the regions and that regional innovation policy shall be applied. With this, the differentiated regional innovation policy based on closer analysis should be presented in the future. Even if this research analyzed the regional innovation type through most recent indicators, this study could be further supplemented by analyses on temporal stability for the regional innovation types and a dynamic approach for the changes. In addition, indicators to represent the relation among the innovation subjects and an indicator based on the theory of the regional innovation should be also developed.

Acknowledgment: The study was conducted as part of the KISTEP Fellowship Program in 2014. The results of the study belong to Korea Institute of Science and Technology Evaluation and Planning (KISTEP).

18 Even if this research did not deal with the matter, the governance of the regional innovation policy will be an important indicator. For such governance, the following will be included: a degree of intervention of a central government, a degree of resource for the policy enforcement of a local government, strategies of a local government, business planning capabilities, and others.

References

Ajmone Marsan, G. and K. Maguire (2011). Categorisation of OECD regions using innovation-related variables, 2011/03, OECD Publishing.

Aumayr, C. M. (2007). European region types in EU-25. The European Journal of Comparative Economics, 4, 2, 109–.147.

ESPON (2013). KIT: Knowledge, innovation, territory. Final Scientific Report.

Garcia Fernandez, F., Y. Sanchez Tovar, A. Mora Vazquez (2013). Analysis of regional innovation capability in Mexico. In Máarquez, B., Cervantes, L., Ochoa, A., and Castillo, N. (Eds.), Competitiveness' Key Factor S: The Organization's Internal Resources, Its Heterogeneous Distribution and Its Difficulty to Imitate Them. Juáez: Universidad Autóoma de Ciudad Juarez, 163–77.

Hollanders, H., J. Derbyshire, R. Tijssen, S. Tarantola, and L. R. Leon. (2012). Regional Innovation Scoreboard. 2012 Methodology Report.

Husson, F., J. Josse, and J. Pagè. (2010). Principal component methods: Hierarchical clustering–artitional clustering: Why would we need to choose for visualizing data? , Agro Campus Technical Report.

Husson, F., S. Lê and J. Pagè. (2011). Exploratory Multivariate Analysis by Example Using R. Boca Raton: CRC Press.

Hvidsten, T. R. and J. Komorowski (2009). Clustering: Hierarchical and K-means. The Linnaeus Centre for Bioinformatics.

Izsak, K. (2012). Regionalisation of research and innovation policies in Europe. Technopolis Group Belgium.

Josse, J., S. Lê and J. Mazet. (2014). "FactoMineR" Package: Multivariate Exploratory Data Analysis and Data Mining with R. August 28, 2014.

Kim, S.-S. (2005). Analysis of introduction of performance management system in R&D field. Innovation Journal, 8, 1, 237–60.

Liu, M. C., J. C. Wang, and M. T. Wu. (2014). Typology and knowledge productivity of regional innovation system: Evidence from China. Journal of Business and Economics, 5, 1, 49–0.

Ministry of Science and Technology (2005). Act on the Performance Evaluation and Management of National Research and Development Projects.

Na, J.-M. (2003). Characteristics and spatial pattern of regional innovation activity Nakayama, K. (2014). Analysis of exploratory multi-variable data according to MFA. Kansai Kakuin University Research Data.

Navarro, M. and J. J. G. Martís. (2009). Typologies of innovation based on statistical analysis for European and Spanish regions. Working Papers INNOVA, 2009-4, OECD Publishing.

Navarro, M., J. J. Gibaja, R. Aguado, and B. Bilbao. (2008). Patterns of innovation in the EU-25 regions: A typology and policy recommendations. Orkestra Working Paper Series in Territorial Competitiveness, 2008-047, OECD Publishing.

Pagé, J. (2004). Multiple factor analysis: Main features and application to sensory data. Revista Colombiana de Estadistica, 27, 1, 1–6.

Petruchenya, A. (2013). Regional Innovation Systems in Russia: Towards a Typology of Regions and Policy Recommendations. Lund University.

Pons, X. A. (2014). The role of intermediaries in solving system problems in regional innovation systems. Dissertation. Bilbao: University of Deusto.

Siller, M., C. Hauser, J. Walde, and G. Tappeiner. (2014). The multiple facets of regional innovation. Working Papers in Economics and Statistics, 2014-19, OECD Publishing.

Wintjes, R. and H. Hollanders. (2010). The regional impact of technological change in 2020.

Yoon, J.-W. (2014). Research on gaps in technology innovation capability among regions in China. International Area Studies, 17, 4, 231–58.