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The role of domestic-firm knowledge in foreign R&D collaborations: Evidence from co-patenting in Indian firms

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Abstract

In this paper, we analyse the role of international patent collaborations in the performance of domestic firms and how the relationship is augmented by the pre-existing capabilities of the domestic firms. Using data on Indian firms, we study patterns of co-invention by Indian firms and foreign partners. The results confirm the crucial role played by the absorptive capacity of domestic firms in enhancing the benefits from the patent collaboration. The evidence we present in this work contributes to existing knowledge on the microeconomics behind the process of technological capability accumulation and catching up in developing countries.

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1 Introduction

It is widely recognised that technological innovation is a main driver of sustained economic growth. Innovation emerges from knowledge recombination (Nelson and Winter, 1982; Weitzman, 1998; Schumpeter, 2017), while the fragmentation and dispersion of knowledge across different organisations makes R&D collaborations an important vehicle of technological diffusion. International patenting collaborations that involve both developing and developed country firms therefore contribute to technological diffusion from advanced to developing countries and to the economic catch up of the latter (Montobbio and Sterzi, 2011; Giuliani et al., 2016).

Several factors such as the rising costs of research, risks associated with innovation, the emergence of global value chains, and more importantly, richer sources of knowledge outside of certain countries increasingly push firms to engage in research collaborations with global partners. International inventive activities contribute crucially to the rates of innovation of developing countries. The rapid increase in the number of patents assigned to developing countries such as China and India is in large part due to the presence of multinational enterprises and international collaboration activities with developed countries (Branstetter et al., 2014). These encourage the transfer of technology and know-how because developed countries tend to be closer to the technological frontier and developing countries tend to be receivers of these advanced technologies. As a result, studies have found that patents arising from co-invention activities involving actors operating in emerging economies tend to be of higher quality than indigenous patents (Alnuaimi et al., 2012). Similar results are reported by Branstetter et al. (2014), who find that co-invented patents involving Indian firms receive almost 30 percent more non-self-citations compared to indigenous Indian patents.

Research collaborations increase the innovative potential of firms through the generation of more complex, diverse, and novel innovations (Quéré, 2003; Phene et al., 2006; Savino et al., 2017). However, the integration of knowledge coming from different environments by domestic firms depends on their competence in acquiring and exploiting diverse and complex external knowledge—their absorptive capacity—as put forth by Cohen and Levinthal (1990). Evidently, firms differ widely in terms of their knowledge base and their capability to acquire and recombine new knowledge. As a consequence, not all domestic firms that have access to external knowledge through collaborations with foreign firms benefit from it in the same way. As documented by Keller (1996, 2010), who looked at the effects of technology purchasing, developing countries do not achieve sustained patterns of growth unless the acquisition of technology is accompanied by investment in absorptive capacity. Fu et al. (2011) point out the complementary role played by indigenous innovation efforts in gaining benefits from foreign technology acquisition resulting from foreign direct investment (FDI). While the moderating role of absorptive capacity has been considerably explored with respect to FDI and multinational enterprises, the role of absorptive capacity with respect to co-patenting activities between firms in advanced and developing countries is less explored. Although FDI might involve some necessary transfer of research and development, the nature of such knowledge transfer is rather different from co-patenting, which is the development of new-to-the-world knowledge.

In this respect, this work adds to previous studies that have investigated the role of absorptive capacity (AC) in firms from developing countries: our contribution rests in the investigation of AC in the process of jointly developing new technologies, that is entirely different from the process in which a foreign investor establishes business operations abroad. In the case of FDI, knowledge is created in a firm's home country and then diffused in a developing country, mostly in the form of new products and processes. Hence, the knowledge transfer mostly occurs through new product purchasing, training personnel, personnel exchange, learning through a franchise system, etc. Conversely, joint patenting is a more direct measure of knowledge spillover and transfer as it involves direct collaboration between the research and development activities of the partners involved. Indeed, patenting is a 'complex' activity (Coad et al., 2021) and, hence, patenting firms have more sophisticated capabilities, positioning these activities on the last stage of the 'capability escalator', according to Cirera and Maloney (2017).[1] Therefore, while the conventional avenues of technology transfer, such as FDI and technology purchasing, involve firms in the 'maturing' stage of the capability ladder (Table 7.1 in Cirera and Maloney, 2017), by focusing on international research partnerships we address the mechanism at play in more complex and dynamic corporate organisations that have reached a 'mature' stage. Hence, in this paper we investigate whether absorptive capacity plays a role—even for technologically advanced and complex firms—in accruing benefits from a co-patenting activity with a foreign partner.

We therefore attempt to address two research questions: *Firstly*, is there a relationship between co-patenting and firm performance? *Secondly*, what is the role played by the absoprtive capacity of domestic firms in moderating the relationship between co-patenting and firm performance? The empirical analysis is based on a novel merged panel dataset obtained from two databases: Prowess, which contains information on Indian manufacturing firms, and PATSTAT, an exhaustive database collecting information about patents filed worldwide at national and regional patent authorities. Our results indicate that absorptive capacity (AC) plays a crucial role in assisting firms in developing countries benefit from co-patenting with firms in advanced countries. More notably, a minimum level of AC is a necessary condition to benefit from these collaborations, without which co-patenting could be detrimental to firm performance.

