Technovation 34 (2014) 546–558

Contents lists available at ScienceDirect

Technovation

journal homepage: www.elsevier.com/locate/technovation

Patent indicators for macroeconomic growth—the value of patents estimated by export volume

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ARTICLE INFO

Available online 27 May 2014

Keywords:
Patents
Patent value
Exports
International trade

ABSTRACT

This paper examines the linkage between patenting and export performance for selected countries at the level of technology fields. Some empirical studies show considerable correlation between the patenting behavior of countries and their economic success in international markets. Adding to the existing literature, the aim of this analysis is to assess whether the indicators that are supposed to reflect patent value—such as patent citations or family size—have any explanatory power in estimating the export value of countries by technology fields.

For this study, a panel dataset was compiled consisting of annual data (1988–2007) on international trade from the UN-COMTRADE database and patent data from the EPO Worldwide Patent Statistical Database (PATSTAT).

The results show that exports are a very useful way of placing a valuation on patents. Patents and exports are strongly correlated, although there are visible deviations from this parallelism. IPC classes and inventor counts prove not to be relevant in predicting the export value of patents, while family size has restricted predictive power. When analyzing patent applications, forward citations, in particular, are more promising than granted patents.

1. Introduction

This paper examines the linkage between patenting—as an output indicator of technology-oriented invention/innovation processes (Grupp, 1998)—and export performance for selected countries at the level of technology fields. In several empirical studies, it was shown that there is a close connection and considerable correlation between patents and economic success in international markets (Dosi et al., 1990; Gehrke et al., 2007; Grupp et al., 1996; Münt, 1996; Porter, 1998; Wakelin, 1997; Wakelin, 1998a, 1998b). For example, based on a time series analysis of a set of industrialized countries, Blind and Frietsch (2006) showed that patents explained export streams, especially in high-tech sectors but also in low-tech areas. This is not only because a patent filing indicates a successful technological invention but also because a patent restricts others from using the covered technology, at least for a given time period. Therefore, filing a patent in a specific market, or more precisely at the relevant patent office, indicates that a product incorporating the patented technology is intended to be sold in this market. This corresponds to the discussion in the empirical and theoretical literature, which assumes that the long-term development of market shares is not only driven by price competition but also by technology and quality competition (Kleinknecht and Oostendorp, 2002; Legler and Krawczyk, 2006; Maskus and Penubarti, 1995). As Aghion and Howitt (1992, 1998) pointed out in their model of Schumpeterian competition, new and improved products are major sources of economic growth (growth through creative destruction). In the context of international trade, product quality and price determine competitiveness, which then influences market share. This is also because complete reliance on imitation will not enable a country to catch up with the technological frontier since R&D activities generate certain technological capabilities as well as a certain amount of innovation-relevant tacit knowledge within a country, which can be seen as a

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http://dx.doi.org/10.1016/j.technovation.2014.05.007
0166-4972/

prerequisite for future technological advance (Blind, 2001; Lundvall, 1988; Nelson, 2000). Thus, a country's economic history—e.g., its past technological capacity—determines its present potential for technological innovation and the effective diffusion of those innovations through the entire economy (Blind, 2001), which is in turn related to economic performance.

Therefore, it can be expected that patents—as an output indicator of R&D processes—are strongly related to the export performance of countries. However, as argued above, this does not necessarily establish the fact that innovation causes exports, since endogeneity issues have to be taken into account, i.e. innovation may not only result in higher exports, but higher exports may subsequently influence innovation activities (Chang et al., 2013; Hsu and Chuang, 2014; Lachenmaier and Woßmann, 2006; Madsen, 2007; Sun and Du, 2010). Thus, adding to the already existing literature, where cross-sectional data is utilized for the most part, we test the theory using a longitudinal dataset and advanced estimation techniques that deal with the issue of endogeneity. In addition to this methodological contribution, we seek to make theoretical headway by claiming that qualitative differences in innovative outputs—i.e. differences in the technological and economic value of patents—should contribute differently to the export performance of countries. This assumption can be seen as expanding the product life cycle model of international trade (Dosi and Soete, 1983, 1991; Krugman, 1979; Posner, 1961; Vernon, 1966, 1979), stating that advanced countries that are first to develop new products will dominate the export markets, which has not yet been acknowledged in the economic literature to our knowledge. More specifically, we go one step further by raising the question whether exports can be used as a means of measuring the technological and economic value of patents. Even more significantly, one could ask whether patent characteristics, which are supposed to indicate a patent's value, exert any influence on the relationship between patents and exports. Therefore, the overall aim of this analysis is to show whether different patent quality indicators have any explanatory power in estimating the export value of countries by technology fields.

