Preliminary Study on Regional Science and Technology Indicators

- Evaluating S&T Resources for Regional Innovation -

(NISTEP Report No. 51)

3rd Policy-Oriented Research Group

1.Objectives

Amid recent advances in the globalization of economic activities, the implementation of policy measures aimed at tackling the hollowing out of regional industries has become an urgent task, and the importance of regional innovation based on regional S&T activities, along with that of the utilization of the fruits of such activities, is widely recognized as one of the effective measures to achieve this goal. However, despite the fact that there is general awareness of the extreme unevenness of the geographical distribution of regional S&T resources, it has not been adequately assessed in quantitative terms, and the theoretical understanding about matters that need to be assessed is still limited.

For this reason, a preliminary study aimed towards devising "regional S&T indicators" designed to measure regional S&T resources on a quantitative basis was undertaken.

2.Study Method

The study was carried out by the National Institute of Science and Technology Policy (NISTEP) and the Institute for Future Technology (IFTECH), the latter commissioned by the Science and Technology Agency.

In concrete terms, NISTEP took on the task of a basic examination of regional S&T indicators in terms of main concepts behind them, their composition, etc. based on existing study results, and decided on the overall direction of the study encompassing, among other things, the scope of data to be collected and framework of indicators, based on the examination results. In the course of this examination, due attention was paid to the deliberation results of the "Regional Science and Technology Indicator Research Committee" (Chairman: Prof. Kinji Gonda, Senior Director-in-Research, NISTEP and Professor at Tokai University), a consultative committee set up within NISTEP with academics and other experts as its members.

Based on these results, IFTECH then collected relevant data and attempted to develop a database and formulate regional S&T indicators. An attempt was also made at analyzing the concentration of regional S&T resources using the obtained data as well as classifying local government based on cluster analysis and identifying cluster characteristics. Prior to the commencement of the work, subcommittee meetings of the "Regional Science and Technology Indicator Research Committee" were held to hear experts' views on individual detailed matters

Lastly, future tasks and recommendations that emerged from this preliminary study were compiled by NISTEP.

3. Study Results (Outline)

(1)Basic examination of regional S&T indicators

Through the basic examination of regional S&T indicators, which was undertaken based on existing reference material and deliberations by the "Regional Science and Technology Indicator Research Committee", the overall direction of the study encompassing the composition of indicators and other matters was determined as follows:

1)In light of factors including the project being still at the preliminary study stage, the work would focus on devising a system of "descriptive" indicators designed to represent overall activities in a balanced and quantitative manner.

2)Generally speaking, S&T activities are characterized by the achievement of diverse

objectives through the use of individual bodies of scientific knowledge and technologies. In this study, however, the purposes of regional science and technology were defined as the ″promotion of technological innovation and provision of a driving force for regional invigoration through the accumulation/buildup of intellectual assets and S&T capabilities″ as well as the ″improvement of the quality of life for community residents through timely and flexible responses to various regional needs″ in consideration of the study objectives.

3)Although the term ″region″ is used to denote various geographical area sizes, ranging from a municipality to a group of countries, for the purpose of this study, it is used to denote a prefecture.

4)R&D activities take place on the basis of a broad and multi-layered S&T support base, while their fruits take various forms, ranging from direct outputs, such as research papers and patents, to indirect ones, including increased community awareness brought about through the social impact of production activities. In view of the aspect of a region as the place to live for the region's researchers, the factor of S&T culture and creativity should also borne in mind. Efforts should therefore be made to ensure that regional S&T indicators reflect the overall impact of the S&T activities, instead of just covering R&D activities.

5)Based on the above considerations, it was decided to adopt a system of regional S&T indicators based on four categories of regional S&T resources as follows: ″social infrastructure″ that provides researchers with a place to live and otherwise supports R&D activities in a broad sense; ″S&T infrastructure″ that indirectly supports R&D activities through, for example, the fostering of R&D personnel and R&D-support activities; ″R&D infrastructure″ that directly supports R&D activities through, for example, R&D resources and R&D systems; and ″R&D outputs″ consisting of both direct outputs, such as research papers and patents, and indirect outputs, including flow-on effects to the regional industry and economy as a whole. Also, the results of regional R&D activities impact on the regional community residents in the form of knowledge, culture, and goods & services, while the regional community residents influence regional R&D activities as part of their external resources (see Fig. 1).