The paper is structured as follows. In Section 2, we first review the literature on R&D

[1] Cirera and Maloney (2017) introduce the 'capabilities escalator', where firms advance from basic production capabilities to the ability to adopt and adapt technologies and then invent. Here, the 'mature' stage refers to the last step/stage of the capability ladder, while 'maturing' is the middle stage where they build the necessary technological capabilities before advancing to the last stage. A recent work (Coad et al., 2021) empirically quantifies the capability development of firms and order firm activities in a hierarchy where they observe that patenting occurs in the last stages of the capabilities ladder.

collaborations in order to delineate the theoretical foundations of patenting collaboration activities, and then we review the literature on the role of absorptive capacity in relation to R&D collaborations. In Section 3, we describe the data used and present some descriptive statistics. In Section 4, we investigate the relationship between co-patenting and firm performance, focusing on the moderating role of the absorptive capacity of firms. Section 5 offers some concluding remarks.

2 Theory and literature

2.1 Research collaborations and spillovers

Knowledge is one of the most strategically important resources in generating a competitive advantage for firms (Winter, 1987; Barney, 1991). The creation of knowledge plays an important role in the success of organisations, since 'even small, incremental knowledge can distinguish an organization from its competitors' (Cohen, 1998, p.23). This knowledge-creation process most often builds on the recombination of existing knowledge and capabilities (Nelson and Winter, 1982; Schumpeter, 2017), while the fragmentation and dispersion of knowledge across different organisations strongly hinders the generation of innovation exclusively within firm boundaries (Tether, 2002; Lawson et al., 2015).

For this reason, R&D collaborations represent an important vehicle of new knowledge creation and innovation for firms. Firms engaging in collaborative R&D activities can access external resources, share R&D risks and costs, and accelerate the speed of R&D (Riccobono et al., 2015; Zhou et al., 2018). R&D activities are complex and multi-disciplinary (Cassiman and Veugelers, 2006), however, and very few firms are able to keep pace with technological advancements solely by undertaking independent R&D activities. This is particularly true for firms in developing countries, which are commonly confronted with innovation-unfriendly environments (Kafouros and Aliyev, 2016; Khan et al., 2018).

Knowledge flows from the collaborating partner to the focal firm are called incoming spillovers and represent a main advantage of and incentive for collaboration (Belderbos et al., 2004). Knowledge flows from the focal firm to the collaborating partner are labelled outgoing spillovers: firms usually seek to minimise these spillovers in order to avoid favouring competitors. The possibility of benefiting from incoming spillovers is indeed positively associated with the probability that a firm will embark on an R&D collaboration (Cassiman and Veugelers, 2002).

Incoming spillovers do not automatically translate into advantages in terms of innovative capabilities or profitability, however. On the contrary, firms need to be able to appropriate and exploit these spillovers of knowledge before they can reap any significant benefits. The advantages of benefiting from a research collaboration can therefore be overshadowed by the challenges that the firm must overcome to appropriate the incoming knowledge flows (Cassiman and Veugelers, 2002) and create value from the partnership (Belderbos et al., 2014). In this regard, Hagedoorn (2003) argues that collaboration in the form of co-patenting activities may represent a second-best solution compared to self-patenting. In this vein, Belderbos et al. (2014) claim that co-owned technology is less likely to be further developed compared to solely-owned patents and could increase strategic behaviours between partners that reduce the reciprocal appropriability of knowledge.

It follows that incoming spillovers may be particularly relevant for organisations operating in developing countries, since interacting with partners that are often positioned closer to the technological frontier can increase innovative capacities. However the challenges related to the appropriation of incoming spillovers are intensified for firms based in developing countries that collaborate with foreign organisations operating in advanced economies. This is due to the difficulties emerging from collaboration between diverse partners (Kafouros et al., 2020). For instance, the average difference in technological capability between the firms of advanced and developing countries reduces the likelihood of the firms from developing countries benefiting from incoming spillovers (Li, 2011). In turn, the presence of and need to share tacit knowledge characterising each R&D collaboration further reduces this likelihood (Montobbio and Sterzi, 2013). As a result, technology transfers tend to be more successful when the technology gap between partner organisations is reduced (Glass and Saggi, 1998; Vishwasrao and Bosshardt, 2001). Moreover, inventions and technologies realised in developed countries usually exploit an intensity of capital and of skilled labour that is less available in developing countries (Fu and Gong, 2011). These characteristics suggest that co-invention could be less appropriable and less productive for firms based in developing countries compared to those in developed countries.

In line with these arguments, Alnuaimi et al. (2012) find that international R&D collaborations within a multinational corporation network benefit advanced-country subsidiaries to a higher extent compared to developing-country subsidiaries, as these have difficulties in internalising external knowledge. Similar results are found by Giuliani et al. (2016), according to whom cross-country collaborations in the form of joint patents between BIC countries (Brazil, India, and China) and EU countries exert a positive effect in terms of innovative capabilities for firms in developing countries only if the collaboration takes place within a multinational corporation; instead, indigenous firms collaborating with European firms are not able to reap the same benefits from the collaboration.

2.2 Research collaborations and absorptive capacity

We have argued that firms in developing countries face various difficulties in appropriating and creating value out of incoming spillovers from a foreign R&D collaboration. The literature analysing the determinants of incoming spillovers from advanced towards developing countries is mostly within the context of technology transfer in the form of the purchase of technology or knowledge spillovers from FDI. This literature firstly highlights that the presence of advanced-country knowledge spillovers in developing countries does not generate benefits per se and, secondly, suggests that in order to generate benefits a minimum level of AC is required. We intend to pursue this line of reasoning and test the role of AC in developing-country firms gaining benefits from foreign R&D collaborations.

