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The Globalization of Technology in Emerging Markets: A Gravity Model on the Determinants of International Patent Collaborations

FABIO MONTOBBIO
University of Turin, Italy
Kites, Bocconi University, Milan, Italy

and

VALERIO STERZI *
Université Bordeaux Montesquieu IV, Pessac Cedex, France
Kites, Bocconi University, Milan, Italy

Summary. — International technological collaborations (ITCs) and face-to-face interactions are an important vehicle of knowledge diffusion. This paper analyzes ITCs among USPTO patents' inventors in eleven emerging economies and seven advanced countries (1990–2004) and a novel database on companies' country of origin. Technological proximity and sharing a common language are key drivers of ITCs. When the applicant's ownership is in the emerging country ITCs depend positively upon transport and communication costs (geographical distance and longitude) and negatively upon the strength of intellectual property rights (IPRs). Stronger IPRs positively affect ITCs from subsidiaries of multinational firms.

Key words — patent collaboration, knowledge diffusion, intellectual property rights, emerging economies

1. INTRODUCTION

Endogenous growth models have shown that commercially-oriented innovation efforts by profit-seeking firms promote technological progress and productivity growth (Aghion & Howitt, 1992; Romer, 1990) and international knowledge spillovers are key drivers of catching up and income convergence (Fagerberg, 1994; Grossman & Helpman, 1991). Recent empirical literature on international knowledge flows has made important progress and identifies different channels of knowledge spillovers: import flows, cross-border investments, and a disembodied direct channel of codified information. Most of this literature focuses on developed or Organization for Economic Co-operation and Development (OECD) countries, however, the literature shows that imports are a significant channel of technology diffusion (e.g., Coe, Helpman, & Hoffmaister, 1997; Keller, 2004). Some evidence suggests also that technical knowledge is transmitted through exports. Finally foreign direct investments (FDIs) from multinational corporations generate technology spillovers (in particular vertical spillovers), through the physical presence of the plant and labor turnover (Keller, 2010, chap. 19; Keller & Yeaple, 2009a). In particular, as emphasized by Keller's survey (2010, chap. 19), empirical evidence shows that geography and physical distance importantly shape the diffusion of technical knowledge.

The idea that international knowledge spillovers affect productivity growth enhancing technological adoption and innovation in developing countries (Keller, 2010, chap. 19; Montobbio & Sterzi, 2011) stimulates governments and international organizations to place the domestic dissemination of frontier knowledge high up on their policy agenda (e.g., World Bank, 2010). At the same time, recent empirical literature has also shown that knowledge spillovers tend to be localized [1] and require absorptive capacity (Cohen & Levinthal, 1989; Griffith, Redding, & Van Reenen, 2004). This is because technological knowledge includes not only materials and knowledge codified in blueprints, manuals, publications, and patents but also know-how, routines, and organizational capabilities, much of which is tacit in nature (Cimoli, Coriat, & Primi, 2009; Dosi, 1988). Tacit knowledge (e.g., related to technical know-how or nonstandard production) is costly to transfer, and its transferability is limited by its embeddedness in individuals, teams, and organizations.

As a consequence, knowledge diffuses more rapidly when interpersonal links in the form of joint research efforts and collaborations create opportunities for learning which go beyond the exchange of codified information. In particular, recent evidence underlines that research collaborations create social networks which can foster mutual learning and, as a result,

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individuals and companies that actively participate in a network of knowledge exchange (Breschi & Lissoni, 2009; Hoekman, Frenken, & Van Oort, 2009; Singh, 2005) are more innovative.

This paper therefore analyses international technological collaborations between patent inventors in a "North–South" gravity model looking at the interactions between *emerging* and *advanced* countries under the assumption that technological collaborations imply face-to-face interactions that are a key vehicle of knowledge spillovers. However, while scholars have been widely aware of the nature of globalization in terms of trade and financial openness, there is no clear consensus about the extent of globalization of technological activities.

Academics and international organizations acknowledge that R&D activity is increasingly done at the international level (OECD, 2008). A number of communications technologies, such as fiber optics, social networks, and satellite communications, facilitate international technological activity and, in parallel with the decrease in communications and transport costs, geographical distance should have a declining impact on technological collaborations and research ventures.

