Development of the Case-Based Reasoning System for Regional Science and Technology Policy: An Interim Report

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Abstract--**Various types of policy to promote regional science and technology have been introduced in Japan since the 1980's. Although those policies have achieved a degree of success in fostering entrepreneurs and developing human networks, some remaining problems have been pointed out regarding the fact that the policy target of sustainable revitalization of regions has not been realized. In this Paper, we report an interim result of the project aims to develop a decision-making support system with applied case-based reasoning to contribute to the resolution of these problems. Case-based reasoning is a technique for problem-solving based on the solution of similar past cases. The system of reasoning has been put to practical use in engineering problem-solving, diagnosis, decision making on managerial issues, legal reasoning and so on. By applying the technique of planning and problem-solving to regional science, technology and innovation policy, the sharing of useful knowledge for regional revitalization among regions becomes possible. The scheme of this project includes a large-scale acquisition of case information, construction of database, analyses of success factors of policies, and the development of rules of inference and their implementation.**

I. INTRODUCTION

Japan's regional science and technology policy, i.e., "policy with the objectives of promoting regional science and technology with an eye to regional development" [2] is considered to have been formed beginning in the 1980s with the conscious integration of regional policy and science and technology policy [3]. Of course, the 1980s were when development began on science parks in regions designated by the national government. This was based on laws such as the Technopolis Law (enacted 1983) and the Key Facilities Siting Law (enacted 1988). Subsequently, Article 4 of the Science and Technology Basic Law of 1995 specified the role of local governments in the promotion of science and technology as follows. "The local governments are responsible for formulating and implementing policies with regard to the promotion of [science and technology] corresponding to national policies and policies of their own initiatives in accordance with the characteristics of their jurisdictions." During the 2000s, initiatives to strengthen ties among regional universities, public research institutions, and nearby businesses were promoted through industrial cluster projects (Ministry of Economy, Trade and Industry) and intellectual cluster creation projects (Ministry of Education, Culture, Sports, Science and Technology).

Through these processes, Japan's regional science and technology policies have already compiled a 30-year history. Various issues related to the policy effects have been pointed out. The above-cited report of the Council for Science and Technology Policy acknowledges that policies to date have contributed to points such as the formation of human networks. However, it also points out issues such as 1) entities to commercialize technologies that have reached the prototype stage do not exist in the regions, 2) markets have not been developed, and 3) synergistic effects among the various local measures have not been realized. Moreover, the report judges that desired policy targets (outcomes) have not been reached.

Effective solutions to such problems, however, could be found through sharing among regions the empirical knowledge accumulated over 30 years of policy development. Even so, there is currently no system for sharing and utilizing case study data related to science and technology policy in the various regions. This research therefore aims to support the planning and implementation of regional science and technology policy by attempting to develop a decision-making support system based on "case-based reasoning."[1] This paper, along with presenting the basic concept, is an interim report on the total results of the collection of information on cases, which is carried out as part of system development. It will conclude by touching on future development issues.

II. BASIC CONCEPT

Triggered by the USA's "Marburger Initiative," the recent policy philosophy of "science for policy" has saturated Japanese science, technology, and innovation policy as well, to the point of forming a topical domain. A paradigm shift from an opinion-based policy process to an evidence-based policy process is underway. In the actual policy process, it is likely that most of the time, work on policy planning and the solving of policy issues takes place through reference to case information on existing policies rather than relying solely on the opinions of experts on commissions and so on. Our research focuses on this case-based policy process. We conceive the development of a system to scientifically support the process. The research examines the method of "case-based reasoning" for application to this system development.

[1] This research is a topic, "Development of a Case-Based Reasoning System to Support Regional Science, Technology, and Innovation Policy" (project director: Akiya Nagata), adopted under the "Science for Science, Technology, and Innovation Research and Development Program" of the strategic creative research promotion program (Science and Technology for Society) promoted by the Japan Science and Technology Agency.

