An Analysis of the Achievements of JST Operations through Scientific Patenting: Linkage Between Patents and Scientific Papers

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Abstract— **Scientific Patenting, the linkage between patents and scientific papers, is gaining increasing attention as a means of measuring innovation. The Japan Science and Technology Agency (JST) is a funding agency that promotes the creation of innovation and has a mission to provide information on the effects of investments and evaluation under the Science and technology polices. For achieving this mission, the JST has developed an evaluation system that analyzes Scientific Patenting, the linkage between scientific papers and patents, in order to visualize the contribution of the JST's operations to the creation of innovation. Based on the quantitative measurement of Scientific Patenting, linkage between scientific papers and patents, this paper introduces on the result of analysis of researchers supported by JST.**

***Index Terms*—**

I. Introduction

A. Background

Science patenting, linkage between patents and scientific papers, have been studied for some 30 years, beginning when Narin started the study of science linkage in 1976 [1], and it is considered that analysis of non-patent literature cited by patent examiners provides a quantitative and objective indicator of the relationship between technologies and basic science studies. The analyses of Science Linkage between patents and non-patent literature to date, however, have been limited to those of linkage within a sector, such as universities, public institutions, and firms, and no studies have been made on the basis of individual researchers or institutions across sectors. This is presumably because of difficulty in identifying the names of researchers and institutions that are found in the vast amount of scientific papers and patents. Linking data on funding data, human resources, scientific papers and papers individually may be possible to quantitatively determine the relationship between funding, human resources, research, and technologies. We describe linking those data individually as "Scientific Patenting." The Japan Science and Technology Agency (JST), as an independent administrative agency that funds and promotes the creation of innovation, has set, under the heading of the "publication and communication of achievements" and "tasks to be achieved" in its mid-term plan, the following objectives in view of policy requests:

- The JST will keep track of such matters as research details, the status of scientific paper publication, oral presentations, and patent applications on research results, and the social and economic ripple effects of the results, and provide information to society in an easy-to-understand manner.
- The JST will aim to support research of the highest level internationally. For that purpose, the JST will utilize various quantitative indices, such as the number of citation, the number of international science awards received, and the number of invited lectures.

What these objectives indicate is that it is the duty of the JST as an independent administrative agency to analyze how much contribution its operations have made to the creation of innovation by examining the social and economic ripple effects of the research it has supported or by utilizing quantitative indices.

The Third Science and Technology Basic Plan defines innovation as a "breakthrough that generates new social and economic values with advanced scientific findings and technical inventions combined with human insights." In the light of this definition, the JST is required to integrate scientific findings with technological inventions to develop them. For a funding agency promoting innovation like the JST, it is considered imperative to quantitatively keep track of the number of citation which scientific papers (the fruits of researches) are cited in patents (the fruits of technologies) so that it can obtain important basic information for the evaluation of investment effects of its operations and of scientific and technological policies. The 2009 Plan

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for the Promotion of Intellectual Property, published on June 24, 2009, includes the following statements. “With regard to patents and scientific papers of universities, studies will be made in the fiscal year 2009 to draw some conclusions on the establishment of a method to count the number of citation being cited in the applications or notifications of reasons for refusal of other patents. These need to be counted per patent, scientific paper, inventor, and author. The data will be utilized to evaluate the quality of patents and scientific papers as well as to assess researchers." With this context, the JST has developed J-GLOBAL foresight, an evaluation system to analyze and visualize Scientific Patenting, the linkage between scientific papers and patents, for the purpose of assessing the investment effects of its operations. Using J-GLOBAL foresight to analyze the results of researchers supported by JST, this paper will present (1) the researcher’s output supported by JST both in the globe and in Japan based on quantitative indices and (2) detailed analysis of scientific patenting, linkage between scientific papers and patents cited by patent examiners.

B. Analysis Method

The databases used in this analysis are Elsevier B.V.’s Scopus Custom Data for scientific papers, and the European Patent Office (EPO)’s Worldwide Patent Statistical Database (PATSTAT) for patents.

Scopus Custom Data of Elsevier B.V. includes more than 18,000 journals of over 5,000 publishers worldwide, and has over 38 million records of bibliographies and excerpts.

Scopus Custom Data was selected as the database for use in the analysis because it has information on references cited for scientific papers published in and after 1996, contains a vast amount of data, and clearly indicates authors and the organizations they belong to.