Absorptive capacity is the capability of a firm to identify, comprehend, and put to work external knowledge to gain a competitive advantage (Cohen and Levinthal, 1990). It is an intangible asset that results from investing in the production of new knowledge. On the one hand, AC allows a firm to recognise useful knowledge outside its boundaries, and on the other hand, it enables a firm to use and adapt this knowledge to its overall internal needs (Amesse and Cohendet, 2001; Zahra and George, 2002). AC is not about the acquisition of codified blueprints: it involves cognitive capabilities conveyed in a tacit nature that need substantial learning effort to be built (Cohen and Levinthal, 1990; Narula and Marin, 2003).

A variety of studies provide evidence that the level of AC in a country impacts the ability of that country to derive benefit from incoming spillovers (Borensztein et al., 1998; Fagerberg and Verspagen, 2002; Griffith et al., 2004; Mingyong et al., 2006). For instance, Keller (1996) shows that technology acquisition in developing countries does not lead to sustained growth unless it is accompanied by investment in AC. Similarly, studies investigating geographical spillovers in developing countries due to the presence of FDI show that higher levels of AC are associated with greater technological upgrades (Filippetti et al., 2017; Sultana and Turkina, 2020) and greater total factor productivity (Glas et al., 2016).

In the same vein, many studies find similar results through firm- or industry-level analyses (Narula and Marin, 2003; Kneller, 2005; Zahra and Hayton, 2008; Fabrizio, 2009; Zhang et al., 2010; Li, 2011; Khachoo et al., 2018), providing evidence that spillovers favour only those firms or industries that possess the capabilities required to appropriate them. According to Li (2011), technology purchases from domestic firms increase the innovation rate, while technology purchases from developed countries contribute to indigenous innovation only when coupled with previous investment in R&D. With reference to the spillovers deriving from FDI, Blalock and Gertler (2009) show that firms with R&D investments benefit more from the presence of FDI compared to firms that do not invest in R&D. Lu et al. (2017) find that FDI in China negatively affects domestic firms that do not spend on R&D, while this negative effect vanishes for R&D-investing firms. Similarly, Girma (2005) reports that FDI spillovers exert a positive effect only on firms with sufficiently high AC, while they produce negative effects on firms with low AC. These findings are in line with the argument made by Cohen and Levinthal (1990) that firms deliberately invest in R&D due to its 'dual role' in helping both generate new knowledge and as a contributor to absorptive capacity.

The evidence on spillovers from developed countries to developing countries in the form of knowledge purchase or FDI shows that AC is fundamental to making the transfer of technologies effective. Without a minimum level of AC, spillovers of knowledge will not only not be appropriated by indigenous firms but the source of these spillovers could even cause negative consequences for indigenous firms. For instance, while a number of works identify an overall positive influence of FDI on the performance of domestic firms (Cheung and Ping, 2004; Smarzynska Javorcik, 2004; Blalock and Gertler, 2005), a variety of studies find the absence of any effect (Sasidharan, 2006) or even a negative effect (Aitken and Harrison, 1999; Fu and Gong, 2011). Conversely, as previously described there is agreement in the literature regarding the fact that a main determinant enabling FDI and the purchase of technology to produce positive externalities in a developing country is the ability of domestic firms to exploit the knowledge.

In this paper, we extend the investigation of these issues to the case of co-patenting activities between firms in developing and advanced countries. The importance of AC in (international) R&D collaborations between advanced-country firms has already been demonstrated (Kim and Inkpen, 2005; Muscio, 2007; De Jong and Freel, 2010; Seo et al., 2021).

Collaborating on a research project with international partners increases the innovative performance of collaborating firms, conditional on the firms' level of AC (Kim and Inkpen, 2005; Kafouros et al., 2020). Conversely, our knowledge of the positive or negative impacts of co-inventive activities on developing-country firms involved in patent development and the eventual moderator effect of AC are yet to be explored.

3 Data

This study employs firm-level data from the Prowess database provided by the CMIE (Centre for Monitoring Indian Economy Pvt. Ltd.). The CMIE collects information from the annual financial reports of companies, including balance sheets and income statements. It covers both publicly listed and unlisted firms. The companies covered account for around 70 percent of industrial output, 75 percent of corporate taxes, and more than 95 percent of excise taxes collected by the Government of India. In this work, we use Prowess data on manufacturing firms over the period of 1995 to 2015.

To study the relationship between foreign collaborations and the moderating role of absorptive capacity in the performance of firms, we rely on two main dependent variables, namely firm growth (in terms of sales) and relative profitability (i.e. the share of profits from sales of the firm with respect to the other firms in the sector). In particular, we define

$$Firm\_Gr_{i,t} = \log Sales_{i,t} - \log Sales_{i,t-1}, \quad (1)$$

$$Profitability_{i,t} = \left(\frac{Profits_{i,t}}{Sales_{i,t}}\right) / \left\langle \frac{Profits_{j,t}}{Sales_{j,t}} \right\rangle_{j \in S_i}, \quad (2)$$

where $\langle \cdot \rangle_{j \in S}$ is the average over all firms in sector S and S_i is the main sector of activity of firm i defined at the three-digit level. Our main explanatory variables refer to foreign collaborations and absorptive capacity. Foreign collaborations are identified through a dummy variable that takes the value of 1 if the inventors of a patent application are located in India and in at least one foreign country, and 0 if all inventors are based in India. Other works have also used co-patents as a measure of research collaboration, assuming that if firms engage formally in collaborative R&D and if the output of the R&D is measurable by patent indicators, then joint patents from both partners should be good measures of innovative output resulting from the collaboration (e.g. Kim and Song, 2007; Montobbio and Sterzi, 2013). Absorptive capacity is proxied by R&D spending and previous patent applications made by the firm, as in other works (e.g. Griffith et al., 2003; Cassiman and Veugelers, 2006; Nooteboom et al., 2007; Bertrand and Mol, 2013; Filippetti et al., 2017).