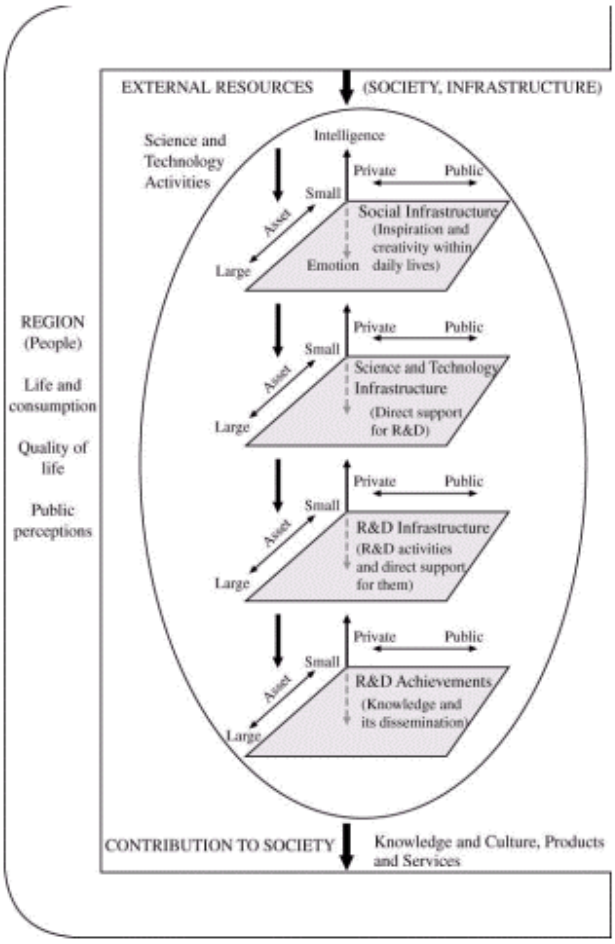


Fig. 1 Framework of Regional S&T Indicators

In the examination, attention was focused on the "highly concentrated nature" of regional S&T resources. This concentrated nature was considered to be attributable to "intangible knowledge" consisting of know-how, background ideas behind research projects, etc., rather than "authored knowledge", including research papers and databases, as the latter type of R&D outputs has a strong tendency towards diffusion, rather than concentration. Also, the concentrated nature of regional S&T resources led to the conclusion that it was necessary to assess each specific S&T resource in each specific region in terms of "absolute advantage" (all or nothing) rather than "comparative advantage". From these facts, the following were identified as desirable attributes of regional S&T indicators:

1)Capable of showing the concentration of intangible knowledge in a region

2)Capable of showing information relating to a region that is necessary to determine the S&T area to be targeted by it in their pursuit of absolute advantage

In this regard, continued investigation is required.

(2)Attempt at devising regional S&T indicators

Taking the results of the basic examination into consideration, an attempt was made at devising regional S&T indicators based on various existing statistical data and research material. At the same time, summary background data was prepared for each region for reference. All the data used was the latest available fiscal year data. In light of the fact that the project was still at the preliminary study stage, data collection was limited to existing data, with no efforts made to collect new data, such as questionnaire surveys.

1)The collected data was compiled after breaking down the above four categories into

subcategories. Meanwhile, when working out subcategories, efforts should normally center around regional systems of innovation (RSI) as regimes of regional innovation. In this study, however, the following items were used on a qualitative and empirical basis, because of the failure of research focusing on RSI to produce useful results:

Social infrastructure:
"Living environment/culture"Researcher's livelihood
"Economy"Regional vitality
"Social climate"Character of prefectural residents etc. (appropriate data not available)

S&T infrastructure:
"Society"Fostering of an interest in science and technology and provision of intellectual stimulation
"Education"Development of S&T human resources
"R&D support"Support for R&D activities

R&D infrastructure:
"R&D resources"Human, material and financial resources
"R&D organizations"Sites of R&D activities
"R&D activities"State of R&D activities

R&D outputs:
"Direct outputs"Production of intellectual assets
"Indirect outputs"Socioeconomic flow-on effects

In addition, an overview of each region was also prepared to illustrate background conditions for S&T activities.