The PATSTAT of the EPO is a patent database with information on over 50 million patent applications in 80 countries worldwide. The database is provided in a format that can be easily introduced to relational databases, and as part of the EPO's bibliographical database (DocDB), has various information on patents, such as application number, publication number, priority date, application date, publication date, name of invention, international patent classification, grouping, and information on references cited including summaries.

Both the patent database and bibliography database have a huge amount of data and, accordingly, the data for use in the analysis was screened at the beginning. Patents were narrowed down to those applied for at one of the following three patent offices—the Japan Patent Office, the United States Patent and Trademark Office, and the European Patent Office—and/or at the World Intellectual Property Organization (WIPO). As for the data for bibliographies, information on references other than scientific papers, such as books, was excluded.

The period covered by the analysis is from 1996 through to the end of 2007, for which information on citation is available on Scopus Custom Data. As a result of screening, the records used in the analysis were narrowed down to some 15 million from Scopus Custom Data and about 8 million from PATSTAT.

In order to create the linkage between scientific papers and patents, the information on scientific papers in Scopus Custom Data was first reformatted to allow for different notation and capitalization conventions and then matched with non-patent literature in patent information.

Also, to conduct analysis per institution, a dictionary of institution names was created to resolve any variations in the notation of their names when implementing name identification. In preparing the dictionary, a dictionary of institution names contained in JST’s scientific and technological literature search service JDream II was used as the basis, and for Japan's major universities and research-oriented independent administrative agencies on which the analysis was focused (152 institutions in total), additional tuning of the data was performed for more accurate identification. In doing so, a process was run to resolve variations in notation on the word level, using a JST-owned dictionary of different notations.

Upon checking the data after the completion of name identification, it was found that in some cases, the institution name record, which was supposed to contain one organization’s name only, contained the names of more than one organization, as in the case of "Tokyo University and the JST." In such cases, another process was performed so that the record matches all the institution names included in it. In the case of "Tokyo University and the JST," for example, after the record first matched "Tokyo University," it was converted to "and the JST" by removing the matched words, and continued to be processed through other patterns than "Tokyo University" in the dictionary until it eventually matched “JST” as well.

For the JST researchers, the papers of 650 major researchers who received funding in and after 1996 under two of the JST’s basic research programs, ERATO and CREST, were extracted from Scopus Custom Data.

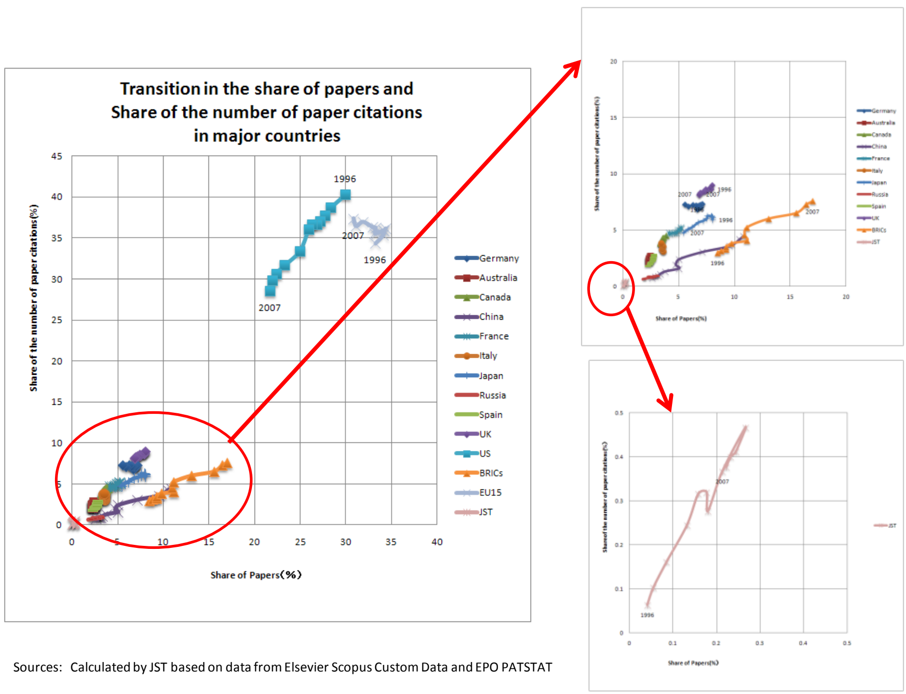
As for these 650 researchers, a dictionary of researcher names was prepared for the use in this analysis by combining each researcher’s ID with his/her institution’s ID. The institution IDs included in the researcher name dictionary were compared with those generated in the process of identification of institution names in order to judge which institution each researcher belongs to and thereby aggregate the data on individual researchers. The non-patent literature found in patent citation information was matched with the academic paper information using mainly the journal name, beginning page, ending page, year of publication, and volume and issue number as keys. However, there were many records lacking some of the keys, and for these records researcher names were used as an auxiliary key so that as many fields as possible can be used for matching.