We also control for a set of explanatory variables that, according to the literature, influence firm performance (see, for example, Bartz-Zuccala et al., 2018). These include firm size and age (Evans, 1987), cash balance and leverage (Bottazzi et al., 2014), and investment activity and growth of profits, to control for the growth momentum of the firm (Coad et al., 2020). Table 1 provides the definitions of the different variables we use, as well as some basic statistics.

As mentioned above, we proxy foreign R&D collaborations using information on joint patents. In particular, we base our analysis on PATSTAT (European Patent Office, 2020), a comprehensive database of patent data maintained by the European Patent Office, which collects data about patent applications filed at patent offices around the world and also records information about patent applicants and inventors for a vast proportion of filings. PATSTAT potentially covers a very long time period, since it allows tracing back the history of even the oldest patent authorities, e.g. the United States Patents and Trademarks Office, which was already operating at the end of the 19^{th} century. Of course, going very far back in time strongly reduces the amount of available information concerning each invention. This is probably due in part to the fact that intellectual property has become a more prominent topic in recent times. Moreover, the technology to effectively record and store detailed

Table 1: Variables, definitions, and summary statistics

Variable	Definition	Mean	Median	Std. Dev.
Firm Growth	Log difference in sales between t & $t-1$	0.174	0.145	0.238
Relative Profitability	Profits over sales, relative to the sector mean	0.130	0.109	0.122
Foreign Collaboration	Takes the value 1 if the firm patented jointly with a foreign firm and 0 if the joint patent is with a domestic firm	0.056	0.000	0.229
R&D Intensity	Research and development expenses/Sales	0.034	0.007	0.090
Patent Count	Number of patent applications	53.060	20.000	115.787
Relative Profitability Growth	Log difference in relative profitability between t & $t-1$	0.002	0.000	0.083
Sales	Total sales from industrial goods	93,347.12	5614.6	301,970.89
Age	Number of years since the year of incorporation of the firm	30.932	26.000	15.984
Investment Intensity	Additions to gross fixed assets/Sales	0.127	0.065	0.159
Leverage	Borrowings/Total Assets	0.309	0.305	0.164
Cash Balance	Amount of cash available to the firm after payment of all expenses	314.545	2.200	955.429

permanent records concerning the rapidly growing number of patent applications has become increasingly affordable in recent decades. Fortunately, detailed patent records reporting geographical information about applicants and inventors are available for the time interval covered by the Prowess data. Moreover, companies and inventors in many sectors and from the majority of countries were already heavily invested in protecting their innovations through patents over that same period. This is particularly important for our purposes since we want to trace technological collaborations between Indian firms and foreign partners. To this aim, we need a way to match patents to the countries of residence of the inventors taking part in these collaborations. The popularity of patents in many industries and the wide coverage afforded by PATSTAT over the period of interest allows us to achieve an adequate coverage concerning the above information.

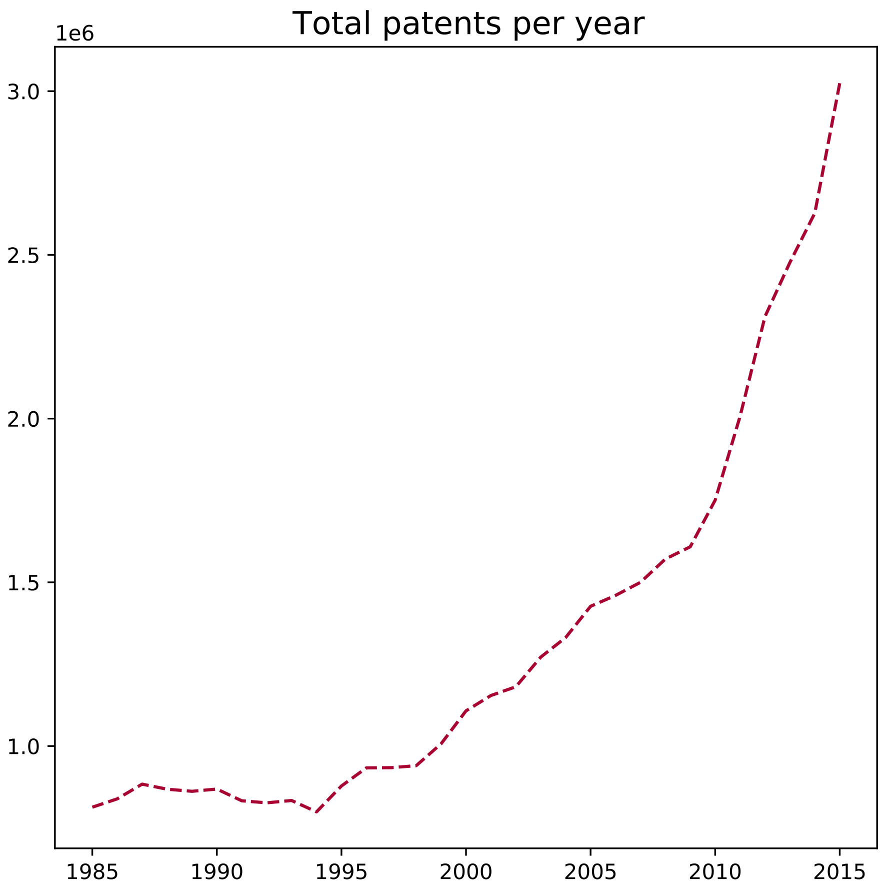
For this study, we use a novel dataset obtained by merging Indian firm-level data (Prowess) and patent data (PATSTAT). The merging is accomplished with the help of Bureau Van Dijk's (BvD) Orbis database, a commercial database collecting publicly available data on firms from all over the world. The relevant feature for our purposes is that Orbis reports the unique patent application identifiers (*appln_id*) that PATSTAT assigns to patent documents and adds these identifiers to the information about the firms identified as patent applicants. Both Orbis and Prowess provide the CIN (national identification number of the firm), which allows us to match the datasets. Even though the above mapping of Prowess (CIN) with PATSTAT (*appln_id*) via Orbis (CIN/*appln_id*) allows us to match most of the Indian firms with information about their technological partnerships, for some firms we were not able to complete this mapping using the firm and patent identifiers. For these cases, we were able to manually match the firm names provided by both Prowess and PATSTAT databases.