2)Based on these subcategories, existing statistical data and research material were widely searched, and an attempt was made to construct regional S&T indicators based on the 41 data items obtained (see Table 1). But, it should be borne in mind that some important data such as that relating to the social environment or private R&D expenditures could not be obtained, making the representation of regional S&T activities somewhat incomplete.

3)To eliminate interregional disparities attributable to variations in population and economic strength, the data was standardized, with quartiles showing regions' approximate relative positions attached to the indicators (see Table 1).

Table 1 S&T Resource Concentration of Top 10 Regions

Item	Raw number			Standardized			Item
	0 – 39	40 – 59	60 – 100	0 – 39	40 – 59	60 – 100	
Total floor area per house (m^2)	—	—	—	○			Total floor area per house (m^2)
City park area per capita (m^2)	—	—	—	○			City park area per capita (m^2)
Number of hospitals		○		○			Number of general hospitals per 100,000 of population

Item	Raw number			Standardized			Item
	0 – 39	40 – 59	60 – 100	0 – 39	40 – 59	60 – 100	
Number of welfare facilities	○			○			Number of welfare facilities per 100,000 of population
Satellite broadcast subscription rate (%)	—	—	—	○			Satellite broadcast subscription rate (%)
Number of cultural facilities etc.		○			○		Number of cultural facilities etc. per 100,000 of population
Number of hotel rooms		○		○			Number of hotel rooms per 100,000 of population
Gross prefectural product (100 million yen)			○	○			Per capita gross prefectural product (10,000 yen)
Final accounts of local governments (100 million yen)		○		○			Ratio of final accounts of local governments to gross prefectural expenditure (%)
Labor population (1,000 workers)		○		○			Ratio of labor population to overall population (%)
Number of business establishments (all industries)		○		○			Number of business establishments per 100,000 of population
Value of product shipments (100 million yen)		○		○			Per capita value of product shipments (10,000 yen)
Number of public libraries		○		○			Number of public libraries per 100,000 of population
Number of science museums etc.		○		○			Number of science museums etc. per 100,000 of population
Value of annual retail sales of books etc. (million yen)			○	○			Per capita value of retail sales of books etc. (yen)
PC ownership rate (%)	—	—	—	○			PC ownership rate (%)
Number of students (postgraduate + undergraduate + technical college diploma)			○		○		Number of students per 100,000 of population
Number of universities and technical colleges		○		○			Number of universities and colleges per 100,000 of population
Proportion of high school graduates enrolling in university courses (%)	—	—	—	○			Proportion of high school graduates enrolling in university courses (%)
Total S&T related expenditures (100 million yen)		○		○			Ratio of S&T related expenditures to overall expenditures of local governments (%)
Number of information service business establishments			○	○			Number of information service business establishments per 10,000 business establishments
Number of business establishments engaging in R&D-support testing and analysis			○		○		Number of business establishments engaging in R&D-support testing and analysis per 10,000 business establishments
Number of science parks					○		Number of science parks per 10,000 business establishments
Number of patent attorneys			○			○	Number of patent attorneys per 100,000 of population