Prior to the matching process, the dictionary for different notations of institution names that was used for identification purposes was used again to convert notations for the greater accuracy of the matching process.

In order to examine the level of matching accuracy, 50 patent information records were randomly chosen to visually check whether non-patent literature in the citation information properly matched the academic paper information. This showed that almost all the information records were properly matched.

II. ANALYSIS RESULTS

Fig.1 Transition in the share of papers and share of number of paper citations in major countries



Sources: Calculated by JST based on data from Elsevier Scopus Custom Data and EPO PATSTAT

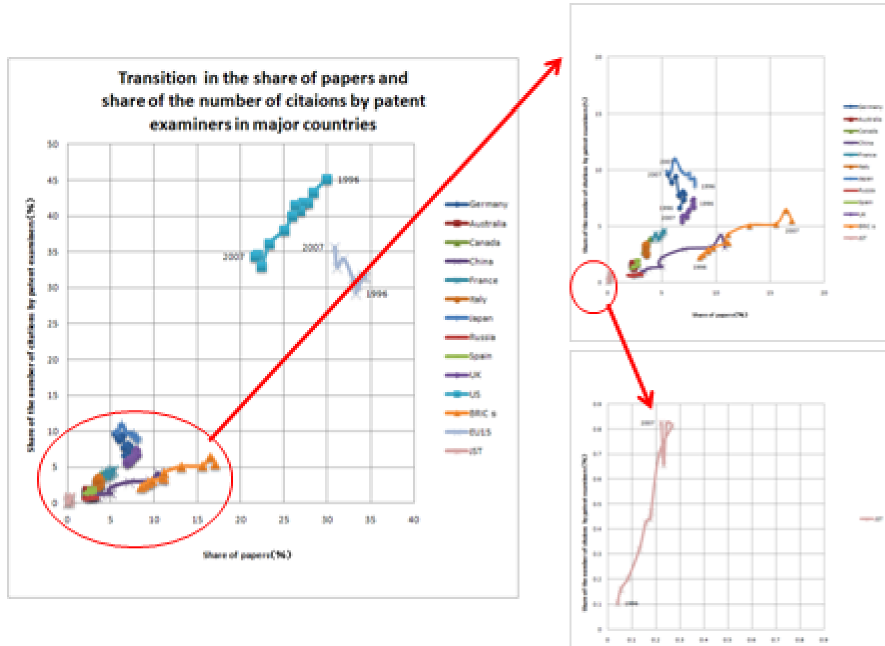
The left graph of Figure 1 has world shares of the number of scientific papers released between 1996 and 2007 as the X-axis, and those of the scientific papers' citation as the Y-axis. The top-right graph of Figure 1 excludes the U.S. and the EU from the left graph, and the bottom-right graph plots the JST papers.

Japan had the second largest world share of the scientific papers published in 1996, but was surpassed by the UK in 2000, by China in 2004, and by Germany in 2005; it had the fifth largest share globally in 2007.

As for the scientific papers' citation, Japan had the fourth largest world share from 1996 to 2006 after the U.S., UK, and Germany, but was overtaken by France in 2007 to be in fifth position worldwide. Japan's world share of citation was 5.94% in 1996, but after peaking at 6.28% in 1999, it decreased every year to be 4.77% in 2007. The U.S. remains the world's leader both in the share of scientific papers and of the citation. However, its world share of scientific papers declined annually from 29.94% in 1996 to 21.65% in 2007. Its share of the citation also decreased annually from 40.32% in 1996 to 28.55% in 2007.

Turning next to JST-funded researchers, the number of scientific papers published by the representative researchers of the ERATO and CREST programs accounted for 0.04% in 1996, but their share continued rising to 0.22% in 2007. Their share of the citation was 0.06% in 1996, which rose to 0.47% in 2004, and, although showing some declines thereafter, still remained as high as 0.38% in 2007. The left graph of Figure 2 plots the world shares of scientific papers published between 1996 and 2007 on the X-axis and those of citation which scientific papers were cited by patent examiners on the Y-axis. The top-right graph of Figure 1 excludes the U.S. and the EU from the left graph, and the bottom-right graph plots the JST papers. As stated before, Japan's world share of scientific papers was No. 2 in 1996 but dropped to No. 5 in 2007.

