Analysis of Industrial Technology Convergence based on Patent Information

Sung-Uk Bae, Jea Min Yoo, Dong Gi Kwag, Sung-Jun Park and SungMin Bae*

Abstract-- The purpose of this study is to understand the technological trends of industries based on patent information. The study analyzes the US registered patents of the past five years primarily for the 'Energy Machinery', 'Medical Equipment', 'Office Machinery And Computers' 'Energy Machinery', 'Medical Equipment', and 'Office Machinery And Computers' industries which have developed as an issue recently for the machinery industry. The results show that there were different technological trends per industry, the 'Office Machinery And Computers' was limited to a specific industry and reciprocally associated, and the degree of technology convergence is increasing for 'Medical Equipment' industry owing to various industrial technologies.

Keywords — Patent Information, Co-classification Analysis, Citation Analysis, Degree of Technology Convergence

I. Introduction

TODAY, patent information has received the attention of key countries and corporations as an index of technological innovation and industrial progress. This is because patent information is the result of scientific and technological activity as well as a component of knowledge foundation for research and development activity. [1]

The government also collects patent information and patent data, analyzes domestic and overseas patent trends to unearth new spheres of corporate enterprise and of technology, and plans national research and development projects.

By utilizing the number of patent registrations, co-classification information, and citation information from patent information, this article analyzes the developmental tendencies of industrial technology. Based on this, the article recommends an index for comparing the developmental tendencies of technologies among industries by clarifying the Degree of Technology Convergence.

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II. Literature Review

A. Characteristics of patent information

Based on the foundation which protects individual and corporate inventions, a patent is employed ultimately to promote industrial development and advanced industries of the future by utilizing patent information. [2,3] Also it is utilized to predict the present level of technology and the direction of future technological innovation by employing the standardization and objectivity of patent information. [4,5] Moreover there is an increasing utilization and utility of patent information owing to international patent classification.

As a method of classification which has been set internationally for the registration items of a patent and utility model, the International Patent Classification or IPC was enacted by the World Intellectual Property Organization in October 1975. It is amended every five years according to technological development. IPC is utilized with the judgment classification as standard for an applied invention and is also utilized for collection of patent document data, organizing or searching of patent information, survey of technological trend, statistical index related to the industrial intellectual property right of a country, etc. Patent information retains diverse information and can create new information from multiple directions based on patent analysis. [6]

This study organizes and utilizes patents at the main group level from among the stratified structures of the 'Section', 'Class', 'Sub Class', 'Main Group', and 'Sub Group' of IPC.

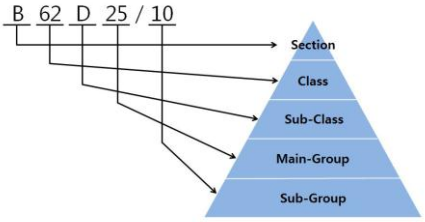

Fig. 1 IPC Level

B. Method of analyzing patent information

The method of analyzing patent information comprises of patent co-classification analysis and patent citation analysis. The patent citation analysis is a method which clarifies the relationship among technologies by utilizing patent information which has been consulted when applying for a patent.

Comprising of forward citation analysis and backward citation analysis, it is a method which analyzes the relationship of citation patents of corresponding patent.

The patent co analysis is a method that is based on examining the number of fields with which a patent is linked simultaneously, from among the fields classified according to the predefined characteristics of technology. [7] The patent co classification analysis recognizes the relationship of the superior level with the inferior level based on technology classification system and can change the level of analysis when necessary. Also because it entails the information when an application is submitted, the patent co classification analysis has relatively less likelihood of error divergent from time difference and facilitates analysis.

C. Analysis of corporate competitiveness utilizing patent information.

There have been earlier studies on the influence of patent information on corporate competitiveness. The US medical industry has explained the relationship of citation frequency relative to registered patent with financial achievements. [8] It found that the increased retail had some relationship with earnings but none with the earnings rate, when considering the relationship of the number of patent registrations of the Fortune 500 companies with corporate management. [9]

As shown above, we can infer analogically from a range of information and based on patents. Also presently, many studies analyze the relationship of technological development with actual patent registration by employing various methods of analysis. Yet not many studies have examined the actual relationship of patent relationship with industrial progress.

D. Analysis of technological competitiveness utilizing patent information

If the number of patents is simply the standard of quantitative level, then the relationship of patent citation can be viewed as implying the measurement criteria of qualitative level. The simple number of patents retained by a corporation cannot provide an accurate estimation of its technological competitiveness. [2] The mere number of patents does not reflect the worth of knowledge, and such knowledge can be analyze more clearly by considering the relationship of patent citation. [10] Therefore it would be difficult to provide an analysis when technological competitiveness is computed from a quantitative perspective without considering it from the qualitative perspective of patents.