Item	Raw number			Standardized			Item
	0 – 39	40 – 59	60 – 100	0 – 39	40 – 59	60 – 100	
Total expenditures on testing and research at public research institutes (100 million yen)		○		○			Ratio of total expenditures on testing and research at public research institutes to overall expenditures of local governments (%)
Number of research scientists			○		○		Number of research scientists per 100,000 of population
Number of engineers			○	○			Number of engineers per 100,000 of population
Number of researchers at national and local government research institutes		○			○		Number of researchers at national and local government research institutes per 100,000 of population
Number of teachers at universities and colleges			○	○			Number of teachers at universities and colleges per 100,000 of population
Number of main frame computers delivered			○	○			Number of general-purpose computers delivered per 10,000 business establishments
Number of advanced technology facilities (e.g. clean rooms)		○		○			Number of adavanced technology facilities per 10,000 manufacturing industry business establishments
Number of national and local government research institutes		○		○			Number of national and local government research institutes per 10,000 business establishments
Number of private research institutes			○		○		Number of private research institutes per 10,000 business establishments
Number of non-profit research institutes			○			○	Number of non-profit research institutes per 10,000 business establishments
Number of joint research projects		○		○			Number of joint research projects per national government–run tertiary institution
Number of grants-in-aid research projects			○			○	Number of adopted grants-in-aid research projects per 1,000 research scientists
Number of patent applications			○			○	Number of patent applications per 10,000 business establishments
Distributed prefectural income (1,000 yen)	—	—	—		○		Per capita distributed prefectural income (1,000 yen)
Value of manufacturing industry product shipments per employee (1,000 yen)	—	—	—		○		Value of manufacturing industry product shipments per employee (1,000 yen)
Product added value per employee (1,000 yen)	—	—	—		○		Product added value per employee (1,000 yen)
Number of venture businesses		○			○		Number of venture businesses per 10,000 business establishments

(3)Analysis based on experimental regional S&T indicators

1)Examination of uneven interregional distribution of S&T resources etc.

For each of the collected data items (raw data and standardized data), the ratio was taken of national total and the value of each individual prefecture (hereinafter referred to as the ″ratio″), with an examination made of the interregional distribution of S&T resources based on this result.

i)Concentration in Top 10 regions

For each data item, subtotal of the ratios of the top 10 regions was calculated. The number of items with relatively large concentrations, where the total exceeds 60, was one out of 10 (raw

number) and zero out of 12 (standardized) with the social infrastructure, while it was 12 out of 22 (raw number) and three out of 24 (standardized) with the S&T infrastructure and R&D infrastructure. This confirmed that unevenness was greater with items that were closely associated with R&D activities, compared to general social items.

ii)Examination via cumulative distribution curves (human resources and organizations)

For various collected data items (raw data and standardized data), cumulative distribution curves were dawn by plotting the values from regions with high ratios to those with low ratios on a cumulative basis.

Cumulative distribution curves on human resources and organizations were compared in terms of general items (population and number of business establishments), R&D items (number of scientists and number of private research institutes) and S&T support items (number of patent attorneys and number of R&D-support testing and analysis business establishments), with R&D items exhibiting a fairly large unevenness in distribution for both human resources and organizations. S&T support items exhibited an extremely large unevenness for both human resources and organizations (see Figure 2).