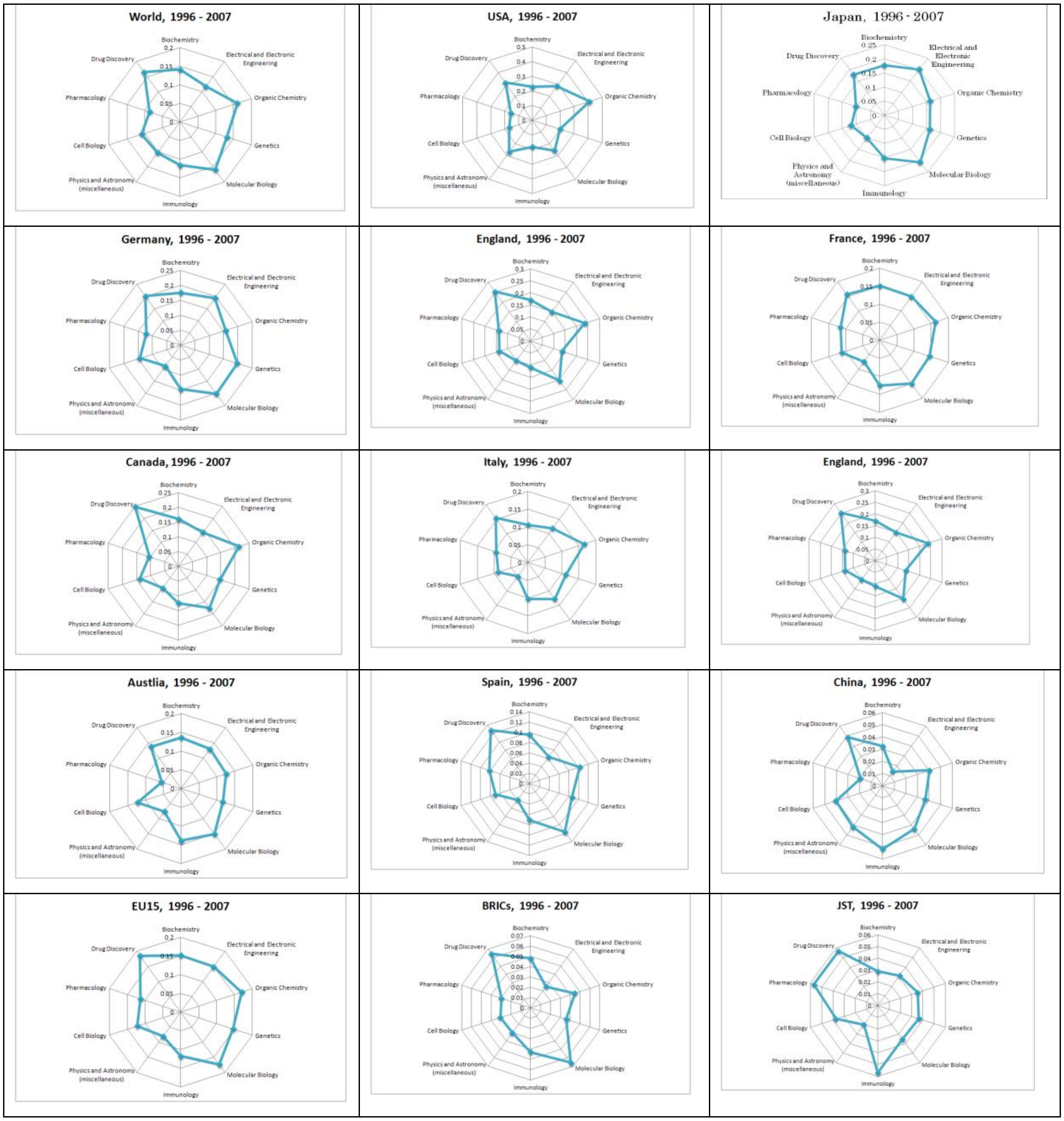
Fig.2 Transition in the share of scientific papers and share of the number of citations by patent examiners in major countries



Sources: Calculated by JST based on data from Elsevier Scopus Custom Data and EPO PATSTAT