Case-based reasoning is known as a method for solving new problems based on solutions to similar problems in the past [1] [4]. Since the 1980s, there have been many attempts to develop problem-solving systems equipped with reasoning engines based on this methodological perspective. It has seen practical use in fields such as engineering problem-solving, medical diagnosis, legal reasoning, and knowledge management. However, case-based reasoning faces the criticism that even though it is an approach that uses evidence-based reasoning, unless that evidence is comprises data that can stand up to statistical analysis, it is nothing more than judgment based on anecdotal evidence. Addressing that criticism has been an important issue. Our research's system development therefore adopts inferential statistics methods to supplement the reasoning process in an attempt to do so. In order to adopt inferential statistics methods a database of case information is necessary. With diverse empirical data accumulated from each region, regional science and technology policy is one of the few fields that make construction of such databases possible.

Our research collected data concerning the science and technology policies of various regions and compiled it into a database, which was used to perform statistical analysis of the success factors of various kinds of policies. Next, based on the results of this analysis, reasoning rules weighted towards relevant past cases are developed for users facing a given policy issue. Finally, the database and the reasoning rules are integrated, and a decision-making support system is constructed.

This decision-making support system has a function that enables a person in charge of regional science and technology policy who faces a problem in policy planning or implementation to input data regarding the problem and search previous case information that will contribute to solving the problem. In fiscal 2015, the final year of this research's plan, the system developed is to be made publically accessible via the internet. In order to establish use of the system, initially it will be made public through a membership system. The scope of users will be gradually expanded while the system is upgraded in light of feedback from user members.

III. CASE STUDY SURVEY OF LOCAL GOVERNMENTS

A. Overview of survey

This research began in October 2012. To date, preparatory interviews with four regions that are pursuing industrial cluster projects have been performed, and case information based on a nationwide questionnaire survey of local governments has been collected. Below, this paper reports interim total results of the questionnaire survey entitled "Basic survey of regional science, technology, and innovation policy."

For the survey, questionnaires were mailed at the end of March 2013 to the 1,789 local governments that comprise all of Japan's prefectural and municipal governments. As of the end of November 2013, 1,781 responses had been collected (99.6 percent collection rate).

Survey topics were science and technology policy, environment and energy policy, and design policy. Questions spanned the policies' state of implementation and purposes, details of specific policies implemented, costs, information sources used during planning, collaboration inside and outside the region, policy effects, and so on. This report reviews survey results on the status and purposes of initiatives and the state of implementation of various policies for science and technology policy only.

B. Overview of initiatives concerning science and technology policy

The survey first asked about the state of implementation of basic initiatives related to science and technology policy through fiscal 2012. Table 1 shows total results by type of local government.

TABLE 1. IMPLEMENTATION STATUS OF SCIENCE AND TECHNOLOGY POLICIES

	Percentages of local governments implementing (%)			
	Prefectures	Cities/Wards	Towns/Villages	Total
Formulation of guidelines/vision	81.4	3.1	1.0	3.9
Formulation of a basic plan	41.9	1.4	0.6	2.0
Establishment of a council/commission	58.1	2.5	0.5	2.8
Creation of a white paper	11.9	0.0	0.0	0.5
N	43	807	929	1779

Of the prefectural governments that responded, 81.4 percent had achieved "Formulation of guidelines/vision." At that level of local government, clearly there was a general trend to move to examine the direction of local science and technology policy. Additionally, 58.1 percent responded that they had implemented "Establishment of a council/commission," and 41.9 percent that they had implemented "Formulation of a basic plan." This indicates that at the prefectural level, it is no longer rare for a local government to take an organizational stance towards concrete policy-making or to set actually policy.

At the municipal (city/ward/town/village) level, however, few local governments had implemented such initiatives. Because municipalities account for the overwhelming majority of respondents, less than 10 percent of all local governments had implemented any of the above three policies.

As for "Creation of a white paper," only 11.9 percent of local governments at the prefectural level had implemented that policy, and none had at the municipal level.

C. Purposes of implementing science and technology policy

Next, the survey asked about the purposes of implementing science and technology policy. Responses in this category were received from local governments that had implemented some sort of science and technology policy or were planning it. Table 2 shows the percentages of the 191 responding local governments selecting each purpose.