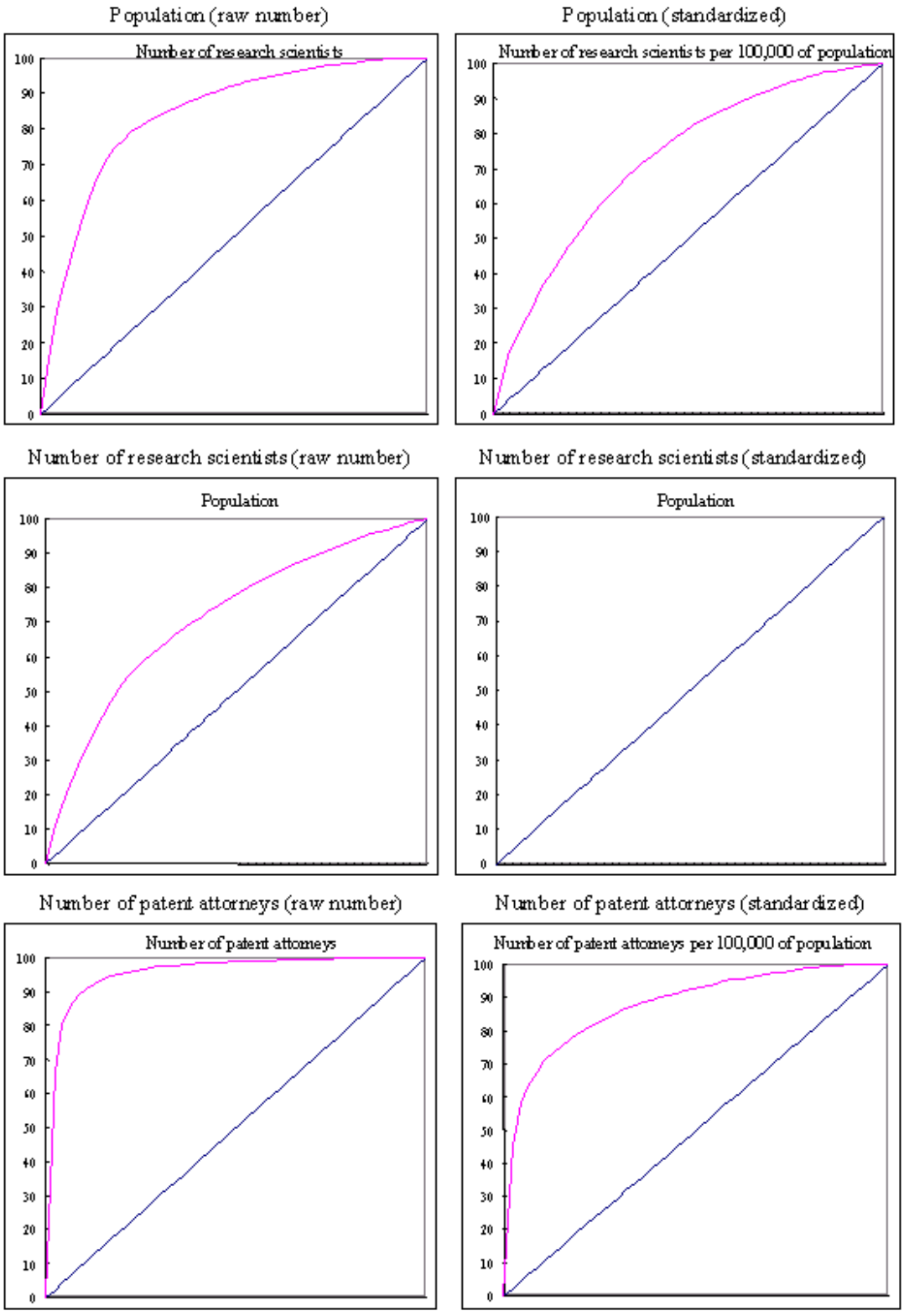


Fig. 2 Examples of Uneven Interregional Distribution (Human Resources)

2)Typification of regions and study of the characteristics of regional types

Based on the 41 data items obtained, indices were prepared for the 10 subcategories, with prefectures typified via a cluster analysis and characteristics of regional types identified. The 10 subcategories were ″living environment/culture″, ″economy″, ″society″, ″education″, ″R&D

support", "R&D resources (human)", "R&D resources (material)", "R&D organizations", "R&D activities" and "R&D outputs".

The cluster analysis resulted in the classification of regions into the following five groups (clusters): 1) Tokyo, 2) Kanagawa and Ibaraki, 3) Miyagi, 4) Kyoto, Osaka and Aichi and 5) the remaining 40 prefectures. Table 2 shows the characteristics etc. of each group, while Figure 3 shows radar charts of indices by cluster.