However, Japan remained No. 2, following the U.S., in the world share of the citations which scientific papers were cited by patent examiners from 1996 through 2007. While Japan's share of scientific papers declined annually from 8.03% in 1996 to 5.44% in 2007, its share of the citations which scientific papers were cited by patent examiners remained high: 8.57% in 1996, over 11.02% in 2005, and still as high as 9.91% in 2007. As described above, the share of scientific papers by JST-funded researchers under the ERATO and CREST programs continued rising steadily from 1996 to 2007, and their share of the citations which scientific papers were cited by patent examiners also increased from 0.11% in 1996 to 0.83% in 2007. Figure 3 is a radar chart that is based on academic fields and uses the citation by patent examiners per scientific paper as the index, and includes the top 11 nations in terms of the times cited, the EU, and BRICs countries, as well as the JST. Overall, the field that is most strongly linked to patented technologies is life sciences, such as biochemistry, genetics, molecular biology, immunology, cell biology, and drug discovery. Looking at a country, in the U.S. and UK the fields that have a strong impact on technologies are drug discovery and organic chemistry, and in Germany they are drug discovery, molecular biology, genetics and other life sciences, and electrical and electronic engineering. In France, the fields of drug discovery, electrical and electronic engineering, organic chemistry, molecular biology, and biochemistry have an almost equal impact on technologies. In Canada, the impact of drug discovery is outstandingly strong. In Japan, the impact of science on technologies can be seen in the fields of electrical and electronic engineering and molecular biology. The JST is characteristically strong in drug discovery, pharmacology, and immunology.

Fig3. Proportion of scientific papers cited by patent examiners by field in major countries



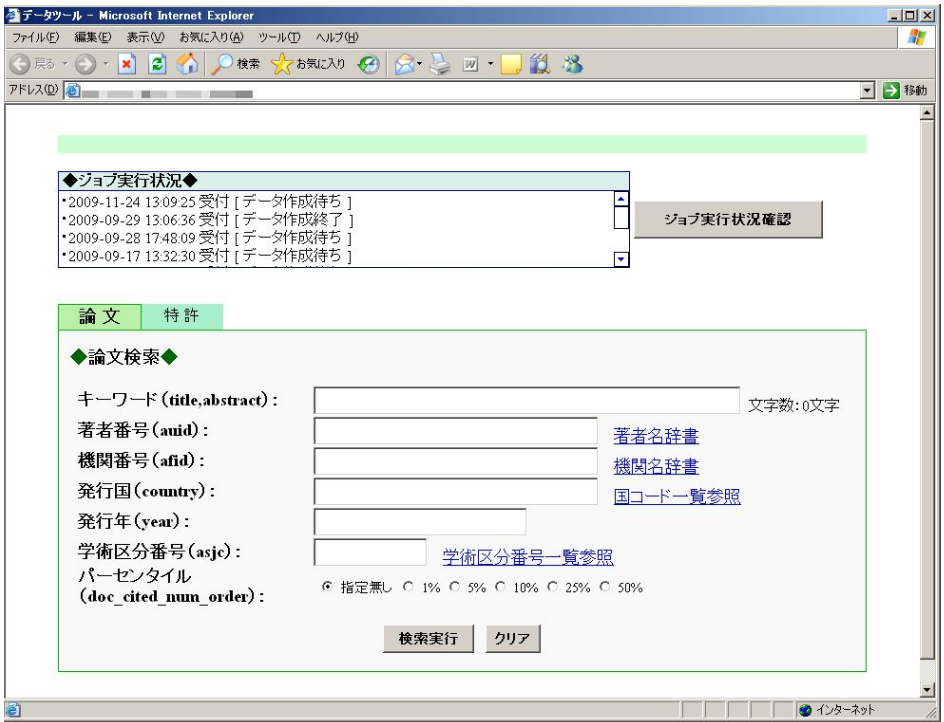
Note: Due to differences in the number of scientific papers and the times cited by patent examiners, the graphs employ different scales for major countries, areas, and the JST.