TABLE 2. PURPOSES OF IMPLEMENTING SCIENCE AND TECHNOLOGY POLICIES

	Percentages of the local governments concerned (%)			
	Prefectures	Cities/Wards	Towns/Villages	Total
Promotion of local industries	94.7	83.9	62.1	82.7
Job creation	81.6	63.7	31.0	62.3
Educational/cultural promotion	52.6	41.9	41.4	44.0
Measures against regional environmental problems	50.0	23.4	51.7	33.0
Enhancement of safety and security	47.4	12.9	20.7	20.9
Regional revitalization	15.8	16.9	27.6	18.3
Other	21.1	4.8	3.4	7.9
N	38	124	29	191

As seen in the table, at the prefecture level, "Promotion of local industries" was the most common response, at more than 90 percent. It was followed by "Job creation," with more than 80 percent. "Educational/cultural promotion," "Measures against regional environmental problems," and "Enhancement of safety and security" each had a rate of about 50 percent.

At the city/ward level, the most common responses were similar to those at the prefecture level. In order from the highest, they were "Promotion of local industries," "Job creation," and "Educational/cultural promotion." However, the rate for "Measures against regional environmental problems" was in the 20s, and that for "Enhancement of safety and security" was in the teens, in both cases much lower than the rates of the prefectures.

At the town/village level, responses about purposes tended to be even more distinctive. As it was at the prefecture and city/ward levels, "Promotion of local industries" was the most common response. It was followed by "Measures against regional environmental problems" at about 50 percent. The rate of almost 30 percent for "Regional revitalization" was also distinctive to the town/village level.

D. Implementation status of various policies

The survey also captured the implementation status of specific policies during fiscal 2012. Table 3 tallies the percentages of local governments responding that they had implemented each policy.

As seen in the Table, every local government at the prefecture level had implemented "Technical consultation, etc., by public research and development institutes" and "R&D support for companies, etc." The implementation rates for "Measures on scientific and technological information," "Support for and collaboration with universities, etc.," and "Educational campaigns for the public" were each at or above 80 percent. The lowest implementation rate was for "Operation of research parks," at only about 20 percent.

At the city/ward level, the implementation rate for each policy was markedly lower than at the prefecture level. The highest rate was for "Independent R&D support for local companies, etc.," at only 11.9 percent. The next highest rates were for "Operation of science museums and other museums" and "Support for and collaboration with universities, junior colleges, and vocational high schools on R&D, technical transfer, etc.," both with between 7 and 8 percent.

Implementation rates at the town/village level were even lower than at the city/ward level. The highest rate was for "Measures and initiatives on the collection and transmission of scientific and technological information," at a mere 1.1 percent.

E. State of utilization of information sources

Table 4 tallies the results of responses regarding information sources used when setting science and technology policy during fiscal years 2010 to 2012.

As shown in the Table, 97.4 percent of local governments at the prefecture level referred to "Trends in science and technology policies of the national government." This was the highest figure. It likely reflects the fact that regional science and technology policy carried out by the national government often includes measures to support the prefectures. Among the prefectures, the next-highest responses were "Past policies of the local government" and "Intentions and problem awareness of the head of the local government."

At the city/ward level, "Information exchange with companies and trade groups" was the most common response at 66.2 percent, followed by "Intentions and problem awareness of the head of the local government" and "Problem awareness of the local government's employees," which also had high rates. At the town/village level, "Intentions and problem awareness of the head of the local government" was the most common response at 53.6 percent. The top three was rounded out by, in order, "Problem awareness of the local government's employees" and "Past policies of the local government."

TABLE 3. IMPLEMENTATION STATUS OF VARIOUS POLICIES

	Percentages of local governments implementing (%)			
	Prefectures	Cities/Wards	Towns/Villages	Total
Technical consultation, etc., by public research and development institutes	100.0	2.6	0.2	3.8
R&D support for companies, etc.	100.0	11.9	0.4	8.1
Establishment and management of universities, junior colleges and vocational high schools	63.6	0.6	0.0	1.9
Support for and collaboration with universities, etc.	81.4	7.1	0.9	5.6
Expenditure on research conducted by medical institutions	51.2	1.2	0.1	1.8
Operation of science museums and other museums	75.6	7.6	0.9	5.8
Measures on scientific and technological information	82.2	6.3	1.1	5.5
Operation of research parks	20.9	1.1	0.1	1.1
Educational campaigns for the public	80.0	4.7	0.9	4.6
Activities through semi-public sectors	48.8	2.2	0.0	2.2
N	45	807	929	1781

