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Title

The internationalization of corporate invention: national and sectoral contributions.

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1. Objective of the paper

The continuing globalization of the R&D activities of firms is a subject of considerable interest to policymakers (OECD, 2005; UNCTAD, 2005) as innovation is recognized as a main driver of productivity and growth as well as a vital resource in addressing societal challenges. As there is a strong link between innovation and corporate R&D, policy concerns focus on the potential loss of competitiveness of countries and domestic firms as well as on the potential impoverishment of the local knowledge base. Especially the rise of Asian R&D (Heimeriks & Boschma, 2012) leads to a growing concern among policy makers for hollowing out of the national innovation system (Narula & Zanfei, 2005). And yet, we currently have only some approximate and contrasting views about the drivers of the internationalization of corporate invention in recent years.

It is increasingly recognized that the internationalization of corporate R&D is a heterogeneous process and significant differences in the international dispersion of innovative activity across industries and countries have been identified (Narula and Zanfei, 2005). The existing literature highlights two broad categories of drivers of internationalization of R&D. First, several studies emphasize the existence of a *home bias* in the choice of R&D localization of multinational firms (Bas & Sierra, 2002; Carlsson, 2006; Pavitt & Patel, 1999). In addition when internationalization takes place this is often into neighboring countries (Guellec & Van Pottelsberghe de la Potterie, 2001). This strand of literature thus emphasizes the importance of national and regional institutions and arrangements (Storper, 2010). A second strand of literature has identified considerable industry-specific differences which encourage or discourage concentration in as few locations as possible (Cantwell, 1999; Kogut & Zander, 1993) and consequently some sectors are characterized by a higher R&D intensity and a higher rate of R&D internationalization.

For countries that seek to be an attractive location for R&D activity and to capture the benefits of new technological developments it becomes a pressing issue what national and sector specific strategies are available. Such strategies need to accept and take into account the heterogeneity in R&D internationalization patterns. The main research question of this paper is therefore:

What are the patterns of internationalization of corporate R&D and to what extent do sectoral and national characteristics drive these internationalization patterns?

In order to address the need for more systematic analysis of patterns of corporate invention, we introduce the Corporate Invention Board (CIB). The CIB combines patent data from the PATSTAT database with financial data of the from the ORBIS database about more than 2000 companies with the largest R&D investments.

The CIB complements the “Industrial R&D Investment Scoreboard” produced annually by European Commission’s Institute for Prospective Technological Studies. The industrial R&D Investment Scoreboard analyses the performances of the 2000 industrial companies (1000 based within the European Union, 1000 in the USA and 433 Asian

companies) with the highest annual R&D investments. Through patents' statistics, we focus on the outputs of these R&D investments providing information on technologies and on geographical location of these investments. CIB thus covers a very significant share of private R&D investments: the industrial corporations studied in the project account for 80% of world total private R&D.

This unique database allows us to characterize the nature and the extent of technological internationalization, and to analyze the transformation of global patent portfolios of industrial groups in the last decades. As such, the CIB allows for a more evidence based approach than most existing studies that rely on surveys (Gorg & Strobl, 2001), or on a sample of patents within a given sector or country (Patel & Vega, 1999).

Countries aim to be an attractive location for R&D (both foreign and domestic) for several reasons related to the benefits associated with high skilled labour and the increased absorptive capacity of the knowledge system (Verspagen, 2001, Erken and Kleijn 2010). The home country of a multinational corporation (MNC) is usually also its preferred R&D location. The R&D activities of firms seem more difficult to internationalize than other firm activities and the internationalization of the innovative activities of MNCs has lagged behind that of their productive activities. The reasons for this centralization of R&D in the home country is explained both from the alignment and co-evolution of MNCs with the innovation system in their home country and from economies of scale and agglomeration in R&D. The past decade has, however, seen a notable increase in the internationalization of corporate R&D (Dunning and Lundan, 2009) increasing the relevance of research into the locational factors that determine foreign R&D investment.

This research on locational factors distinguishes two sets of motives for international R&D. In the early literature, such R&D was mostly found to be of a home-base exploiting nature (Casson 1991, Pearce 1990, Pearce and Singh 1992). This type of R&D, also called product adaptive R&D, focuses on the exploitation of the home based capabilities of the MNC abroad. While the availability of R&D personnel in the host country does play a role in the location decision, the size of the host market (mostly measured in GDP) is the most important locational factor here.

In recent years a rise in a second type of R&D has been observed. This R&D, termed home-base augmenting R&D, focuses at generating new knowledge and competencies for MNCs has increased since the 1990s (Cantwell and Mudambi 2005, Kuemmerle, 1999). Home-base augmenting strategies are argued to be particularly important for MNCs that seek to protect their global competitive position and cause firms to move their R&D into locations which have an advantage in a certain area of technology, Florida (1997) calls this a 'technology-oriented posture'. The quality of the host innovation system is thus important for this type of strategy.