A testament to the ductility of patent data is its growing popularity in the empirical literature, especially in contributions and domains that focus on large datasets. At the same time, the increasing importance that patenting activity has acquired over the past decades is clearly reflected in the growth in the number of filed patents worldwide, as shown in Figure 1.

Of course, there is significant heterogeneity in the number of patents filed by different countries. Figure 2 ranks the 20 countries with the highest number of filed patents in the 1985–2015 period and shows that although patenting in India has not yet reached the same intensity as in world leaders such as the United States or China, it has nevertheless reached a level that is comparable (or even superior to) several industrialised countries.

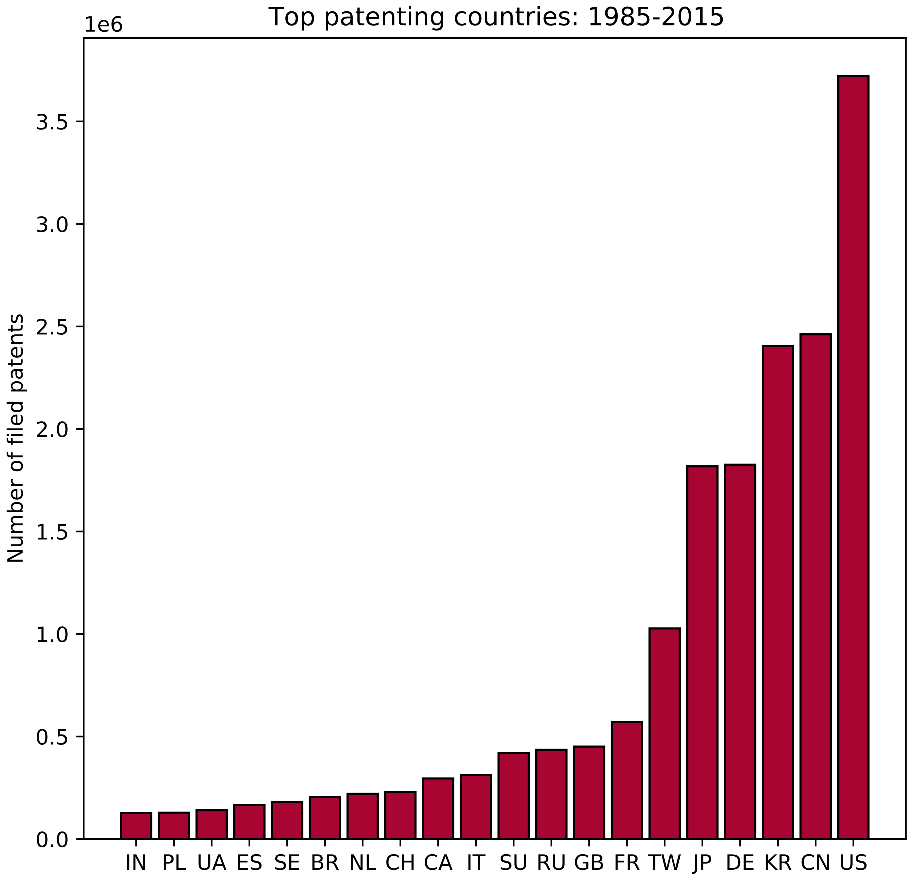
Figure 3 further shows that the trend in the number of filed patents in India over recent decades has mirrored the global trend. This figure also plots a time series of the share of

Figure 1: Time series of global patenting activity, as proxied by the number of active patent families every year. Number of patents filed yearly worldwide. The trend grows at an increasing rate throughout the period of analysis (source: European Patent Office, 2020).