Therefore two perspectives of patent information must be considered, so that one can provide an analysis of technological competitiveness which entails both measurable information and the level of its intrinsic worth.

III. METHODOLOGY

A. Raw Data

This study analyzes technology convergence per industry by utilizing information for US registered patents for the past five years from 2008 to 2012. To link Eh patent information with the industry, the study utilized "Linking Technology Areas to Industry Sector" which is a report submitted to European Commission by a German, French, and British research institute. The "Linking Technology Areas to Industry Sector" links IPC Subclass with forty four industries. This study random sampled a total of 222,948 patents from among the patents registered from 2008 to 2012 relative to 'Energy Machinery', 'Medical Equipment', and 'Office Machinery And Computers' among the industries. Based on the random sampling, this study analyzes the relationship with other industries by utilizing patent co classification and patent citation.

B. Frame Work

To analyze technology convergence per industry, this study recognizes and compares the number of patents simultaneously classified and cited with other industries primarily for five industries analyzed.

In other words, the study analyzes the linkage with other industries primarily for the co classified IPC code of the patent of the analyzed industry. With the same method, this study analyzes the linkage with other industries primarily for the IPC code of the citation patent and of the patent of the analyzed industry.

For the next stage for comparing the degree of convergence of each industry with other industries, this study defines the degree of technology convergence and compares the industrial technology convergence for each industry.

C. Degree of Industrial Technology Convergence

For this study, the degree of industrial technology convergence denotes the degree of association of a given industry with another industry. Also it is computed by utilizing the ratio of co classification of the patents of a given industry with another industry and the ratio of citation of the patents of another industry. In other words, it computes what percentage of the patents registered with the analyzed industry is co classified with another industry and cites the patents of another industry. Then it employs the value acquired from the combined log value of the co classification ratio and the citation ratio.

This is because we can consider it a convergence when diverse technologies or industries are combined to create a new technology or industry. We also consider patent citation information as combining of technology and patent co classification information as creating new technology.

IV. ANALYSIS PER INDUSTRY

A. Overview

Figures 2 and 3 compare the ratio of citation and the ratio of co classification of patents corresponding to the 'Energy Machinery', 'Medical Equipment', and 'Office Machinery And Computers' industries from among the US patents registered from 2008 to 2012. We find that the degree of citation and co classification per detailed field differs even for the detailed industry of the same machine industry.

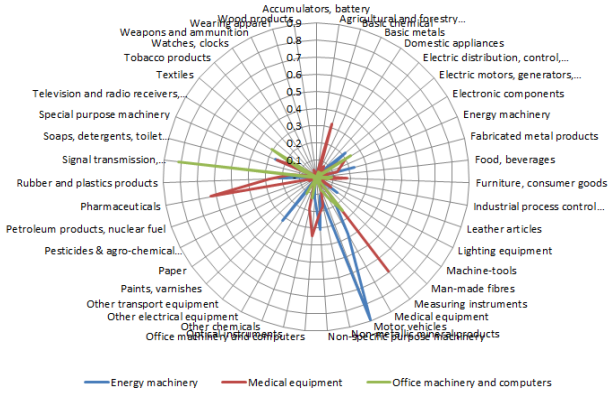

Fig. 2 Citation Ratio of 3 Industries

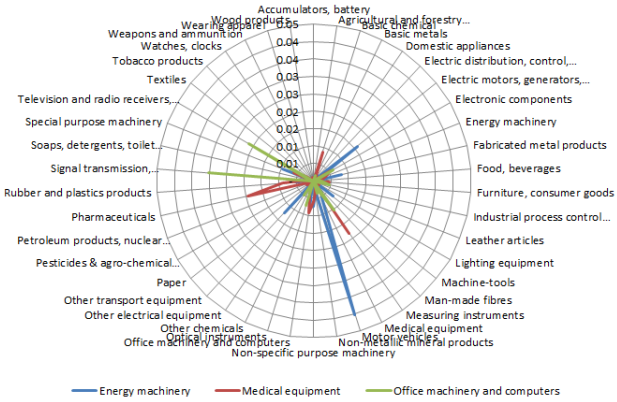

Fig. 3 Co-classification Ratio of 3 Industries

To examine the degree of citation and co classification, this study defines and compares the citation ratio and co classification ratio. The degree of citation denotes the ratio of patent which cites another industry and not the analyzed industry from among the patents of the analyzed industry. Also the co classification ratio denotes the ratio of number of patents which are co classified as another industry from among the patents of the analyzed industry.