At the same time, some authors (Granstrand, Hakanson, & Sjolander, 1992; Patel & Vega, 1999) show that the technological activities of the world's largest firms continue to be firmly embedded in their headquarters in the home countries. In parallel, Picci (2010), focusing on OECD countries, studies the degree of internationalization of innovative activities using patent data and finds a statistically significant impact of geographical distance. He shows that even if R&D internationalization is now more pronounced than it was 20 years ago there is a "lasting lack of globalization" that is surprising in the light of the abundant anecdotal evidence of both increased domestic R&D activities in emerging countries and offshoring R&D activities to countries such as China and India.

Moreover, the scale and scope of international technological collaborations are affected by the legislation on intellectual property rights (IPRs) which has changed rapidly in recent years after approval of the Trade-related aspects of intellectual property rights (TRIPs) agreement signed in 1994 and adopted and implemented by different countries at different points in time. One of the main economic justifications of the TRIPs agreement is that IPR reinforcement in emerging countries facilitates knowledge transfer and dissemination from advanced countries. [2] It is relevant then to control for the impact of IPR legislation on technology transfer and spillovers brought about by international technological collaborations between inventors.

In addition, the impact of geographical distance and IPR legislation on international technological collaborations—and, in turn, on knowledge transmission—depends upon the typology of firms involved in the innovative project. It is therefore important to distinguish whether international technological collaborations occur with the joint contribution of different companies in different countries or within the laboratory of a multinational corporation (MNC) located in an advanced or emerging country or, finally, within the laboratory of a company from an emerging country. This paper contributes to the literature, building a novel database that takes into account not only the residential address of inventors and assignees but also the *ownership* of companies and their nationality. In parallel, the specific composition of the international team of inventors and the relative weight of the different countries in the team are also taken into account. For example, if the international team of inventors contains a large majority of inventors from an advanced country and the patent is applied for by a company with an address in the advanced country, we can expect that the international collaboration is the result of a movement of skilled labor from the emerging to the advanced country. This type of international collaboration (and its determinants) is clearly different from a collaboration occurring in a laboratory of a MNC subsidiary located in the emerging country.

We use patent data from the US Patent and Trademark Office (USPTO) and we collect economic and institutional data from different sources. The sample covers 18 countries: a group of large emerging economies (Argentina, Brazil, India, Israel, China, South Korea, South Africa, Mexico, Malaysia, Singapore, and Turkey) and their relationship with seven advanced countries (USA, UK, Japan, Italy, Germany, France, and Canada). In order to model the impact of geographical distance and the impact of IPR reinforcement on technological collaborations between emerging and advanced countries, we use a modified version of a gravity equation and different empirical specifications, using panel data and Poisson pseudo-maximum likelihood (PPML) in order to tackle various econometric problems.

Our main results are that geographical distance is not important *per se* and distance matters mostly through trade and cultural similarities. Results are slightly stronger for time zone differences. Technological proximity is a very important factor that favors collaboration. Fixed effects models show that countries experiencing an increase in IPRs protection tend to be more involved in international collaboration. This effect is greater for those countries that have stronger trade relationships, and is positive only in the emerging countries characterized by a very low level of IPR legislations before the TRIPs agreements.

Importantly, for a subset of countries, we show that these determinants of international technological collaboration vary according to the type of collaboration considered and country of origin (emerging *vs.* advanced) of the companies involved. For example, for collaborations deriving from laboratories of multinational subsidiaries, we have no effects of geographical distance and a positive effect of IPR reinforcement. On the contrary, for collaborations that involve only a company from the emerging market, communication and transport costs—proxied by geographical distance—turn out to be important and the effect of the reinforcement of IPRs is negative.

The paper is organized as follows. In Section 2 we present recent evidence on the geography of knowledge spillovers and discuss to what extent co-inventor relationships can be considered an indicator of knowledge flows. In Section 3 we present our model of weightless gravity used to study the determinants of international technological collaborations between emerging and advanced countries. In Section 4 we present data and the empirical model. Section 5 discusses the results of the econometric analysis. Finally, Section 6 concludes.

2. INTERNATIONAL TECHNOLOGICAL COLLABORATIONS AS SOURCE OF KNOWLEDGE FLOWS

Technological diffusion is a major vehicle of technological change that in turn contributes importantly to productivity and economic growth. In particular the analysis of international technological diffusion is key to understand whether less-developed countries are able to catch up. Endogenous growth models typically consider technology as nonrival and underline that technological investments have both private and public returns. As a consequence technological activity creates external or spillover effects. However, these external