Table 2 Typification of Regions and Characteristics of Regional Types

Prefecture	Characteristics	Future direction
Cluster No. 1: Tokyo	• The scores far outstrip the national average for all indices except for social infrastructure (living environment/ culture). In particular, the index for R&D organizations exceeds 100, while those for S&T infrastructure (R&D support) and S&T infrastructure (education) exceed 70. • Concentration in R&D organizations, R&D support services and universities was particularly large. • Tokyo is by far the single most heavily concentrated center of S&T resources.	• A firm R&D infrastructure has been established, and this is largely attributable to past investments made by private companies. • As the social infrastructure is considered inadequate, efforts need to be made to improve amenities for community residents based on the firm R&D infrastructure.
Cluster No. 2: Kanagawa Ibaraki	• Scores exceed the average in terms of the S&T infrastructure (R&D support), R&D infrastructure (human resources) and R&D infrastructure (facilities), R&D organizations, R&D activities and R&D outputs. Scores are particularly high for human resources, exceeding 90 in Ibaraki and 70 in Kanagawa. • From the original data, it appears that the former is attributable to national research institutes, and the latter private research institutes.	• The important task for Kanagawa is to build distinct regional R&D activities by fully utilizing its private research institutes and researchers. • For Ibaraki, it is important to develop a distinct S&T infrastructure by, for example, expanding exchanges between national and private institutes and researchers.
Cluster No. 3: Miyagi	• The R&D activities index score is 79, which is markedly higher than other regions. • From the original data, it can be seen that there is a significant contribution of grants-in-aid research projects, particularly those involving academics at Tohoku University.	• It is important to examine the strengthening of the mechanism aimed at putting S&T seeds to industrial use and provision of support for the efforts to turn universities into COE through links between its universities and regional industries.
	• The regions score well in a balanced manner, with the exception of the	• Although the regions boast well-balanced S&T and R&D

Cluster No. 4: Kyoto Osaka Aichi	social environment index (living environment/ culture). • Some differences can be observed within the cluster as follows: high university concentration and well-developed S&T (education) base (Kyoto); high R&D organization concentration (Osaka); and all-round high scores (Aichi).	infrastructures, it is still important to build on the existing potential and pursue further advancements by coming up with a distinct direction for future regional S&T infrastructure development.
Cluster No. 5: Others (remaining 40 prefectures)	• Although the analysis failed to identify overall characteristics, common characteristics can be seen within constituent subclusters.	• Although the analysis failed to identify overall characteristics, common characteristics can be seen within constituent subclusters. It is important to study these characteristics for each subcluster