Survey based research has identified the most important locational factors identified in this as the availability of researchers, access to specialized R&D, market access and a predictable IP rights framework (EU 2006). In this survey, the cost of research personnel was among the least important factors. While some of the factors that are identified in survey based research are sector or technology specific, other factors relate to the quality of the national innovation system. Such factors include the quality of basic research, workforce skills, systems of corporate governance, the degree of competitive

rivalry and local inducement mechanisms, such as abundant raw materials, the price of labor and energy, and persistent patterns of private investment of public procurement (Pavitt and Patel, 1999, p. 94). One possible effect of globalization is that through imitation, technology diffusion and transfer national systems may converge up to a point (Carlsson, 2006; Niosi and Bellon 1994) influencing the relative importance of locational factors related to the national innovation system (Grandstand et al., 1993; Florida, 1997).

For policymakers insight in the relative importance of these two types of locational factors is pivotal as it helps policymakers to identify their strengths and weaknesses of their attractiveness as a location for R&D for different types of firms.

In order to get scope we focus on patents. Earlier patent-based studies by Le Bas and Sierra (2002) focus on Europe and on technology/sector specific advantages. Patel and Vega (1999) focus on technology/sector specific advantages. Guellec and van Pottelsberghe de la Potterie (2001), data until 1995. Picci (2010) focuses on country-related factors. Dachs and Pyka (2010) focus on Europe. Erken and Kleijn (2010) use private R&D capital stock as an indicator for the quality of the innovation system Patel and Vega (1999) and Le Bas and Sierra (2002) both distinguish between home-base exploiting strategies versus home-base augmenting strategies. Le Bas and Sierra and Patel and Vega only focus on RTA at sectoral level. While in the literature also some national factors where (non sector specific factors) were identified as important.

This paper combines the empirical breadth of earlier patent-based analyses papers but compares the relative contribution of national and sectoral factors, includes more recent data and also Asian firms.

2. Approach

Patents provide a useful source of data, despite well-known limitations (Archibugi & Pianta, 1996). However, existing patent datasets suffer from a number of drawbacks; they fail to capture the technological component which is part of global R&D investments (OECD, 2008) and figures on industrial R&D investment do not disentangle the geographical and technological components of these investments (Hernández, Tübke, & Brandsma, 2008). The proposed project will go beyond the current limits in empirical research by using a unique dataset called The Corporate Invention Board (CIB). Through patents' statistics, we focus on the outputs of R&D investments of multinational firms, thus providing information on technologies and on geographical location of their investments. Furthermore, the multinational firms are assigned to different sectors (Hernández et al., 2008).

In order to have an internationally patent-based reliable indicator, we consider only priority patents registered by more than one country; a category we label "transnational priority patents". The propensity to patent in a foreign country varies from nation to nation depending on a variety of factors that include the intensity of commercial relations, the similarities among the legal systems, and the linguistic diversity (Archibugi and Pianta 1996). The main purpose of using transnational priority patents is to provide a relevant basis for an international comparison by correcting national

specificities that affect most the quantitative characterization of inventive activities. National discrepancies are thus filtered within the second patent system the transnational priority patent is required (by definition) to go through.

In order to better understand the reason behind the EU's deficit in business R&D intensity, we consider quantitatively the relative contributions of the sectoral structure of R&D efforts (structural effect) visàvis the R&D intensity efforts in each country (intrinsic effect) following the approach of Haveman and Donselaar (2008), Erken and van Es (2007), Hollanders and Verspagen (1998), and van Velsen (1988)

3. Expected results

Our data allows to characterize the overall trends in internationalization over the period 1993-2005. In earlier studies both national characteristics and sectoral characteristics have been identified as determinants of internationalization patterns, however two large scale patent studies focus only on sectoral characteristics (Patel and Vega, 1999; Le Bas and Sierra, 2002). The importance of both sets of characteristics is also reflected in the two most important internalization strategies identified in earlier work: Home base exploiting and Home base augmenting. While technological competences in the host country may also play a role in home base exploiting strategies, the main driver here is the size of the foreign market, (a national characteristic), we therefore use GDP as an indicator for this strategy.

Home base augmenting strategies do explicitly rely on technological competences in the host country, these competences might be general but can also be sector specific. We therefore use both the size of the overall portfolio of transnational priority patents as an indicator as well as sector/technology specific advantages of the host country as measured by *relative comparative/technological advantage* (as in Patel and Vega and Le Bas and Sierra).

Furthermore, decomposition analysis is a widely used analytical technique for retrospectively decomposing changes in a set of countries. The analysis identifies the comparative advantage in particular sector of patent production. Decomposition analysis recognizes that some national patenting activities are likely to be growing at a faster rate compared to the total set of patenting activities under study and other countries will be growing more slowly. Countries are expected to specialize in certain sectors and produce output in that sector, thereby increasing its output in that sector.

As such, the decomposition analysis reveals how well countries are performing by systematically examining the total, national, and sectoral components of change in technological knowledge production. A decomposition analysis will provide a dynamic account of total patenting growth of a country that is attributable to growth of the total patent production, a mix of faster or slower than average growing sectoral activities, and the competitive nature of the national activities in the context of their national innovation systems.

Generally, countries experience changes within their patenting output that are more concentrated in certain sectors than the global patent output as a whole. This difference can be attributed to the specialisation of a country. Countries with one or more rapidly

growing sectors of research might display a high rate of output gain as a result of the expansion. Likewise, an country with several declining sectors of research might experience (relative) output loss. In examining the national contributions, we will divide those changes into various structural effects lends insight into national trends by means of the decomposition analysis.

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