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Identifying promising technologies using patents: A retrospective feature analysis and a prospective needs analysis on outlier patents☆

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ABSTRACT

This study suggests a patent-based methodology for identifying emerging technologies by combining a retrospective technological feature analysis and a prospective market-needs analysis. To do this, first, the candidate promising technologies were identified by applying bibliographic coupling to patents, thus producing a list of outlier patents. Then, the measures to evaluate both technological and market characteristics of the candidate technologies were developed, where retrospective patent analysis and sentiment analysis on customer opinions are required. Finally, the candidate technologies are mapped onto two-dimensional space according to the values of the two measures; the final promising technologies are determined to be those that have high values for either technological characteristics or market characteristics. The suggested methodology was applied to an automobile industry, through which its feasibility and usability were verified. This study is one of the few studies to develop technology-evaluation measures based on an ad-hoc analysis of technological characteristics. In addition, it attempts to link patent databases to market databases, aiming to directly reflect customer needs to evaluate the potential of a technology in a market. The approach suggested in this study can be applied to recent patents with little citation information for assessing their value to be deemed as promising technologies; this is expected to contribute both academically and practically to the existing literature on patent analysis.

1. Introduction

Technology forecasting is one of the most significant activities for the discovery of new business opportunities and for the minimization of Research and Development (R&D) risks in new technology developments, accordingly attracting attention from both industries and academics (Cho et al., 2016). In particular, patent documents, characterized by enormous size and variety of technological information, have been one of the most frequently used data sources to forecast and identify promising technologies (Ernst, 1997). Patent analysis enables to understand technology development directions and trends in an effective way (Kim and Lee, 2015; Albino et al., 2014; Wu and Leu, 2014; Jeong et al., 2015). Hence, previous studies have attempted to identify the following types of technologies (Noh et al., 2016): vacant technologies, where further R&D is possible (Lee et al., 2009b); converging technologies, where increasingly active knowledge exchanges are observed or drivers of such technologies (Geum et al., 2012; Caviggioli, 2016; Karvonen and Kässi, 2013); and emerging technologies, where more R&D investments are being made (Park et al., 2016, Joung and Kim, 2017) based on patent data. The findings from these studies can be used as a basis for identifying promising technologies. In these studies, not only bibliometric parts but also descriptive parts of patent documents have been analyzed using various data analysis techniques such as data mining and text mining (Noh et al., 2016, Madani and Weber, 2016).

In spite of their meaningful contributions by developing a novel patent-based approach to help identify new opportunities from promising technologies, the existing studies are subject to several limitations. First, a number of existing studies relies on patent-citation information to assess technological superiority. It is assumed that a patent highly cited by subsequent patents is a valuable technology; therefore, a promising technology is defined as a collection of highly cited patents (e.g., Noh et al., 2016; Park et al., 2016) or a technological area with a relatively high share of such patents (e.g., Lee et al., 2009a, b). However, citation frequency increases with time, which resulted in a disadvantage for newly published patents. To overcome such limitations,

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the concept of a modified citation frequency was suggested in which the patterns of patent citation are analyzed to predict a citation frequency for the total life cycle of the patent (e.g. Noh et al., 2016; Park et al., 2016). Nevertheless, for the most recent patents with no citations, the modified citation frequency cannot be applied.

Second, the previous studies have mainly emphasized the technological characteristics of identifying promising technologies; few studies have focused on linking these technological characteristics to market needs. Until a new technology is implemented in products or services, their market information is hardly available. Yet, market needs are one of the most critical criteria to evaluate whether a technology will be promising or not (Tuominen and Ahlqvist, 2010; Reinhardt and Gurtner, 2011; Pichyangkul et al., 2012).

Finally, though extensive research has been dedicated to the identification of promising technologies, little effort has been made to conduct an ad-hoc analysis to investigate if the technologies evaluated as promising have actually become promising. To prove the utility of the methodologies suggested in a number of previous studies, the promising technologies identified by those methodologies should be monitored to examine the evolution trajectory for those technologies via ad-hoc analyses. Nevertheless, there is a lack of studies that investigate the validity issues regarding the suggested methodologies through comparison of projected results with actual results.

