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## International patenting: An application of network analysis<sup>☆</sup>

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### ABSTRACT

The aim of this paper is to examine the behavior of patenting abroad using social network analysis on the patent data for 192 countries in the period 1995–2009. We estimate the metrics of the international patenting network for the years 1995, 2000, 2005 and 2009 in order to recognize and possible evolution of the network. Our findings indicate that in the fifteen years period the international patenting network evolved with increasing number of connections, increasing weights and became more connected. The estimated metrics of the network verified the previous findings of the literature that the countries which exhibit high innovative activity attract patents from abroad. Also, the estimated preferential attachment indicator suggests that the probability of patenting a new patent in a foreign country is highly correlated with the authority index.

### 1. Introduction

With the advent of globalization and financial economic interactions among countries international patenting has become widespread. In the pursuit of economic growth, every country has sensibly invested in international cooperation, learning innovation, technology diffusion and knowledge. The international diffusion of new products and processes is often regarded as a major driving force of world economic growth. [Eaton and Kortum \(1996\)](#) found that more than 50% of the productivity growth in every OECD country, other than the U.S., results from ideas originated abroad.

Since the late 1980s, major changes have eventuated in the field of patents, namely: the changes in the patent framework inside the US, the TRIP agreement under the Uruguay round and the significant upsurge of international trade and foreign direct investment. These changes led to a significant expansion of the international patenting activity. As a result, international patenting has attracted an increasing attention in literature even though in a less degree comparing to other measures of international technology diffusion. [Eaton and Kortum \(1996\)](#) found that physical distance, human capital and patent protection framework of the destination country affect the patenting abroad decision. [McCalman \(2001\)](#) estimated the impact of the GATT – Uruguay round on the transfer of income and [McCalman \(2005\)](#) estimated the impact of the TRIP agreement on the short and long run growth. [Chan \(2006\)](#) found that intellectual property protection is a significant factor in the decision of the agricultural biotechnology firms to patent abroad. [Harhoff, Hoisl, Reichl, and Van Pottelsberghe de la Potterie \(2007\)](#) relied on a gravity model that aims at explaining patent flows between inventor and target countries within the European patent system. More recently, [Picci \(2010\)](#) adopted a gravity model to study the determinants of the intensity of collaboration between pairs of countries and discussed the extent and the determinants of the internationalization of European inventive activity. [Archontakis and Varsakelis, \(2011, 2016\)](#) adopted the gravity model based on the theoretical foundation of [Anderson \(1979\)](#) to explain the flow of patents in the OECD countries.

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Previous literature has used econometric techniques to evaluate the decision of patenting abroad. The aim of this paper is to examine the behavior of patenting abroad using social network analysis on a patent dataset for 192 countries in the period 1995–2009. We estimate the metrics of the international patenting network for the years 1995, 2000, 2005 and 2009 in order to detect the topological characteristics of the network and the time evolution of the network. Our findings indicate that in the fifteen years period the international patenting network evolved with increasing number of connections, increasing weights and became more connected. The estimated metrics of the network verified the previous findings of the literature that the countries which exhibit high innovative activity attract patents from abroad. Also, the estimated preferential attachment indicator suggests that the probability of patenting a new patent in a country is highly correlated with the authority index.

The rest of the paper is organized as follows. [Section 2](#) offers a theoretical foundation of the for international patenting activity and sets the research hypotheses of the paper. [Section 3](#) presents the data, the empirical results and the discussion. Finally, [Section 4](#) offers some concluding remarks and policy implications.

## 2. Theoretical background and hypothesis settings

Even though patent is a flawed measure of innovation process output, because not all innovations are patented and patents differ greatly in their economic impact, a patent indicates new knowledge-technology ([Griliches, 1979](#)). Patents are considered as important innovation indicators that document the end of an innovation process and show how an organization can commercialize an innovative idea. The main aim of patenting is to protect innovation from imitators but this protection is provisional since the decision to patent depends among other factors on the registration cost and the renewal fee.