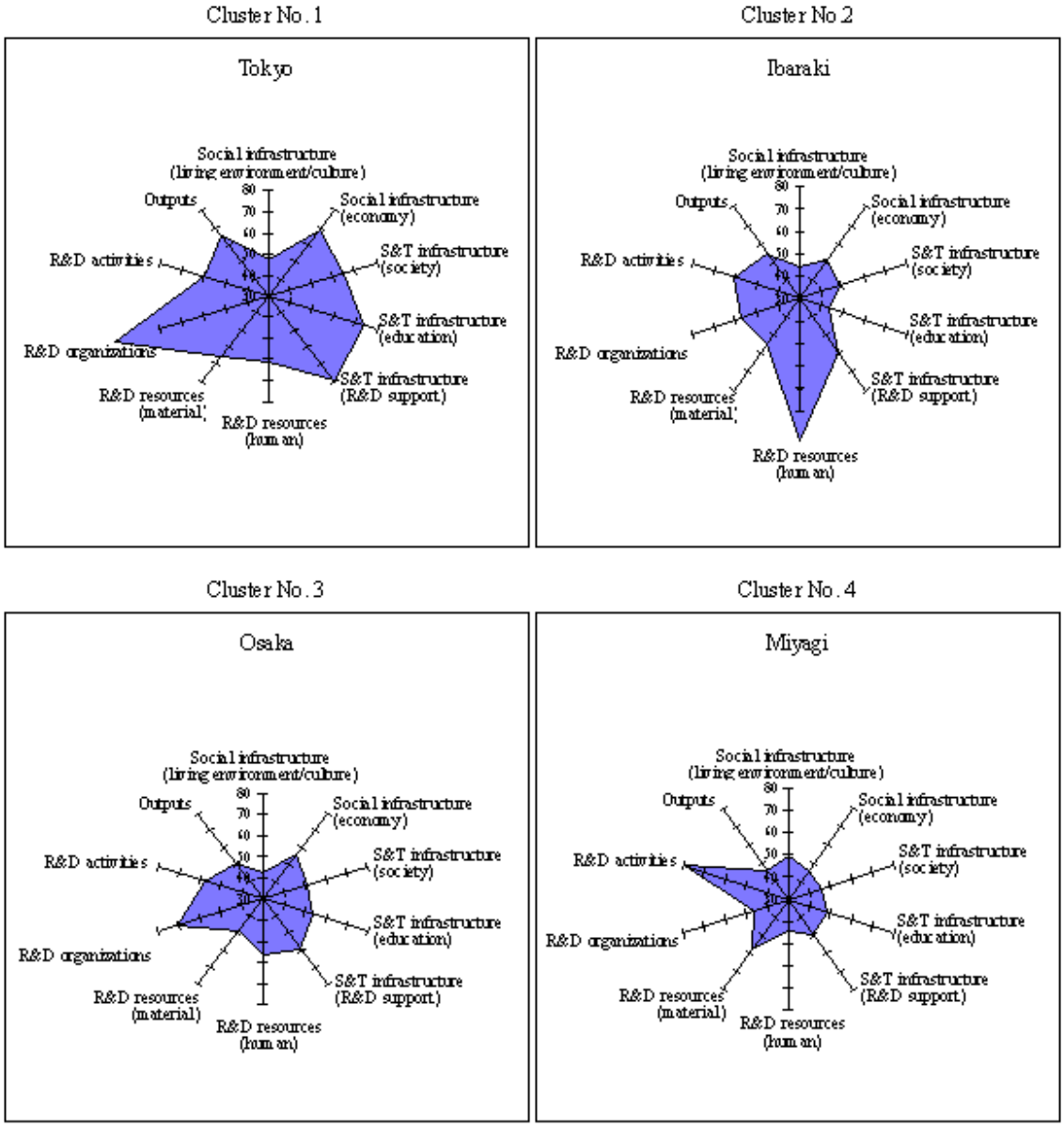


Fig. 3 Indices Radar Charts by Cluster

(4)Future tasks and recommendations

In the course of the study, the following six issues emerged as future tasks and recommendations:

1)S&T promotion policy measures based on regional characteristics

The distribution of S&T resources is extremely uneven from region to region, and the concentration of S&T resources can be classified into certain types including industry-led, university-led, government-led and balanced.

Thus, when formulating policy measures for different regions with different S&T resource concentration characteristics, it is necessary to come up with those that can flexibly respond to differences in characteristics between regions, rather than uniform measures. Uniform measures may lead to wider interregional disparities. Within each region, it is also necessary to apply policy measures that take into consideration regional characteristics, instead of standardized ones.

2)Shift from ″comparative advantage″ to ″absolute advantage″

Science and technology exhibits a strong tendency towards geographical concentration, so that the distribution of S&T resources is not a function of regions' comparative advantages. Rather, it is more likely to occur in one region or a small number of them in a concentrated manner. For this reason, the formulation of regional S&T policy must focus on ″absolute advantage″, rather than ″comparative advantage″. When examining regional S&T promotion measures, including those concerning S&T areas to be targeted by regions in their pursuit of absolute advantage, it is necessary to let each region decide from a strategic viewpoint, rather than forcing standardized measures on them. The task relating to regional S&T indicators is the collection of data that will facilitate the research on S&T areas to be targeted by regions in their pursuit of ″absolute advantage″.

3)Elucidation of regional systems of innovation

Although the importance of a regime for regional innovation as a means of regional economic development has been recognized, little research has been done so far. For this reason, studies geared towards the elucidation of regional systems of innovation (RSI) are keenly awaited.

4)Concentration of regional S&T resources and ″tacit knowledge″

S&T resources have a strong tendency towards geographical concentration due to ″tacit knowledge″. Therefore, the accumulation of ″tacit knowledge″ in science and technology and its utilization in the industry are important goals for regional S&T promotion measures. The task relating to regional S&T indicators is the translation of the accumulation of ″tacit knowledge″ into indicators.