Recognizing these limitations, this study suggests a patent-based methodology for identifying emerging technologies by combining a retrospective technological feature analysis and a prospective market-needs analysis. To do this, we defined a promising technology as "a technology that is likely to have a substantial impact on other technologies as well as those that can respond to market needs." Then, the candidate promising technologies were identified, from which the final promising technologies were selected according to several criteria developed to evaluate the characteristics of the technology and market. More specifically, first, the candidate promising technologies were identified from outlier patents; these are patents that have recently published but have little similarity with the existing patents in terms of their contents, thus not having been included in any of the established major technological areas. Here, bibliographic coupling was adopted to cluster patents and find outlier patents. It is a method to group patents based on their similarity in references, and hence can be used to cluster patents without citation information according to their content similarity. However, the outlier patents may include the output of trial-run projects or academic projects, or even decoy patents, and thus are only "candidates" of promising technologies; further analyses are required to filter such less-valuable patents from the all outlier patents and leave only meaningful ones. Second, the measures to evaluate the technological characteristics of candidate technologies were developed by comparing the technological characteristics the can be observed at the early stage of patent applications, and by choosing only those that present statistically significant differences between promising technologies and non-promising technologies at the late stage of patent applications. We expect that these characteristics can be antecedents of promising technologies. Third, measures to evaluate market characteristics of candidate technologies were developed by extracting market needs on the products or services toward which the technologies are targeted directly from an online customer center. Opinion mining can be a suitable technique not only in identifying customer needs but also in understanding whether the needs pertain to increasing satisfaction (i.e., stimulating excitement) or reducing complaints. Finally, the candidate technologies are mapped onto two-dimensional space according to the two criteria of technological characteristics and market characteristics; the final promising technologies are determined to be those that have high values for either technological characteristics or market characteristics.

This study is one of the few studies to develop technology evaluation measures based on the ad-hoc analysis of technological characteristics. In addition, it is one of earliest attempts to link patent data to market data, aiming to directly reflect customer needs for evaluating the potential of technology in a market. In addition, it attempts to link patent data to market data, aiming to directly reflect customer needs to evaluate the potential of a technology in a market. Although previous studies have tried to consider a market potential of a patent, they have relied mostly on patent information. Unlike them, this study combined two different data sets – patents and customer reviews to measure a market potential, which differentiate this study from the existing literature. The approach suggested in this study can be applied to recent patents with little citation information for assessing their value as promising technologies, which is expected to contribute both academically and practically to the existing literature on patent analysis.

The present study is organized as follows. After the theoretical and methodological background is explained in Section 2, the approach proposed in this study is described in Section 3. Then, the case study results, in which the proposed approach was applied to automobile technologies, are presented, and the feasibility and utility of the proposed approach are discussed in Section 4. Finally, contributions, limitations, and future research directions are addressed in Section 5.

2. Background

2.1. Theoretical background

The term "promising (or emerging) technology" has been frequently used in a number of studies; however, no definition of it exists. To fill this research gap, Cozzens et al. (2010) reviewed literature and summarized four major concepts pertaining to the definition of emerging technologies: (1) fast recent growth, (2) transition to something new, (3) untapped market or economic potential, and (4) an increasing basis in science. Later, in a similar manner, Rotolo et al. (2015) defined four aspects of emerging technologies: (1) radical novelty, (2) relatively fast growth, (3) coherence, and (4) uncertainty and ambiguity. Based on these studies, we can conclude that promising technologies are recently emerged technologies with high uncertainties but with high possibilities of technological growth and market impact. According to these normative definitions, the criteria for a promising technology are defined and used to identify such technology (Noh et al., 2016).

The existing approaches to evaluate promising technologies can be classified into two types: 1) qualitative evaluation by experts and 2) quantitative evaluation based on data. In addition, various approaches have been adopted to identifying and prioritizing promising technologies, such as analytic hierarchy process (AHP) (e.g., Lee et al., 2014), Delphi (e.g., Bañuls and Salmeron, 2008), clustering (e.g., Song et al., 2012), roadmaps (e.g., Fleischer et al., 2005), and foresights (e.g., Bierwisch et al., 2015). However, as the complexity of technology increases and the scope of technological applications expand, the validity of qualitative evaluation by experts may be limited. To complement expert decision-making, quantitative approaches have been developed. Among them, one of the most commonly adopted approaches is patent analysis. Patent documents contain semi-structured bibliographic information in addition to the descriptive information that explains the technological components, principles, and benefits in detail. Patent data are easy to assess, being open to the public, and have been accumulated for several decades. Owing to these distinguishing characteristics of patent data, these data have continuously been regarded as main knowledge sources for innovation studies (Kim and Lee, 2015).

Patent data provide objective technological information, which help understand new innovative technologies; thus, they been widely used for the assessment of technological levels or for the investigation of R&D trends (Trappey et al., 2012; Kim and Lee, 2015; Jin et al., 2015). The data have also been used to identify promising technologies and to further take advantage of new business opportunities from those technologies. For example, they were used to discover vacant technologies via technologies defined by patents (e.g. Lee et al., 2009b, Jun et al., 2012; Choi and Jun, 2014), assess promising technologies using patent