patents co-developed with at least one international partner. There is a noticeable cyclical pattern in the yearly data, which is probably due to some burstiness in patenting activity. Nevertheless, an increasing trend is clearly visible in the time series, showing that the growth of Indian patenting has gone hand in hand with a higher propensity to engage in co-patenting with foreign partners. Among the foreign partners, the USA ranks first in terms of the number of patents co-owned with Indian firms, as shown in Figure 4. The left panel presents

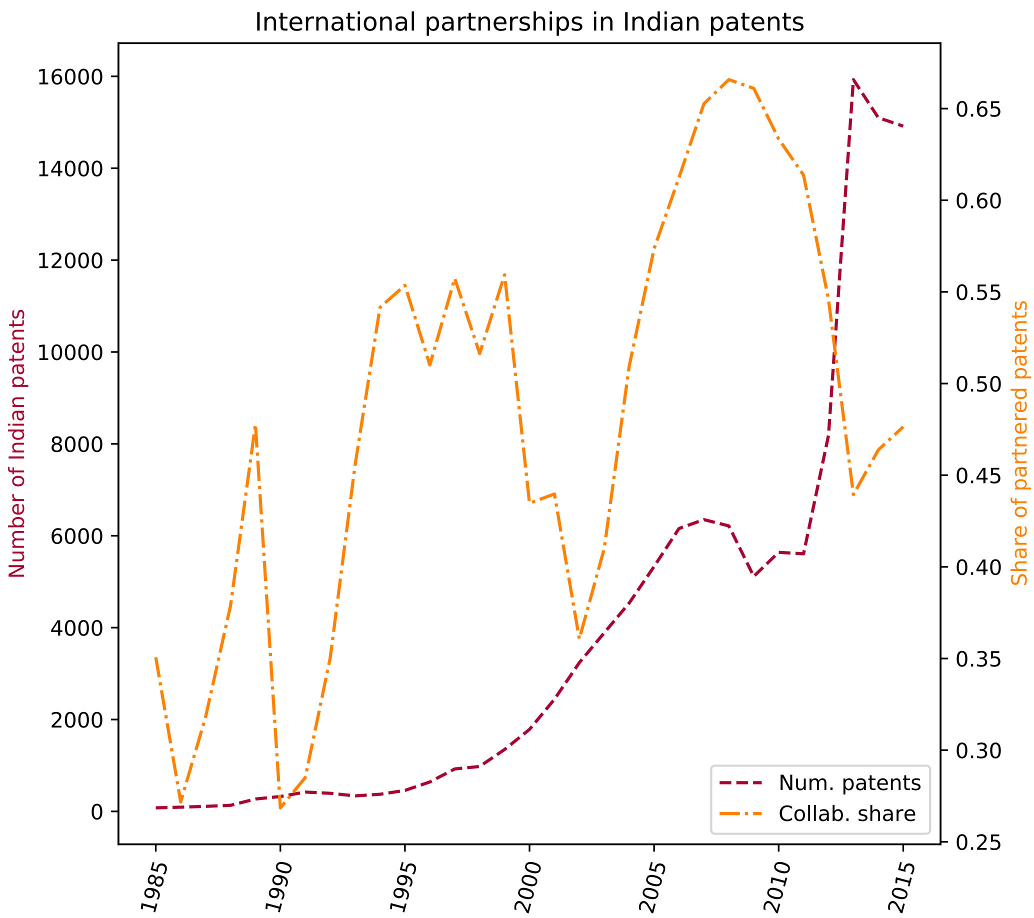
Figure 2: Top patenting countries



patent counts on a linear scale, while the right panel does the same on a log scale. The linear graph clearly reveals a predominance of partnerships with the USA that dwarfs the contribution of all other countries. However, using a log scale shows that the landscape is more complex: co-patenting has not only involved many (mostly developed) partner countries in past decades but the number of collaborations has also grown steadily, in line with the overall increasing trend in Indian (and international) patenting activity.

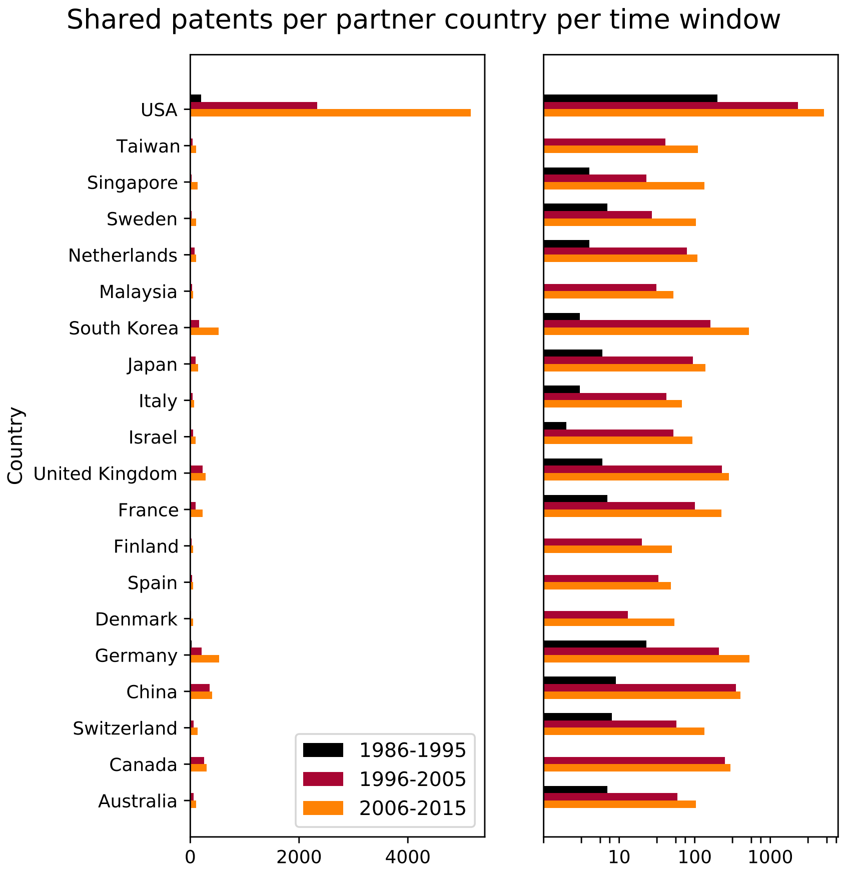
Table 2 reports some comparative statistics for firms that jointly develop patents with