5)S&T and cultural climate

An important factor to be considered in the promotion of regional science and technology is regional S&T climate (cultural climate regarding creativity). In concrete terms, it is necessary to strive to develop a regional society with a ″challenging spirit″, apart from accumulating R&D resources, consisting of personnel, materials and funds.

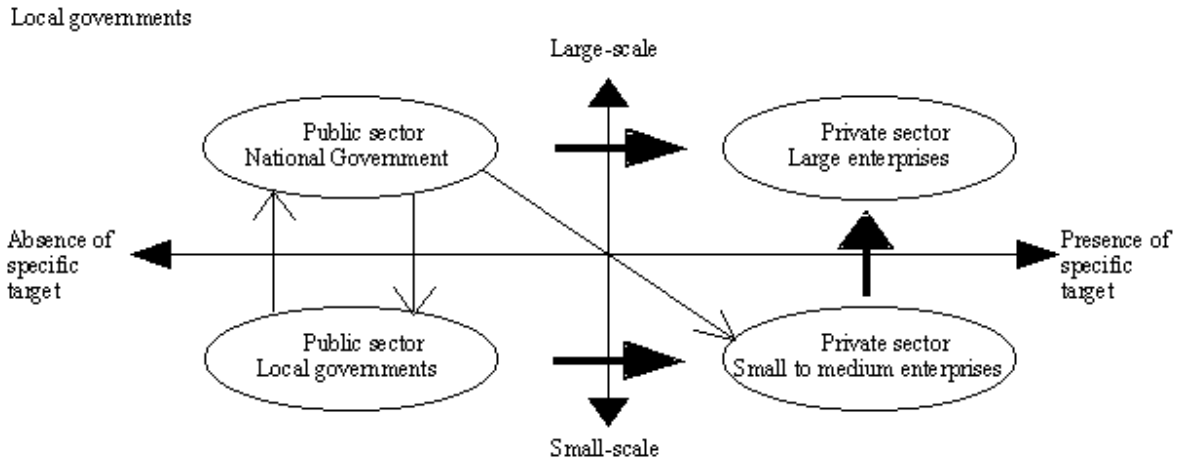
The task relating to regional S&T indicators is to further elucidate the social infrastructure relating to regional science and technology through research on the impact of various social factors on R&D activities and identification of the factors which have a great impact on research and development.

6)Regional S&T focusing on small and medium-sized enterprises (SMEs)

At large enterprises, R&D outputs are widely shared within their respective organizations by transporting them across regions, making it an important task for a region to ensure that R&D outputs produced in the region take root in the region. In general, however, it is often more appropriate to focus on SMEs when examining local governments' regional S&T promotion measures. Also, in light of the fact that the public sector is expected to cover S&T areas that are too risky for the private sector to address, ″R&D areas that lie upstream of those usually pursued by SMEs (i.e. basic research etc.)″ appear to be suitable for local government initiatives.

While the National Government should pursue large-scale basic research projects, it is important that any small to medium scale spin-off technologies generated in these projects be transferred to local governments and SMEs. Conversely, it is also important that any R&D projects being undertaken by local governments be transferred to the National Government (conversion to national projects), if they become more appropriate for pursuit as large-scale R&D projects in the course of their progress.

The diagram below shows the targets of R&D activities in a schematic manner.



4.Conclusions

Based on a basic examination of regional S&T indicators, an attempt was made to devise regional S&T indicators from existing statistical data, with S&T indicators consisting of 41 data items.

Using these data, an examination of the distribution of S&T resources, typification of prefectures and analysis of prefectural type characteristics were undertaken, with the tendency for S&T resources to concentrate geographically confirmed using tables and graphs. Prefectures were classified into five groups, with their characteristics etc. studied.

Lastly, the following six issues were identified as future tasks and recommendations: 1) S&T promotional measures based on regional control; 2) elucidation of regional systems of innovation; 3) concentration of regional S&T resources and tacit knowledge; 4) shift of focus from comparative advantage to absolute advantage; 5) S&T and the environment; and 6) regional S&T focusing on SMEs.