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Is Co-Invention Expediting Technological Catch Up? A Study of Collaboration between Emerging Country Firms and EU Inventors

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Summary. — Firms from emerging countries are going global, and Europe is attracting around one-third of their direct outward investments. Growing internationalization constitutes an opportunity for technological catch up. In this paper we analyze Brazilian, Indian, and Chinese cross-border inventions with European Union (EU-27) inventors, during the period 1990–2012. Our results suggest that these inventions represent an opportunity for emerging country firms to accumulate technological capabilities, access frontier knowledge, and appropriate the property rights of co-inventions. This paper contributes to understanding catching up by emerging country firms.
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1. INTRODUCTION

Emerging countries have experienced rapid internationalization of their firms in terms of their increasing share of world stock of Foreign Direct Investment (FDI), which has reached 39% of global direct investment outflows (UNCTAD, 2014), and of their growing involvement in global value chains (OECD, 2013). Among emerging countries, Brazil, Russia, India, China, and South Africa (BRICS) are the most important outward investors toward developed economies: as of 2012, 42% of their outward FDI stock was in developed countries, with 34% in the EU (UNCTAD, 2013).

Although there are differences across countries, this impressive economic dynamism has prompted scholars to ask whether and how firms from emerging countries are progressing from production to innovation (Altenburg, Schmitz, & Stamm, 2008) and improving their technological capabilities. This issue is central to the analysis of country catching up, because the degree to which these companies are able to generate valuable, new-to-the-world innovations may influence their future growth prospects (Fu, Pietrobelli, & Soete, 2011; Montobbio & Sterzi, 2013; Vivarelli, 2014). Data on innovation in emerging countries show some increase in research and development (R&D) expenditures, and exponential growth of patent applications especially in China and India (Branstetter, Guangwei, & Veloso, 2013). [1] For example, the share of Chinese R&D expenditure in China's Gross Domestic Product (GDP) increased from less than 1% in 2000 to almost 2% in 2012. [2] Moreover, recent studies provide evidence that companies from emerging countries are increasingly connected to international production and innovation networks (Branstetter *et al.*, 2013; Chen, Jang, & Chang, 2013). In particular, cross-border R&D collaborations between emerging country firms and other international actors are attracting the attention of analysts in relation to the capacity of emerging country firms to spur production of joint patents (Picci, 2010).

International collaborations involving co-inventions (or cross-border inventions) are considered a valuable channel for the transfer of knowledge from developed to developing countries (Montobbio & Sterzi, 2011, 2013) because they are often characterized by intensive knowledge sharing over extended periods of time (Alnuaimi, Singh, & George, 2012), and by face-to-face interactions between inventors with different levels of technological competence, both of which facilitate international knowledge spillovers (Agrawal, Cockburn, & McHale, 2006; Fleming, King, & Juda, 2007). Some studies show that patents resulting from international collaborations among inventors are more valuable and more important than those representing the work of individual, isolated inventors (Bercovitz & Feldman, 2011; Fleming, Mingo, & Chen, 2007; Singh & Fleming, 2010), since collaboration brings knowledge variety and sparks creativity (Fleming, Mingo *et al.*, 2007; Reagans & Zuckerman, 2001; Weitzman, 1998). This means that cross-border inventions may be a way for emerging countries to improve their innovation capacity, accumulate technological capabilities, and catch up with the advanced countries.

Despite their potentially positive developmental impact, cross-border inventions involving emerging countries have not been analyzed in depth. Most studies focus on R&D collaborations among firms and inventors in advanced countries (e.g., Leiponen & Helfat, 2011; Penner-Hahn & Shaver, 2005), and almost exclusively US patents and patentees (Breschi & Lissoni, 2009; Furman, Kyle, Cockburn, & Henderson, 2005; Singh, 2008). There is very little empirical evidence available on Europe. In studies that do include developing/emerging countries the focus is often on the operations of advanced country firms' subsidiaries in these countries (Alnuaimi *et al.*, 2012; Branstetter *et al.*, 2013; Chen *et al.*, 2013; Montobbio & Sterzi, 2011, 2013). Barely any study investigates the nature of cross-border inventions from the perspective of developing/emerging country firms.

The present paper addresses this gap in the literature by analyzing the extent to which firms from Brazil, India, and China

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(BIC) are involved in cross-border inventions with European Union (EU-27) actors. We acknowledge that the BIC countries are a heterogeneous group but their selection is justified by their being large countries which in different ways are active in shaping the global development agenda and gaining power within relevant international political circles as the World Trade Organization and the G20 (Hofmeister & Vogt, 2011; Hopewell, 2014; Reid, 2014).

In this paper, we compare the value and characteristics of BIC-EU cross-border inventions with those of a sample of analogous European Patent Office (EPO) patents filed exclusively by BIC inventive teams (i.e., domestic inventions) [3] in the period 1990–2012. We also distinguish between BIC Multinational Companies (MNCs) and BIC domestic firms (DFs) i.e., BIC firms with no FDI, and assess differences in the value and characteristics of cross-border and domestic inventions between these two types of firms.