Figure 3: Evolution of Indian technological partnerships across time



foreign partners and firms that do not. We observe that the former category is larger, with slightly greater firm growth and profitability and higher patent counts. However, there is no significant difference for many other characteristics such as age, R&D intensity, investment intensity, leverage, etc. Table 3 reports a correlation matrix for the variables used in the study.

Figure 4: Co-ownership of patents: India's main partner countries



4 Foreign R&D collaborations and firm performance

In this section, we study the relationship between the foreign R&D collaborations of firms and their performance. We estimate the following equation:

$$Y_{it} = \alpha + \beta X_{it-1} + \gamma Foreign\_Coll_{it-1} + \xi_i + \epsilon_{it}, \quad (3)$$

where Y_{it} represents two dimensions of the performance of firm i at time t, namely, sales growth and relative profitability. Our main explanatory variable of interest is the Foreign

Table 2: Comparison of summary statistics for firms collaborating in research with foreign partners versus others

Variable	No foreign R&D coll. Mean	Std. Dev.	Foreign R&D coll. Mean	Std. Dev.
Firm Growth	0.137	0.291	0.210	0.186
Relative Profitability	0.112	0.124	0.148	0.120
Profitability Growth	-0.004	0.088	0.008	0.079
Sales (in INR million)	16,315.65	538,547.6	23,537.74	65,394.18
Age	30.358	15.606	31.505	16.363
Investment Intensity	0.109	0.199	0.146	0.118
Leverage	0.306	0.190	0.312	0.137
Cash in hand	585.417	1716.033	43.674	194.826
R&D Intensity	0.039	0.147	0.029	0.034
Patent Count	39.615	100.756	66.505	130.819

Table 3: Correlation matrix

	Firm Gr.	Profitability	Sales	Age	Invest. Int.	Leverage	Cash Balance	R&D Intensity	Patent Count
Firm Gr.	1								
Profitability	0.156***	1							
Sales	0.0244	-0.453***	1						
Age	-0.194***	-0.153***	0.302***	1					
Invest. Int.	0.205***	0.265***	-0.106***	-0.220***	1				
Leverage	0.009	-0.177***	0.016	-0.085***	0.026	1			
Cash Balance	0.0138	-0.446***	0.743***	0.320***	-0.126***	-0.0288	1		
R&D Intensity	0.063*	0.034	-0.084***	-0.185***	0.820***	-0.064**	-0.096***	1	
Patent Count	0.072**	0.114***	-0.078***	-0.177***	-0.003	-0.018	-0.092***	-0.006	1

R&D Collaboration dummy, which takes a value of 1 if the firm filed a patent application together with a foreign partner and 0 if the patent is not in collaboration with a foreign partner. X_{it-1} is the vector of independent variables that we defined in Section 3. The controls include year and sector (two-digit industry) dummies. The firm fixed effects ξ_i absorb the time-invariant component, and ϵ_{it} represents the idiosyncratic shock term. The independent variables are lagged by one year. We estimate equation 3 by means of pooled and fixed effect OLS estimations. We use a fixed effects estimation since it allows us to control for time-invariant unobserved firm characteristics that could be correlated with the independent variables.

The results are reported in Table 4. Columns I and II report the results when the dependent variable is sales growth, while firm profitability results are displayed in columns III and IV. Moreover, columns I and III report the results of the pooled OLS in which we also include sector dummies. Instead, columns II and IV present the results of the fixed effects regression in which we include time dummies to account for across-firm patterns as well as firm dummies to control for time-invariant firm characteristics.

Table 4: Foreign R&D collaborations and firm performance

	Sales Growth OLS	Sales Growth FE	Profitability OLS	Profitability FE
Log Sales	-0.0323***	-0.5388***	0.0029**	-0.0270***
	(-11.32)	(-45.91)	(2.24)	(-7.31)
Log Age	-0.0511***	0.8176***	-0.0225***	-0.0610***
	(-7.31)	(25.61)	(-10.29)	(-4.84)
Investment Intensity	-0.0813***	-0.1900***	-0.0221***	-0.0608***
	(-11.76)	(-20.16)	(-8.23)	(-16.87)
Log Leverage	-0.0032	-0.0680***	0.0009	0.0110***
	(-0.66)	(-6.26)	(0.50)	(2.87)
Cash Balance	0.0126***	-0.0025	0.0008	-0.0032***
	(6.02)	(-1.00)	(1.19)	(-3.47)
Profitability Growth	0.5091***	0.1285***	0.6735***	0.2549***
	(11.68)	(3.88)	(55.72)	(16.57)
R&D Intensity	0.2618***	0.4750**	0.0206***	0.0991***
	(4.41)	(2.05)	(4.89)	(15.42)
Foreign Coll.	0.1495***	0.0696***	0.0240***	0.0124***
	(9.26)	(6.40)	(5.13)	(3.01)
Time Dummies	Yes	Yes	Yes	Yes
Sector Dummies	Yes		Yes	
Observations	2504	2504	2504	2504
R^2	0.260	0.643	0.811	0.603
Firm clusters		120		120

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
All columns include time dummies; columns I and III include sector dummies.
Column I - OLS with firm growth, column II - fixed effects with firm growth, column III - OLS with profitability, column IV - fixed effects with profitability.

