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A novel approach to forecast promising technology through patent analysis

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ABSTRACT

Forecasting promising technology is a relevant opportunity for management of companies and countries. Furthermore, researchers in research and development (R&D) have recently considered that patents include detailed information on developed technologies. For these reasons, we suggest a novel approach to forecasting PT using patent analysis. The overall process of the proposed methodology consists of three steps. First, to form technology clusters, we clustered patent documents on the basis of the cooperative patent classification (CPC), which represents a more detailed technology classification system than the international patent classification (IPC). Second, regarding the process of defining technology clusters, we examined the combination of CPCs of each formed clusters. Finally, patent indicators such as forward citations, triadic patent families, and independent claims are analyzed to assess whether the technology clusters are promising. We collected patent data on the wellness care industry from the United States Patent and Trademark Office (USPTO) to verify the proposed methodology.

1. Introduction

Promising technology is a key technology that underlies the steady growth of companies and countries. Its influence on a company's investments and production and on overall national industries is significant. Additionally, a promising technology is changing quickly and unexpectedly. As such, companies and countries that focus rapidly on promising technologies to lead the industry are able to increase their competitiveness such that it becomes directly connected to survival (Jeong and Yoon, 2015).

Hence, properly forecasting promising technologies is integral for decision makers of both corporations and countries. Upon further examination, first, it was found that the establishment of an efficient research and development (R&D) strategy establishment is possible. Deriving a comprehensive notion that can satisfy the needs of a future envisioned society as well as the market, forecasting promising technology is being recognized as an essential stage in the R&D process (Albright, 2002). Specifically, a national R&D agenda budget can be influenced by the political environment during the R&D planning stage (Halal et al., 1998). This greatly increases the anxiety towards failure regarding future R&D endeavors. Accordingly, the allocation of an R&D budget should be based on objectivity and validity, as to allow for adequately selecting and focusing on a promising technology sector. In other words, by exploring a future environment that humans may face, forecasting promising technology can present a direction on the right path for the early stages of R&D.

Next, the autonomously led development of products and services becomes possible. As an output of R&D, the developed technology acts as a firm foundation for the development of future products and services (Wang et al., 2015). That is, being able to forecast products and services that can lead the future allows for heightened competitiveness compared to rival players.

Accordingly, in the past, such as with the Delphi and scenario methods, attempts have been made to forecast promising technology using expert opinions in related technology areas. However, the promising technology forecasting approach of these expert groups caused problems, including complexity and excessive time required for the procedure, social costs attributable to the mobilization of a large labor force, the absence of credibility for each expert's scope of technology, and different opinions on the interpretation (Choi and Jun, 2014).

As a solution, companies and countries have been establishing future promising technology forecasting strategies using patent analysis (Lee et al., 2009). Patents not only provide legal protection for intellectual property rights, but also include detailed information about the developed technology (Park et al., 2015a). Therefore, forecasting promising technology via patent analysis is significant for establishing management strategies. For instance, it can be used to prevent R&D investments in unnecessary technology areas (Kim et al., 2008), evade loyalty payments required by accidental technology infringements on rival companies (Kim et al., 2015), and design R&D projects to secure core patents (Ju and Sohn, 2015). In other words, from the viewpoint of R&D decision makers, this study can provide significant insights to strengthen the future competitiveness of a company and become an important means for technology management decisions (Ernst, 2013). Therefore, the purpose of this study is to forecast future promising technology through

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patent analysis. In other words, we utilize historical patent data to objectively and quantitatively determine what the promising technologies of the future may be.

We have come to the following conclusions and summarized the following contributions through our study on the methodology of forecasting promising technology.

1. We are able to identify the specific detailed technological areas that compose different technologies and industries. For this, we utilize the systematic and accurate properties of the patent classification system, as included in the patent information. These technological areas may be convergence, existing, or even technologies that can create disruptive innovation.
2. We are able to determine and verify the evidence of promising prospects in existing technological fields. Based on the application year of the collected patent data, we postulate the training set from 2002 to 2009, and the test set from 2010 to 2013. In doing so, we test the restricted model by examining how much of an influence the current promising aspect valuation of technologies have had on the future. Here, we evaluate technology valuations using patent information.

This study is not based on technology forecasts made using the subjective judgments of experts, but upon patent data analysis, which contains detailed information about the technology used. Therefore, even those without technological expertise can produce objective promising technology forecasts. By identifying the opportunity creation of new technologies, we hope to utilize this as a tool to forecast the promising technologies that can substitute current ones.