However, the economic and technological valuation of patents is one of the biggest challenges in empirical patent analysis. Renewal fees represent one way of assessing the value of patents (Bessen, 2008; Schubert, 2011) and measuring licensing income is another, even though such data is hard to obtain given that neither the licensor nor the licensee have an interest in disclosing it. The most direct way is to survey inventors and ask them for the value of the patent on the day of granting, for instance (Harhoff et al., 1999; Gambardella et al., 2008; Giuri et al., 2006; Giuri et al., 2007) or to ask external persons, in a more experimental setting, about the perceived value of a given technology (Sohn et al., 2013). Finally—and this is the path that is pursued here—export data could be used on a macro or meso level of technologies to serve as a measurable value of patents.

For our study, an integrated panel dataset was constructed consisting of annual data of international trade, patenting, and country characteristics from recent years (1988–2007). The panel comprises 18 OECD countries (Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Sweden, and the United States) and China. All patent and trade data are aggregated into 35 technology groups for each country in each year. This dataset enables us to test our assumptions on a broad-based sample that includes a large number of different countries as well as full coverage of high-technology patents within those countries. The merger of patents and exports was achieved by applying the definitions of a set of 35 high-technology fields and a residual low-tech area, both in terms of SITC (exports) and IPC (patents). This definition relies on Grupp et al. (2000), as well as Legler and Frietsch (2007).

The remainder of this paper is organized as follows. In Section 2, we provide a short account of the literature. Section 3 offers further theoretical underpinning for our research and develops the main hypotheses. In Section 4, we describe our dataset. Section 5 examines the estimation methods and empirical results. Section 6 presents our conclusions and considers areas for future research.

2. Literature review

According to mainstream international trade theories, international trade in goods occurs because of differences in comparative advantage between two countries involved in the manufacture of goods. The most widely accepted and tested factor that affects comparative advantage is factor endowment. The Heckscher–Ohlin (HO) theory predicts that a country abundant in a particular factor relative to other factors will export greater quantities of a good, integrating more of that particular factor. For example, according to the HO theory, the United States should export capital-intensive goods and import labor-intensive goods because it is strong in capital relative to labor. However, paradoxically, empirical data revealed the opposite result, as first presented by Leontief (1953). As a natural response to this paradox, many alternative explanations and empirical examinations were advanced (see Deardorff (1985) for a review of the alternative theories and empirical evidence). As one of those alternative (or complementary) explanations, some scholars focused on the equal technology assumption in the HO model. The assumption made by the HO theory that production technology is the same across countries is not only unrealistic but also fails to explain the impact of technological change on international trade.

The 'product cycle model' of international trade, alternatively known as the 'technology gap model', addresses this gap in the HO trade theory. The product cycle model was first proposed by Posner (1961) and Vernon (1966, 1979) and further elaborated by Krugman (1979) and Dosi and Soete (1983, 1991). In essence, the product cycle model assumes a dynamic change in production technology and a variable ability among countries to exploit new technologies. It further assumes the presence of an imitation lag, i.e. it will take time and involve costs for a following country to absorb superior technologies and apply them to manufacturing processes. Under these conditions, new or advanced products integrating superior technology will form temporary oligopolistic markets before followers can catch up. Therefore, firms located in technologically advanced countries will develop new products and be first movers in integrating the superior technology, consequently exercising a dominant position in the export markets for these products.

The empirical evidence is largely consistent with the product cycle model. Most empirical studies have tested whether the export performance of a country in a particular sector is positively correlated with technological capability (for example, as measured by the stock of patents in that sector). To take one instance, Soete (1981, 1987) showed that there was a positive link, covering 40 industrial sectors, between the export performance of OECD countries in 1977 and the country share of US patents for the past 15 years, after controlling for capital-labor ratio, population, and geographic distance from an assumed 'world center'. He obtained similar results for four different measures of export performance such as export market share, revealed comparative advantage (or Balassa index), export-import ratio, and the export-GDP ratio. He also found strong positive associations for most sectors between export performance, as measured by exports per capita, and technology level, as measured by granted US patents after controlling for investment per employee and wages on value added (Dosi and Soete, 1983). These results, however, revealed sectoral