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Measuring industrial knowledge stocks with patents and papers

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Abstract

Under the National Innovation System (NIS) framework, knowledge stock has been recognized as a key factor for enhancing national innovative capabilities. However, despite the importance of patents and papers for measuring knowledge, previous research has not fully utilized patent and paper databases, and has instead relied on research and development (R&D) data. Therefore, in this research, I introduce a way to utilize both types of useful data when measuring industrial knowledge stocks. As primary data sources, the United States Patent and Trademark Office (USPTO) Web site for patents and the science citation index (SCI) for papers are used. In the case of Korea, the amount of knowledge stock proxied by patents and papers is different from that proxied by R&D, which indicates in turn that using a single indicator such as R&D may be misleading. Although the result may vary depending on the selected nation, the proposed method will be useful for gauging knowledge stocks in a more complementary way.

Keywords: Industrial knowledge stock; Patents; Papers; The USPTO Web site; The SCI database

1. Introduction

Under the framework of the National Innovation System (NIS), the concept of knowledge stock has been emphasized because in order to create more sophisticated knowledge, accumulated knowledge is considered more important than the one-time input of a large volume of knowledge (Metcalfe & Ramlogan, 2005; OECD, 1996). Therefore, many researchers have strived to measure knowledge stock by using R&D data (Griliches, 1979; Mansfield, 1980; Scherer, 1982). However, R&D data have its limitations in that it only represents the input-side of knowledge, thereby making us overvalue the stocks of knowledge (Kleinknecht, Van Montfort, & Brouwer, 2002; Lach, 1995; Park & Park, 2006). Thus, in order to cope with the shortcomings of R&D data, patents and papers, which indicate the output-side of knowledge, have been adopted recently in shaping science and technology (S&T) policies (Archibugi & Pianta, 1996; Moon & Lee, 2005; Okubo, 1997). However, their usage has been limited to a certain technology or scientific discipline, not incorporating the issues relating to industrial policies within a nation.

An industry, as a unit of analysis, is important since it shares a common knowledge ground in terms of technological development and production, and acts as a critical element in the NIS. Therefore, Pavitt (1984), Breschi and Malerba (1997), and Marlerba (2002) focused on elaborating the peculiar patterns of industries and emphasized an industry as the primary unit for analyzing important innovations.

However, despite the aforementioned potential usefulness of patents and papers for measuring knowledge stocks at the industry level, there has not been any sufficient effort to utilize patents and papers so far, for the purpose mentioned.

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Therefore, in this research, I introduce a way to use patents and papers for measuring industrial knowledge stocks. In addition, I will present the case of Korea for the period of 1994–2000 when the knowledge stocks significantly increased, as an illustration.

2. Two knowledge measures

2.1. Usefulness of patents

Due to the importance of knowledge, international economic organizations such as the OECD have made great efforts to suggest measures for knowledge through large-scale workshops.[1] Among others, patents nowadays have drawn great attention and have become the focus of discussion due to their representativeness and comprehensiveness as a knowledge indicator. Earlier, Archibugi and Pianta (1996) elaborated the advantages and disadvantages of patents when they are used in policy making. The main advantages of patents are as follows: (i) they are the direct outcome of inventions with the aim of being used commercially; (ii) they not only harbor information on the rate of inventive activities but also that of their development directions; (iii) they contain large volumes of information related to inventors, descriptions, patent classes, claims, and diagrams of technological outputs; (iv) they are easily accessible. On the other hand, there exist disadvantages such as the following: (i) not all inventions are patented; (ii) patent propensity is different across firms and sectors; (iii) the classification scheme of patents does not correspond to that of economic fields; (iv) each country has its own different patent system.

2.2. Usefulness of papers

The importance of papers is more directly emphasized because compared with patents, they seem to pursue the accumulation of fundamental knowledge which, in turn, may not be directly applied to industrial use. However, Rosenberg and Nelson (1994) and Nelson and Rosenberg (1998) explicitly pointed out the importance of scientific knowledge for industrial development. Therefore, in order to examine the knowledge stocks within the NIS, we should incorporate scientific knowledge. Like patents, scientific papers have their merits and demerits. The merits include the following: (i) scientific papers are the only media that show scientific achievements (Wouters, 1998); (ii) citation patterns can be a useful tool for examining the knowledge exchange among scientists as well as the interdependencies of disciplines (Small & Garfield, 1985). In contrast, the demerits are summarized as follows: (i) the propensity to publish is different depending on the field (Hicks & Katz, 1996; Meyer, 2002); (ii) papers not written in English are often disregarded (Meyer, 2002).

3. Measuring knowledge stocks

The stock in "knowledge stock" is a concept which is equivalent to that in "capital stock" in economics. That is, knowledge stock at a certain point is composed of four distinctive parts—the knowledge input at a certain point, the knowledge stock from the previous period, the depreciation rate, and the time-lag caused by the gestation period. Therefore, we can obtain the knowledge stock of industry i at time t as follows:

$$\mathrm{KS}_{it} = \mathrm{KI}_{i(t-m)} + (1-\delta_{it})\mathrm{KS}_{i(t-1)} \tag{1}$$

where KS is the knowledge stock, KI the knowledge input, δ the depreciation rate, m the time lag, i the industry, and t is the time.

Then since the knowledge stock of time point $t-1$ can be expressed as the sum of the knowledge inputs from the base point to $t-1$, we can get the following equation:

$$\begin{aligned}\mathrm{KS}_{it} = {} & \mathrm{KI}_{i(t-m)} + (1-\delta_{it})\mathrm{KI}_{i(t-m-1)} + (1-\delta_{it})(1-\delta_{i(t-1)})\mathrm{KI}_{i(t-m-2)} \\ & + \cdots + (1-\delta_{it})\cdots(1-\delta_{i(t-b)})\mathrm{KI}_{i(b-m)}\end{aligned} \tag{2}$$

[1] 2006 Workshop on Patent Statistics for Policy Decision Making (Vienna on 23–24 October 2006); conference on research use of patented inventions (Madrid on 18–19 May 2006); and so on.