TABLE 4. INFORMATION SOURCES UTILIZED FOR PLANNING SCIENCE TECHNOLOGY POLICIES

	Percentages of local governments utilizing (%)			
	Prefectures	Cities/Wards	Towns/Villages	Total
Trends in science and technology policies of the national government	97.4	47.9	32.1	54.9
Trends in policies of other local governments	57.9	33.8	21.4	36.6
Trends in science and technology policies in other countries	42.1	8.6	10.7	15.1
Councils and commissions within the local government's own area	52.6	18.7	0.0	22.4
Past policies of the local government	92.1	52.5	46.4	59.0
Intentions and problem awareness of the head of the local government	89.5	61.2	53.6	65.4
Intentions and problem awareness of local assembly members	63.2	29.5	21.4	34.6
Intentions and problem awareness of other politicians	21.1	10.8	3.6	11.7
Problem awareness of the local government's employees	84.2	56.1	50.0	60.5
Researchers in universities, etc.	81.6	50.4	32.1	53.7
Consultants/think tanks	28.9	25.9	14.3	24.9
Information exchange with companies and trade groups	86.8	66.2	35.7	65.9
Information exchange with civic groups and the public	47.4	28.1	14.3	29.8
Industrial property rights such as patents and designs	57.9	17.3	3.6	22.9
Publications, reports, research papers, etc.	73.7	40.3	17.9	43.4
Public study meetings and conferences, etc.	60.5	26.6	21.4	32.2
Other	5.3	0.0	0.0	1.0
N	38	140	28	208

F. Interpretation of the total results

From the above interim total results, it can be surmised that the main actors in regional science and technology policy are local governments at the prefecture level, and that there is no clear division of roles with local governments at the city/ward or town/village level.

However, local governments at the municipal level account for the overwhelming majority of local governments, so even if only 10 percent of city/ward governments, for example, engage in science and technology policy, they would equal a figure close to the total number of local governments at the prefecture level. Thus, if one accepts the prospect that the decentralization of science and technology policy to the regions will further expand, potential users at the municipality level of the system being developed in our research will exist on a scale that cannot be ignored.

Moreover, the survey results indicate that 60 percent of local governments at the prefecture level, 30 percent at the city/ward level, and 20 percent at the town/village level already refer to information on the policies of other local governments that will be provided through the system we are developing. Although this reference rate is lower than are those for national government policies or local governments' own past policies, one reason for that may be that information on other local governments' policies is less accessible than information on the national government's policies. Therefore, provision of the system we are developing is expected to increase the rate of reference to the policies of other local governments.

IV. FUTURE DEVELOPMENT ISSUES

This report is based on the simple interim total results of the questionnaire survey. Above, we outlined the science and technology policies of the provincial local governments that will be the users of the decision-making support system that our research is developing, but the ultimate goal of this research is not the statistical processing and interpretation of data. Instead, it is the collection of information on a large number of cases and the provision of it in the form of case information for sharing among users.

In the development of this knowledge sharing system for regional science and technology policy, our research is examining the development of reasoning rules in parallel with the collection of case information.

A. Searching case information through the application of text mining

Text mining techniques will be applied to search for similar past cases when system users input descriptions of problem states. For example, it will be used when the semantic distances of word patterns that co-occur in identical sentences will be measured to see how similar users' problem states are to past cases, and the case information retrieved is assigned priorities.

B. Weighting of case information through logistic regression analysis

Based on case data, logit models with the success or failure of policy objectives as dependent variables will be estimated. Individual polices and conditions that influence policies will be input as independent variables. Estimated parameters will be converted into odds ratios and reflected as individual policy weights in search rules.

C. Application of Bayesian estimation

The impact of using various information sources during policy planning on the success probability of a policy will be analyzed by using the questionnaire survey's data. Based on Bayes' theorem, this will be taken as the posterior probability of policy effects of referring to information sources, and the information sources that should be prioritized for reference will be specified.

We will take other opportunities to report on the results of our research.

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