This paper is organized as follows. Section 2 reviews the case studies on patent analysis and technology forecasting. Section 3 reveals the proposed methodology for the actual forecasting promising technology analysis. Section 4 presents the experimental results, while Section 5 provides the conclusions and implications of the study.

2. Literature review

2.1. Patent analysis

A patent is an accessible document that contains information on both the developed technology and its usage rights (Park et al., 2005). Such patents grant exclusive rights in exchange for disclosing the technology (Trappey et al., 2011). Therefore, in the case of important software or algorithms, where it is difficult to determine if a competitor has infringed on patents, companies often own these technologies as know-how instead of applying for patents. Furthermore, in some countries, which had inadequate systems for protecting intellectual property rights in the past, companies intentionally did not apply for patents, as their intellectual property rights were not properly protected compared to the high costs and time required for application.

However, presently, countries and companies are increasingly changing their perception and patenting their technologies (Manap et al., 2016) when such technologies include clear technological concepts and reverse engineering is possible. Accordingly, with the growing emphasis on the importance of intellectual property rights that assure exclusive rights over a developed technology, there is an increase in recent efforts to obtain patents (Park et al., 2015b). Furthermore, there is an emergence of non-practicing entities (NPEs) that acquire high quality patents with wide scope (Fischer and Henkel, 2012) to legally challenge the companies that practice patent infringement or make a profit by reselling the patents to other companies (Pénin, 2012). It implies that a patent can contribute significantly towards profit creation if it is utilized for offensive or defensive purposes by an organization.

Patents are also used to develop technologies that are more advanced than the existing versions around these patents (Belvard, 2000). That is, they not only have offensive and defensive functions but can also be used as an efficient technology management strategy.

Especially at a national level, they can be used to establish public policy. For instance, research has been conducted on the direction of future policy for detailed technologies, based on pinpointing leading patent applicants and countries for electrochemical energy storage technology (Mueller et al., 2015). Additionally, research of the time range of patents in the solar thermal utilization sector, technology type distribution, and technology trend analysis had been used to establish governmental energy policies (Zhao and Zhao, 2015). There has been research on patent analysis of global wind turbine companies, which provided a direction for policies for discovering new markets in Asian and European nations and for company policies about encouraging open innovation among companies (Zhou et al., 2015).

From the perspective of technology management planning, identifying the effective technology development trends of rival competitors and reviewing whether or not to introduce new technology can be done through patent analysis. Identifying the technology life cycles of patents in telematics revealed the possibility for new technology creation by connecting mobile devices to cloud platforms (Chang and Fan, 2016). The R&D tendencies and trends in the target sectors for leading companies in the field of amorphous silicon are examined (Tseng et al., 2011). By dividing companies into those with leading technology, those with technological potential, and those with technology quality orientation, based on calculated patent indicators, detailed competitiveness of these companies can be identified. Furthermore, researchers without detailed knowledge of technology can easily determine technological trends and important technologies through patent analysis (Chang et al., 2012). In other words, the study understood the relationships between patents and discovered key patents by forming a patent network based on similar terms that were used in different patents.

Therefore, this study approaches patents, which have become important for countries and corporations, from the establishing policies and technology management perspective because earlier studies have drawn technological implications from patent analysis.

2.2. Forecasting promising technology

Forecasting promising technology plays an important role in decision making for enterprises' and countries' management of technology. In the past, qualitative analysis, such as the Delphi and scenario approach methods, was based on technology forecasts.

In the Delphi analysis approach, the consensus process among experts heightens objectivity and persuasiveness. For example, Delphi analysis has been conducted to predict the future technologies in the public relations sector. Technology experts from various fields and from all over the world participated and reviewed dozens of topics that had previously been overlooked or ignored (Kent and Saffer, 2014). Experts were divided into groups to carry out Round 3 of the Delphi study, as to identify the determinants of business opportunities in the emergent bioenergy industry at both company and industry level (Pätäri, 2010). Therefore, Delphi analysis can be valuable when past data is unavailable or in cases where mathematical modeling is impossible.

The scenario analysis approach is useful as a base for establishing a strategy for a variety of uncertain factors. Such scenario analysis postulates and generalizes how various possible uncertain situations may evolve. Having filled out the technological road map, scenario planning is a prerequisite for making precise predictions possible (Saritas and Aylen, 2010). Using the current technological situations, market needs, evaluation and understanding of products and services, and technological influence analysis, a scenario analysis to satisfy the market needs considering future uncertainties was conducted (Holmes and Ferrill, 2005).

Moreover, a combination of the Delphi and scenario analyses can provide accurate predictions as well. The probability of occurrence for certain future events can be estimated in Round 3of the Delphi analysis,