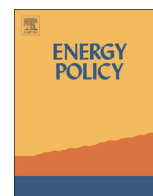




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# Multinational firms and the internationalization of green R&D: A review of the evidence and policy implications<sup>☆</sup>

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## HIGHLIGHTS

- Green R&D is becoming increasingly globalized.
- 17% of the green patents of our sample of 1200 MNCs have been invented abroad.
- Most green R&D offshoring takes place among OECD countries, and towards China.
- Environmental policy is key to attracting multinationals' green offshoring activities.

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## ABSTRACT

This paper presents novel empirical evidence on the internationalization of green R&D by multinational firms (MNCs), as measured by patents data. Using data on inventors' addresses for the set of 1200 MNCs firms patenting in green technologies over the 2004–2009 period, we find that about 17% of green patents result from MNCs R&D investments conducted outside their home countries. MNCs tend to locate their foreign green R&D activities in other OECD markets and in China, in particular in lightings and solar technologies. The empirical analysis reveals that the probability of conducting green R&D abroad increases with the host country's stringency of environmental regulation, market size and (green) R&D intensity. Also, relatively lower wages for scientists and engineers, and stronger protection for intellectual property rights in the host country increase the likelihood for MNCs to offshore green R&D. The paper concludes by discussing the policy implications of this changing global innovation landscape.

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## 1. Introduction

This paper aims to shed light on the internationalization of research and development in green technologies, as reflected in the global R&D location decisions of multinational corporations (MNCs). In recent years, multinational firms have been increasingly expanding their R&D activities outside their home countries, thereby challenging the standard view in economics that assumed that MNCs would keep R&D and innovation close to home, as part

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of their headquartered operations. Between 1995 and 2003, the share of the R&D budget spent outside the home country by European multinationals increased from 25% to 44% according to a survey by Reger (2002). While most R&D investment still goes to developed countries, non-OECD countries, such as China and India are attracting an increasing amount of R&D investment (UNCTAD, 2005; OECD, 2008).

This changing innovation landscape involves all technologies and thereby green technologies that aim to reduce the pollution intensity of production processes and consumption patterns (e.g. renewable energy, electric and hybrid cars, energy-saving lightings, etc). As green technologies tend to be concentrated in the hands of firms in the developed world (Dechezlepretre et al., 2011; World Bank, 2012), better understanding how multinational firms organize their green innovation activities worldwide is important to ascertain how these technologies may diffuse to the rest of the world. The economic literature emphasizes the role of knowledge spillovers from MNCs to local firms, as an important channel for technology transfers (Keller, 2004). Since R&D spillovers tend to be

very geographically localized, due to the tacit nature of knowledge (Jaffe, 1986), attracting R&D investments from MNCs may generate important technology transfers and economic benefits to local firms.

In this study, we aim to provide some first empirical systematic evidence on the globalization of green R&D, a phenomenon for which there is so far only anecdotal evidence. The case of General Motors who opened in November 2012 a new GM China Advanced Technical Center in Shanghai, as part of its global network of R&D labs, illustrates this new phenomenon. The new GM research center in China employs 300 scientists who focus on green technologies related to lightweight materials and battery cells for the development of hybrid, plug-in hybrid, and electric vehicles. In the press, Kevin Wale, Director of GM stated that the new technical center “will ensure that GM keeps up with the needs of our local customers through the development of cutting-edge automotive technology that is cleaner, more efficient and affordable.”<sup>1</sup> John Du, Director of the technical center, motivated further the decision to open this new R&D lab in China by the abundant supply of scientists and engineers in China (“China now ranks first in the world in the number of PhD candidates, and these are talents we want to attract into the GM R&D and engineering workforce”), the proximity to Asian companies in Korea and Japan leading the world in electric car battery research, China’s resources of magnesium used for batteries and light-weight steel, and the presence of a large number of producers of automobile parts in China.<sup>2</sup>

The aim of the current study is to provide insights on the geographic distribution of MNCs’ green innovation activities and to analyze empirically the main motives of MNCs to conduct green R&D abroad. The central research question is: what drives the globalization of green R&D?—or in other words, what are the determinants affecting MNCs’ green R&D location decisions? To answer this question, we use patents data at the firm level for about 1200 multinationals patenting in green technologies over the 2004–2009 period.

