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Evaluating the patenting activities of pharmaceutical research organizations based on new technology indices

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A B S T R A C T

Several citation-based indicators, including patent h-index, have been introduced to evaluate the patenting activities of research organizations. However, variants developed to complement h-index have not been utilized yet in the domain of intellectual property management. The main purpose of this study is to propose new indices that can be used to evaluate the patenting activities of research and development (R&D) organizations, based on h-type complementary variants along with traditional indicators. Exploratory factor analysis (EFA) is used to identify those indices. By applying the proposed framework to pharmaceutical R&D organizations, which have their patents registered in the United States Patent Trademark Office (USPTO), the following three indices are obtained: the forward citation, impact per unit time, and patent family factors. The ranking obtained from the new indices can represent the productive capacity of the qualified patent, patent commercialization speed, and patent commercialization effort of research organizations. The new proposed indices in this study are expected to contribute to the evaluation of the patenting activities of R&D organizations from various perspectives.

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1. Introduction

In the knowledge economy, several technology indicators have been proposed based on patent information, in order to measure the technological impact of R&D organizations (Albert, Avery, Narin, & McAllister, 1991; Karki, 1997). Citations per patent (CPP), patent impact index (PII), and current impact index (CII) are examples of such indicators (Breitzman & Narin, 2001). Recently, the Hirsch index (h-index), which was originally utilized to quantify the research performance of a single researcher or research group in academic publication, has been applied to the patent data (Guan & Gao, 2009; Luan, Zhou, & Liu, 2010; Kuan, Huang, & Chen, 2013).

The h-index was suggested by Hirsch (2005) and combines a measure of the quantity (number of publications) and impact (number of citations). The h-index can be easily calculated and is considered to have certain advantages over other simple citation-based measurements, such as the total number of citations and average citations per paper (Bornmann & Daniel, 2007; Costas & Bordons, 2007).

Although the h-index has generated considerable interest due to its advantages, many researchers have pointed out its disadvantages, such that it may increase even if no new research papers are published, and that highly cited papers are equally considered with less highly cited papers, for the determination of the h-index (Hirsch, 2005; Braun, Glänzel, &

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Table 1
Definition of h-index and its complementary indicators.

Author	Index	Definition
Hirsch (2005)	h-Index	"A scientist has index h if h of his or her N_p papers have at least h citations each and the other $(N_p - h)$ papers have $\leq h$ citations each"
Egghe (2006)	g-Index	"The highest number g of papers that together received g^2 or more citations"
Hirsch (2005)	m-Quotient	h/y, where h is h-index, and y is the number of years since publishing the first paper
Jin (2006)	a-Index	$1/h \sum_{j=1}^{h} cit_j$, where h is h-index, and cit_j is the citation counts of paper j
Jin et al. (2007)	r-Index	$\sqrt{\sum_{j=1}^{h} cit_j}$, where h is h-index, and cit_j is the citation counts of paper j
Jin (2007)	ar-Index	$\sqrt{\sum_{j=1}^{h} cit_j / a_j}$, where h is h-index, cit_j is the citation counts of paper j, and a is the number of years since publishing

Schubert, 2006; Bornmann & Daniel, 2007; Costas & Bordons, 2007). To complement these disadvantages, various h-type variants, including g-index, a-index, and ar-index, have been proposed (Egghe, 2006a; Jin, 2006; Jin, Liang, Rousseau, & Egghe, 2007). Likewise, the patent h-index can lead to misjudgments with regard to an organization's patenting activities. In order to solve these problems, h-type variants can be applied to the patent data. As many technology indicators have already proposed, finding the meaningful factors of individual indicators is also necessary.

The main purpose of this study is to propose new technology indices, based on h-type complementary variants along with traditional technology indicators, which can be utilized for evaluating the patenting activities of R&D organizations. We conduct an exploratory factor analysis (EFA) with the patent data of pharmaceutical R&D organizations, in order to derive new technology indices. These new indices are applied to rank the research organizations in the pharmaceutical field, and are expected to contribute to the identification of R&D organizations with various types of patenting activities.

Section 2 presents the literature review related to the traditional technology indicators, h-index and patent h-index. Section 3 introduces the data and methodology. The experimental results obtained from the pharmaceutical industry are described in Section 4. Finally, we conclude in Section 5, along with suggestions for future areas of study.

2. Literature review

Many well-established technology indicators have been constructed based on patent information, including total number of citations, CPP, PII, and CII (Chen, Lin, & Huang, 2007; Chang, Chen, & Huang, 2012). CPP is obtained by dividing the total number of citations by the total number of patents. PII is calculated by dividing the CPP for a specific field by the CPP for all fields. CII measures how often an analytical unit's patents are cited and compared with the average for all patents in the previous five years (Breitzman & Narin, 2001). Moreover, information regarding the patent family is also appropriate as an indicator of the value of patents (Harhoff, Scherer, & Vopel, 2003; Martínez, 2011). The patent family is a patent group that shares the same invention, and is protected by more than one jurisdiction. Further, there are two kinds of patent family data: patent family size and the number of patent families (Harhoff et al., 2003; Martínez, 2011). The patent family size is the number of jurisdictions that protect the same patent family, and the number of patent families is computed as the total number of patents in a patent family.

As a new technology indicator, Guan and Gao (2009) first proposed the application of the patent h-index to evaluate patent assignees. The h-index was introduced by Hirsch in 2005 as a single indicator to measure both the quantity and impact of the scientific performance of a researcher. The definition of h-index is given in Table 1. It can be easily obtained and applied to not only a single researcher, but also to research groups and countries. However, numerous limitations of the h-index have also been found, such as that it fails to compare scientists with different career lengths; it increases, even if no new research papers are published; and it fails to reflect the qualitative difference between highly cited and less highly cited papers (Hirsch, 2005; Braun et al., 2006; Bornmann & Daniel, 2007; Costas & Bordons, 2007). Due to the limitations of the h-index, modified indicators have been proposed in the literature. For example, an m-quotient is proportional to career length (Hirsch, 2005); a g-index (Egghe, 2006a, 2006b), a-index (Jin, 2006), and r-index (Jin et al., 2007) assign more weight to highly cited papers; and an ar-index was devised to fix the problem of an increasing h-index, even if no new research papers are published (Jin et al., 2007). These definitions are presented in Table 1.

Recently, based on the bibliometric h-index, Guan and Gao (2009) have defined the patent h-index as "the number h such that, for a general group of patents, h patents received at least h citations from later patents, while other patents received no more than h citations." They concluded that the patent h-index is an effective indicator in the evaluation of the technological performance of an assignee, by considering both quantity (number of patents) and quality (number of forward citations). Since the introduction of the patent h-index, some studies on the topic have focused on the evaluation of corporate patenting activities (Luan et al., 2010; Chang et al., 2012; Zhang, Yuan, Chang, & Ken, 2012). An example of a study about applying the patent h-index was that of Luan et al. (2010), in which they investigated patent strategy in Chinese universities