III. SYSTEM DEVELOPMENT

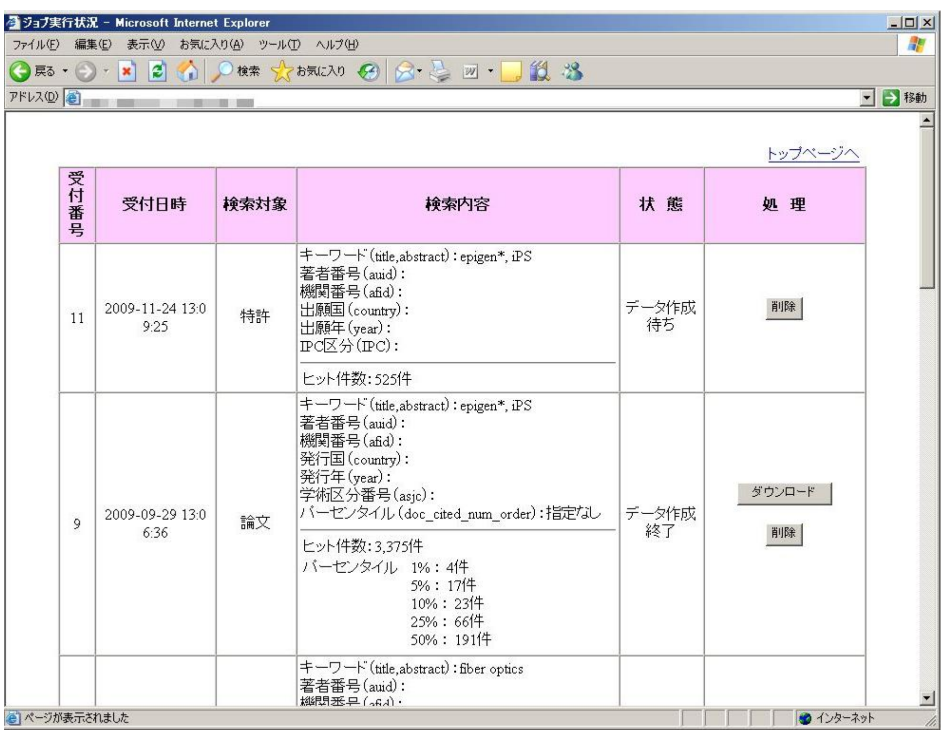
The JST, as a funding agency that promotes innovation, has a mission to provide information on the effects of investments made under its science and technology policies and on an evaluation of such policies, as one of its mid-term objectives. To achieve that goal, the JST organized a database of academic paper and patent information, and as a result, developed a search system, J-GLOBAL foresight, which enables the extraction of information on scientific papers and patents using keywords, including researcher names. At present, the system is available only to the JST staff, and is used to provide information in response to policy requests directed to the JST. The searchable data on scientific papers includes bibliography information, as well as the number of the citations and its percentile, which can be downloaded.

The percentile of the citations indicates the percentage position of an academic paper from the top when scientific papers are classified according to the Scopus Custom Data’s ASJC journal classification code and sorted in descending order of the citations within each classified group. The smaller the figure, the more frequently the paper is cited. For information on scientific papers, the number of the citations in patent information and its percentile are also added. They are introduced as an index that enables the user to infer what kind of scientific papers are cited in patent information. Figure 4 is an image of the input screen for the extraction of information on scientific papers and patents. By inputting search keys for the paper or patent information to be extracted and pressing the "Search" button, the paper or patent information being searched can be viewed for confirmation and then downloaded (see Figure 5).

Fig. 4 Image of the input screen



F 5 Image of Output Screen



IV. Observations

Scientific Patenting indicates a close linkage between science and technology. If the number of the citations which scientific papers are cited by patent examiners can be interpreted to indicate the strength of linkage with science, it is fair to say that Japan's scientific papers are getting more and more closely related to technology year after year, and maintain international competitiveness. The scientific papers published by JST-funded researchers can also be inferred to increase their influence on technology each year. On the other hand, in view of the citation relationship among scientific papers, Japan's presence as well as that of the U.S., have been declining year by year both in terms of the share of scientific papers and that of the citations, while the EU and China are gaining power. The JST can be judged to fulfill its policy role of promoting innovation, as far as based on the quantitative data of scientific papers and patents.

In terms of academic fields, JST-supported papers in the fields of biochemistry, molecular biology, and genetics are most frequently cited in patents. Anderson et al. [2] pointed out that the strongest linkage between patented technology and science is found in the biotechnology field. This trend is also observed at the JST. As a task for the future, a further study will be needed to analyze the linkage between scientific papers and patents in more detail through case studies on JST-funded projects that are already in practical use, in combination with econometrics analysis, such as on market sizes. This will make it increasingly important for research and development strategies to incorporate a linkage with research into their funding plans and thereby to fund researches more effectively.

References

[1] F. Narin, K. Hamilton, and D. Olivastro, “The increasing linkage between U.S technology and public science,” *Research Policy*, vol. 26, no. 3, pp. 317-330, 1997.

[2] J. Anderson, N. Williams, D. Seeimagai, F. Narin, D. Olivastro, “Human genetic technology: Exploring the links between science and innovation,” *Technology Analysis and Strategic Management*, vol. 8, no. 2, pp. 135-156, 1996.