Study on the Measurement of International Knowledge Flow Based on the Patent Citation Network

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Abstract

Patented technology as an important technology innovation output, to some extent, can represent the technology capacity of one country or one region, and reflect the level and status of its innovation activities. The citation relationship among patent literatures shows the pattern of acquisition, absorption and re-use of prior technical methods, prototypes and results. The flow of knowledge and technology generated by patent citation has an important role for making continuous exploration and extension of science and technology. Due to the openness of patent information, the knowledge and technology information of patent can flow without the restriction of geographical boundaries. This information flow can cross the boundaries of countries and technological fields, and correspond to the information interaction between different countries and technological fields. Some researchers (Scherer, 1983; Kaiser, 2002; Duguet, 2005) raised a series of studies by matching patent citation, R&D funding and survey data, and proved that patent citation analysis is an effective method for measuring the knowledge flow.

Reviewing the literature of recent years, the field of patent citation analysis was deemed as a study that involves the statistical analysis of quantitative aspects of technology innovation (Jaffe et al., 1998; Michel and Bettels, 2001; Hall et al., 2005; Criscuoloa and Bart, 2008; Cho and Shih, 2011; Erdi and Makovi, 2013). As for the research of knowledge flow, lots of researchers conduct their studies via patent citation data. Jaffe et al. (2000) explored the data from a survey of inventor to prove the assumption that citations or other proxies are sufficiently correlated with knowledge flows. Tijssen (2001) provided new empirical evidence that patent citation analysis produces systemic quantitative data providing strategic background information regarding nation-specific and sector-specific factors in domestic and cross-border science–technology linkages and knowledge flows. Maurseth and Verspagen (2002) addressed the pattern of knowledge flows as indicated by patent citations between European regions. Hu and Jaffe (2003) examined patterns of knowledge diffusion from the U.S. and Japan to Korea and Taiwan using patent citations as an indicator of knowledge flow. Alcácer and Gittelman (2006) indicated that inferences about inventor knowledge using pooled citations may suffer from bias or overinflated significance level. Emanuele and Fabio (2010) estimated the international diffusion of technical knowledge using patent citations. Roach and Cohen (2013) found that non-patent references (e.g., journals, conferences, etc.), not the more commonly used patent references, are a better measure of knowledge originating from public research.

This paper analyzed the patterns and features of the international knowledge flow during three stages, 1984-1986, 1994-1996, and 2004-2006, from the following dimensions: the distribution of patent transnational citation, the core-periphery structure of patent transnational citation, and the internal knowledge flow among countries or regions of the core group. To analyze the distribution of patent transnational citation can delineate the basic status of international knowledge flow among countries and regions during the different stages. Moreover, analysis of the core-periphery structure of patent transnational citation and the internal knowledge flow among countries or regions of the core group can explore the relationship and merits among countries and regions, and can investigate the international knowledge flow from the perspective of network structure.

Due to the high quality and openness of patent information, US utility patents are widely used in the analysis of international knowledge flow based on patent citation. We used the data derived from the statistic USPTO patent database published by the national bureau of economic research (NBER) (Hall et al., 2001), which contains the information of US utility patents from the year of 1976 to 2006. According to the classification of NBER, the US utility patents are divided by six technology categories1: chemical, computers and communications, drugs and medical, electrical and electronic, mechanical, and others. In this paper, we mainly explored the international knowledge flow of three technology fields: a) computers & communications; b) drugs & medical; c) electrical & electronic.

We used two datasets of this database. One was the "Cite76-06"; another was the "Pat76-06"2. The dataset of Cite76-06 includes the information of citing patent number and cited patent number. We can acquire more than 20 million patent citations from this dataset. The patent citation data were updated to 2006. Hence, we raised a retrospective analysis on the status of patent citation in three stages: 1984-1986, 1994-1996, and 2004-2006. The dataset of Pat76-06 includes the information of patent number, granted year, assignee identifier, and country of assignee, technological category, and so forth.

To combine the aforesaid fields of these two datasets, we constructed a patent citation database which can show the patterns of knowledge flow from one country to another country, and enable us to obtain a weighted digraph. The origin of the edge represents the country of knowledge flow out, which is the country of cited patent. The end point of the edge represents the country of knowledge flow in, which is the country of citing patent. The weight of the edge represents the rate knowledge flow, which is the times of patent cited. To raise a comparative analysis, the paper used the k-core, block-modeling and other methods of social network analysis.

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