Figure 4 shows the industries which have over 30% citation ratio and over 2% co classification ratio relative to the three industries analyzed.

B. *Analysis of Each Industries*

Figure 5 is a graph which shows other industries with over 20% of citation ratio per year for the entire five years relative to the Energy Machinery Industry. Figure 6 is a graph which shows other industries with over 1% of co classification for the entire five years. The citation ratio of 'Motor vehicles' is the greatest but is gradually decreasing, while the citation ratio of the 'Other transport equipment' industry is gradually increasing. A similar pattern is shown for co classification.

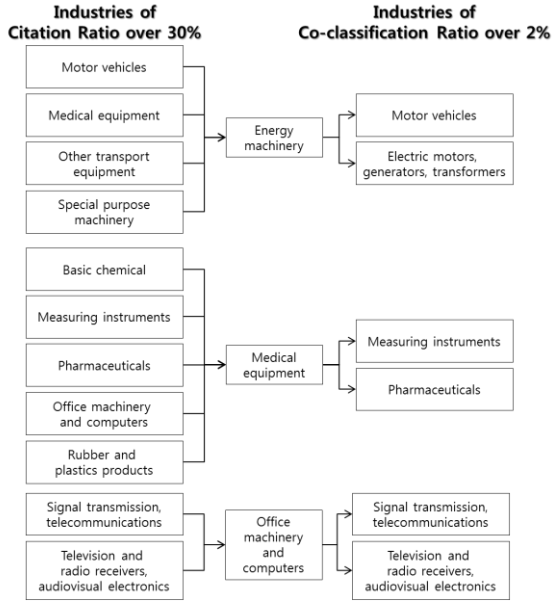

Fig. 4 Results of 3 Industries

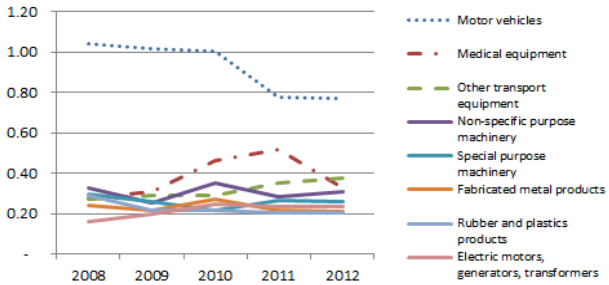

Fig. 5 Citation Ratio of Energy Machinery Industry

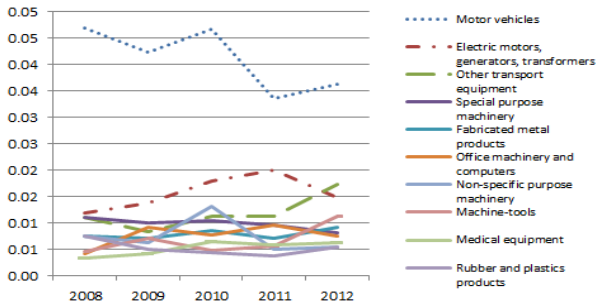

Fig. 6 Co-classification Ratio of Energy Machinery Industry

As shown by Figures 7 and 8, the citation ratio and co classification ratio decrease simultaneously for the 'Measuring instruments' of 'Medical Equipment' industry. Yet both ratios gradually increase for 'Basic chemical' and 'Special purpose machinery.'