Our analysis reveals that cross-border inventions between BIC firms and EU actors are growing, though still small in absolute numbers. Also, cross-border inventions are more valuable (higher quality and larger impact on the generation of subsequent innovations across a variety of technological fields) than domestic ones, suggesting that cross-border inventions represent an opportunity for BIC firms to accumulate technological capabilities, access frontier knowledge, and not least, appropriate the property rights of collaborative inventions involving European actors. We find also that BIC MNCs benefit more from international collaborations than BIC DFs, and explain this difference as the better ability of MNCs to minimize coordination costs and combine the skills of diverse inventors around the globe. Overall, our findings contribute to understanding the new role of emerging countries in changing the global innovative landscape, an area that is also attracting considerable international development policy attention.

The paper is organized as follows: Section 2 outlines the conceptual framework; Section 3 explains the methodology; Section 4 presents the empirical evidence; and Section 5 concludes with some policy implications.

2. INTERNATIONAL R&D COLLABORATIONS AND CROSS-BORDER INVENTIONS AS A SOURCE OF TECHNOLOGICAL CATCH UP FOR EMERGING COUNTRIES

European countries are one of the most important targets for emerging country firms keen to acquire technologies and other strategic assets (Giuliani, Gorgoni, Gunther, & Rabellotti, 2014; UNCTAD, 2013). This raises concerns among European stakeholders about loss of control over their strategic assets but for the emerging countries it represents an unprecedented opportunity to catch up, and to accumulate technological capabilities. According to several studies, emerging countries' investments and their collaboration with developed countries generate international knowledge spillovers (Alnuaimi *et al.*, 2012; Branstetter, 2006; Branstetter *et al.*, 2013; Chen *et al.*, 2013; Montobbio & Sterzi, 2011, 2013).

The literature on international knowledge flows so far analyzes different channels of knowledge spillovers, particularly trade and FDI (Grossman & Helpman, 1991; Lee, 2006). With the exception of some recent case studies on the growing involvement of emerging country firms in blue-skies innovative projects (e.g., Awate, Larsen, & Mudambi, 2012; Hansen, Fold, & Hansen, 2014), generally very little attention has been paid to their international R&D collaborations (Chen *et al.*, 2013; Picci, 2010). Hence, the extent to which emerging countries engage in technological collaborations with international actors, and by so doing enhance the innovativeness of their firms, is largely under investigated.

In conceptual terms, there is no consensus about the impact of international R&D collaborations on the quality of the resulting inventions (Alnuaimi *et al.*, 2012; Furman *et al.*, 2005; Penner-Hahn & Shaver, 2005; Singh, 2008). On the one hand, some scholars believe that R&D collaborations result in better quality inventions because they allow the combination of diverse knowledge and competences, available at the level of the different inventive teams (Levinthal & March, 1993; March, 1991). On the other hand, there are some who point to the high coordination costs of and the difficulties related to integrating existing knowledge when different international inventors and/or R&D units collaborate, suggesting that inventions carried out by isolated inventive teams might be more efficient and more valuable (Furman *et al.*, 2005; Grant, 1996; Singh, 2008). These contrasting views also characterize the literature on cross-border inventions in developing countries, as discussed below.

(a) *Cross-border and domestic inventions in emerging countries*

To investigate whether international collaborations generate better quality inventions than domestic collaborations, Alnuaimi *et al.* (2012) study intra-firm collaborative patents in the US semiconductor industry. They explore the contribution of inventors from developed countries' R&D units to inventions produced by subsidiaries of the same firm located in a developing country. They find that international collaborations have a positive impact on the quality of the patents, measured as the number of patent citations received. However, this study also confirms the difficulties encountered by the inventing teams in effectively absorbing and combining external knowledge, and casts doubt on the capacity of such collaborations to promote the accumulation of technological capabilities in developing countries.

In similar vein, Branstetter *et al.* (2013) investigate Chinese and Indian inventors and find that cross-border inventions (i.e., those involving inventors from countries' other than India and/or China) are more valuable (in terms of citations received), than patents produced exclusively by inventive teams in India or China, and involving no international collaborations. However, their study suggests also that inventors from India and China are mainly involved in less important inventions (e.g., adaptations to existing technologies), and that R&D units located in developed countries are responsible for the most valuable inventions. Similarly, some studies indicate that international collaborations between inventors from developing and advanced countries produce higher quality inventions compared to those resulting from domestic collaborations but they show also that most of the inventive R&D units located in developing countries are subsidiaries of developed countries' MNCs (Alnuaimi *et al.*, 2012; Montobbio & Sterzi, 2011).

This evidence is interesting but leaves open the question of whether cross-border inventions are beneficial for emerging country firms.

(b) *Cross-border inventions by emerging country firms*

While previous research focuses on advanced country MNCs operating in developing countries (Alnuaimi *et al.*, 2012; Branstetter *et al.*, 2013), a new generation of emerging country firms is demonstrating exceptional capacity to catch up with leading firms. For example, in 2013 ZTE and Huawei

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