The article is organized as follows. Section 2 reviews the literature on the determinants of the location of innovation activities and discusses the case of green R&D in particular. Section 3 presents the data used in this study and provides some descriptive analysis on the international geographic distribution of green R&D by multinational firms. Section 4 describes the empirical methodology and results. Section 5 concludes and discusses the policy implications of the globalization of green R&D, both at the national and international level.

## 2. Literature review

In this section, we combine several strands of literature, i.e. the literature on the globalization of R&D in international business and management, the literature on trade and FDI, and the literature on the international diffusion of green technologies in environmental economics, to discuss MNCs’ main motives for locating green R&D investments outside their home countries.

Although there has been no study so far looking at the globalization of green R&D activities in particular, the literature on R&D internationalization in the field of international business and management provides useful insights to understand MNCs’ motives for conducting R&D outside their home countries. This literature relies mainly on case studies of MNC firms and business surveys (see Hall, 2011, and Narula and Zanfei, 2005 for a review),

although some papers have also looked at the international distribution of firms’ inventive activities using patents data just as we do (Cantwell, 1995; Dachs and Pyka, 2010; Harhoff and Thoma, 2010). Cantwell (1995) uses US patents data to investigate the role of foreign-owned firms in US innovation activities. Harhoff and Thoma (2010) extend Cantwell’s work to look at MNCs’ patenting activity worldwide from 1986 to 2005. They find that in OECD countries about 10% of inventors are employed by a foreign company, with a higher share for European countries. They document that the geographical concentration of inventors has been decreasing over time. Regarding MNCs’ strategies, the international business literature identifies two key motives for conducting R&D abroad, namely adaptive R&D and technology-sourcing.

Adaptive R&D refers to the need for MNCs to adapt their products to specific local markets, thereby supporting their local sales and production activities in the host countries. Being close to consumers is an asset in order to better understand local demand and to offer adapted products. In the literature, this strategy is also referred to as ‘asset-exploiting R&D’ (Dunning and Narula, 1995) or home-base-exploiting R&D (Kuemmerle, 1999), since the firm seeks to exploit existing technology developed at home into new market conditions. When adaptive R&D is the main motive for R&D offshoring, the major determinant behind firms’ location choices is the level of demand in the local market. Dachs and Pyka (2010) use European Patent Office (EPO) patents from the period of 2000–2005 and find that cross-border patenting activities are significantly higher when the host market is larger. Firms may find it easier to cover their cost of adaptive R&D in larger markets with higher demand and better sales prospects. Patel and Vega (1999) look at US patenting in high technology fields. They find that in a majority of cases firms tend to locate their technology abroad in the core areas where they are strong at home, suggesting that adapting products to suit foreign markets and providing technical support to local production facilities remains a major factor underlying the internationalization of R&D.

The second main motive of MNCs for conducting R&D abroad, i.e. technology sourcing, refers to the fact that MNCs may want to source local knowledge which is not available at home. Firms may want to improve their existing assets or to acquire new knowledge, for instance by looking for knowledge that is complementary to their home-based knowledge through their foreign-based R&D facilities. In the literature, this strategy is coined ‘technology-seeking’ or ‘technology-augmenting’ (Dunning and Narula, 1995) since firms want to augment their knowledge-base by sourcing new technologies abroad. A location that is home to a major competitor may attract other MNCs in the same industry. By opening up an R&D laboratory close to a competitor, the firm hopes to benefit from knowledge spillovers and to tap into the competitor’s knowledge base. As emphasized in the economic literature on R&D spillovers, the role of geographic proximity and face-to-face interactions between scientists is critical for effective technology transfer to take place (Jaffe, 1986; Henderson et al., 1993). Both MNCs and local firms can thus greatly benefit from concentrating their R&D activities in the same location. Griffith et al. (2004) show that foreign research labs located on US soil have benefited a great deal in terms of total factor productivity of the growth of the US knowledge stock. Harhoff et al. (2014) look at data from German companies engaging in R&D cooperation with US companies over the 1992–2003 period and also find that such cooperation – in particular in the form of co-patenting activities – generated higher TFP growth for both German and US firms.

When technology-sourcing is the main motive for locating R&D overseas, MNCs will be attracted to countries with high technological capabilities, i.e. with a good supply of knowledge and R&D infrastructure. Factors such as the quality and specialization of local universities and research institutions, the quality and size of

<sup>1</sup> [http://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2011/Sep/0921\\_china.html](http://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2011/Sep/0921_china.html).

<sup>2</sup> <http://www.reuters.com/article/2012/11/29/us-autos-china-gm-idUSBRE8AS09920121129>.

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