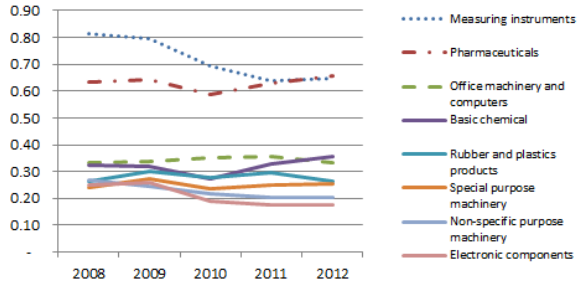

Fig. 7 Citation Ratio Medical Equipment Industry

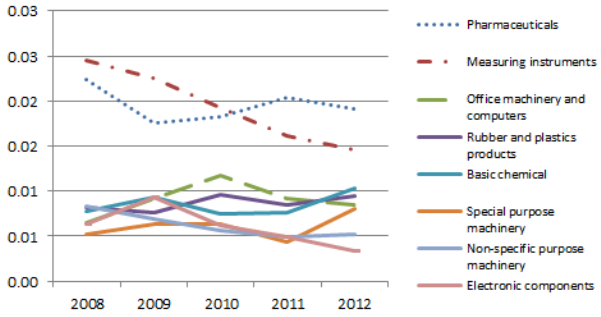

Fig. 8 Co-classification Ratio Medical Equipment Industry

Figures 9 and 10 are graphs which show the citation ratio and co classification ratio per year for the 'Office Machinery And Computers' industry. The citation ratio does not show any change per year and is significant for 'Signal transmission, telecommunications'. Yet the co classification of 'Signal transmission, telecommunications' has recently decreased', and the co classification of 'Televsion and radio receivers, audiovisual electronics' is continuously increasing.

Fig. 9 Citation Ratio Office Machinery and Computers Industry

Fig. 10 Co-classification Ratio Office Machinery and Computers Industry

C. *Degree of Industrial Technology Convergence*

Figures 11 and 12 are graphs which compare the citation ratio and co classification ratio of three industries per year. Energy Machinery shows the highest co classification ratio, while the co classification of Medical Equipment is gradually decreasing. Yet one finds that Medical Equipment has the highest citation ratio.

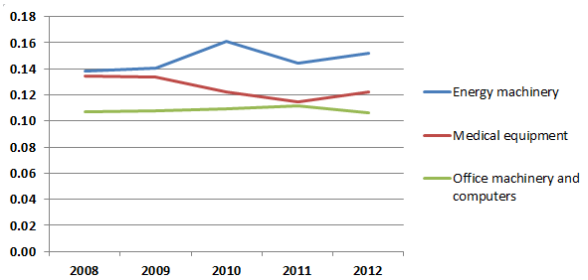

Fig. 11 Co-classification Ratio of Each Industry.

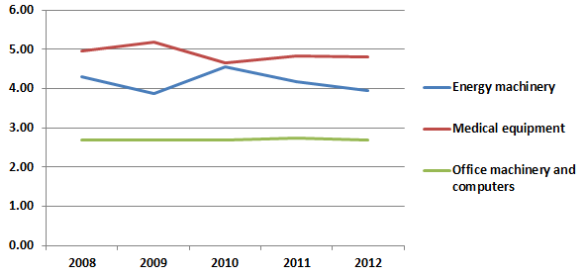

Fig. 12 Citation Ratio of Each Industry.

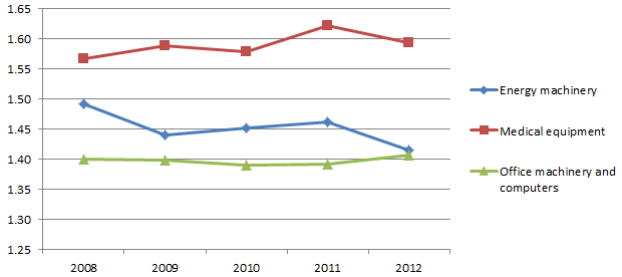

Fig. 13 Degree of Industrial Technology Convergence.

Figure 13 is a graph which compares the degree of technology convergence per industry by utilizing citation ratio and co classification ratio. Office Machinery and Computers shows a similar degree of technology convergence per industry per year. While it is gradually decreasing for Energy Machinery, it is gradually increasing each year for Medical Equipment.

V. Conclusion

As a result of verifying the technological development and direction among industries by utilizing citation ratio and co classification ratio primarily for the patents of three industries, one finds that the 'Office Machinery and Computers' is developing primarily with the 'Signal transmission,

telecommunications' and 'Television and radio receivers, audiovisual electronic' industry and thus shows a relatively limited degree of technology convergence. The 'Energy Machinery' industry is commonly co classified with the 'Motor vehicles' and 'Electric motors, generators, transformers' industry, but the degree of technology convergence for 2012 has decreased somewhat when compared to 2011 because the citation ratio is decreasing. The 'Medical Equipment' industry is commonly co classified with the 'Measuring instruments' industry and 'Pharmaceuticals' industry, shows a significant citation ratio based on various industries, and exhibits a relatively significant degree of technology convergence. In other words, the 'Office Machinery and Computers' is restricted to a specific industry and exhibits the tendency of reciprocal citation and co classification. The ratio of citation of other industries by 'Energy Machinery' is gradually decreasing, but the newly appearing technology tends to expand over to diverse industries. New technologies are appearing for the 'Medical Equipment' industry based on various industrial technologies, and the degree of technology convergence is increasing accordingly.

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