Inventors patent their invention in foreign countries because a single national patent does not protect an invention in the global market. A firm or a patentee decides to patent in a foreign country in order to protect its innovation from imitators that would produce there or export there from a third country. However, only a fraction of source country inventors seek patent protection abroad. The patenting in any additional country costs and consequently firms do not patent their inventions in every country but they choose. Hence, international patenting not only reveals valuable information on the international competitiveness of firms but also signals where innovations are most likely to be used ([Archontakis & Varsakelis, 2016](#)). [Eaton and Kortum \(1996\)](#) suggested that international patenting is correlated with the R & D activity in the home economy. Moreover, the total number of patents the inventors of the home country are granted in the rest of the world are different from the total number of patents granted to the citizens of home country by the country's patent office. This is due to the following reasons. First, as [Cohen and Levin \(1989\)](#) argued, not all patent granted by a patent office have economic value. Second, some of the patents having economic value are not exploited commercially because the patentee does not see any technological or entrepreneurial opportunity in it ([Goniadis & Varsakelis, 2012](#)). Third, some patentees commercially exploit their patents in the home market and do not aim to expand in the international market. Hence, only a share of the patents granted by the home patent office has international economic value and the patentee should protect it in foreign markets. Besides, according to [Eaton and Kortum \(1996\)](#), patentees from one country do not to patent in a foreign one because they are concerned of technology diffusion to their competitors in the destination country. However, [Archontakis and Varsakelis \(2011\)](#) noted that the dramatic institutional change, the introduction and development of the *Internet*, have facilitated in the most high degree information diffusion since the patent office provide information on patents on almost real time. After patenting in one patent office information diffuses in international markets and the disclosure of the inventions is not limited to protecting countries, but is global. Therefore, the exploitation outside the protecting country is almost free or at minimum economic cost while the benefits promised to the inventor in exchange for the disclosure are limited only to the protecting countries.

Domestic firms follow three ways in the internationalization strategy: exports, licensing and foreign direct investment (FDI). During the last decades multinational firms locate the various production stages across different countries; they are organized within global value chains (GVCs). In the case of GVC, the mother company transfers knowledge to its subsidiary in the foreign country related to the specific stage of production (e.g. a certain piece of machinery). Based on this fact, the local rival firms could replicate only this partial knowledge ([Archontakis & Varsakelis, 2016](#)).

In the case of international trade and foreign direct investment the patentees extract the monopolistic rent of the patent while in the case of licensing extract a part of the economic value of the inventions through royalties and fees. In all cases, the inducement to patent in the destination country is the risk of imitation from local firms and firms from other countries which have commercial interest in the destination country, extracting that way part or sometimes the full economic value of the invention. The imitation risk is lower the higher the tacit component while in advanced industrial countries, intellectual property rights may impede imitation of certain capabilities ([Teece, 2004](#)) [15].

A patentee decides to patent in a specific destination country because of the increasing business opportunities and the imitation risk. Imitation comes from three sources: First, the imitation by local firms established in the destination country. A domestic patentee who wishes to protect its invention abroad should patent in countries with high R & D activity. Second, is an attempt to develop special technology in which the recipient country has comparative advantage and which complements the firm's core technology. Third, the imitation by firms established in another than the destination country. Outsiders could imitate and sell the product to the destination country by registering their own patents in the destination country, if they recognize any technological and commercial potential. As long as a domestic invention is unprotected in such countries, outsiders have an incentive but also the potential to imitate.

[Putnam \(1996\)](#) argued that a country's percentage of a total value of patent rights granted worldwide is correlated to the relative size of its domestic economy. [Bosworth \(1984\)](#), using an international data as indicator of technology transfer, finds for the case of the U.K. a strong association between patenting and foreign direct investments. International patenting is a central part of a firm's

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