Our main variable of interest, the dummy for foreign R&D collaborations, is positive and significant in all four regressions. This indicates that firms undertaking a foreign R&D

collaboration perform better than others, on average, and as a result gain in terms of performance.

4.1 Moderating role of absorptive capacity

As discussed previously, knowledge transfer does not happen in a vacuum and there are certain factors that may play a crucial role in the process. In this section, we check whether the absorptive capacity of firms plays a moderating role in the relationship between foreign R&D collaborations and firm performance. We estimate the following two equations:

$$Y_{it} = \alpha + \beta X_{it-1} + \gamma Foreign\_Coll_{it-1} + \delta R\&D\_int + \mu R\&D * FC + \xi_i + \epsilon_{it}, \quad (4)$$

$$Y_{it} = \alpha + \beta X_{it-1} + \gamma Foreign\_Coll_{it-1} + \delta Patents + \mu Patents * FC + \xi_i + \epsilon_{it}. \quad (5)$$

In equation 4, the variables of interest are foreign R&D collaboration, absorptive capacity proxied by R&D intensity, and the interaction term between R&D intensity and foreign R&D collaboration. The purpose of using R&D intensity is to account for innovative capabilities possessed by the firm. The interactive term measures the joint occurrence of innovation-related capabilities, or absorptive capacity, and foreign R&D collaboration. The control variables include firm size, age, investment intensity, leverage, cash balance, profit growth, and sector and time dummies.

As a robustness check, we also proxy absorptive capacity by previous patents filed by the firm, in equation 5. Here the variables of interest are foreign collaboration, absorptive capacity (proxied by the log number of patent applications), and the interactive term between patents and foreign collaboration ($Patents * FC$).

Tables 5 and 6 report the results of an OLS and a fixed effects estimation with the different proxies for absorptive capacity (R&D and patents) and the respective interaction terms, $R\&D * FC$ and $Patents * FC$. As we report in Table 5, absorptive capacity proxied by R&D intensity is positively related to firm performance. The interaction term is positive and significant in all specifications, indicating that when combined with high levels of firm absorptive capacity, foreign R&D collaboration leads to higher performance. The most interesting result is that the foreign collaboration dummy is negative and significant after controlling for the interaction effect, suggesting that for firms with less absorptive capacity, foreign collaborations have a negative impact on performance. This implies that the ability of firms to exploit external knowledge is not simply a factor that *either does or does not strengthen* the performance benefits, but it can also even change the *direction* of the relationship. In other words, foreign R&D collaboration positively affects performance only when complemented with previous investments in R&D. We observe similar results when the previous innovative activities of firms are proxied by previous patent applications (log of the number of patent applications), as shown in Table 6.

To cite Cohen and Levinthal (1990), absorptive capacity can comprise knowledge related to 'basic skills or even a shared language, but may also include knowledge of the most recent scientific or technological developments in a given field.' In other words, the results we observe confirm the insights of Cohen and Levinthal (1990) that absorptive capacity also includes sophisticated and recent scientific knowledge. Indeed, in this work we are focusing on absorptive capacity in the context of the scientific and technological capability of firms. Our findings imply that even for advanced firms doing sophisticated activities like patenting, their level of AC is crucial in order for them to be able to exploit external knowledge.

5 Concluding remarks

In this work, we employed a novel database to investigate whether Indian firms benefit from patent collaborations and to explore the role played by firms' prior knowledge in augmenting

Table 5: Foreign R&D collaboration and firm performance: the role of absorptive capacity (R&D*Foreign Coll. as moderator)

	Sales Growth OLS	Sales Growth FE	Profitability OLS	Profitability FE
Log Sales	-0.0196***	-0.4539***	0.0140***	-0.0436***
	(-4.74)	(-46.59)	(7.92)	(-9.87)
Log Age	-0.0213***	0.9843***	-0.0406***	-0.0871***
	(-2.90)	(29.78)	(-12.50)	(-4.64)
Investment Intensity	-0.1272***	-0.2377***	-0.0131***	-0.0376***
	(-14.42)	(-25.72)	(-3.44)	(-9.98)
Log Leverage	0.0003	-0.1099***	-0.0118***	-0.0011
	(0.06)	(-11.70)	(-4.78)	(-0.26)
Log Cash Balance	0.0057**	0.0059**	-0.0027***	-0.0121***
	(2.40)	(2.21)	(-2.69)	(-11.41)
Profitability Growth	0.6282***	0.0107	0.3953***	0.1449***
	(14.73)	(0.33)	(18.56)	(10.33)
R&D Intensity	0.3385***	1.2104***	0.0576***	0.1360***
	(5.47)	(5.20)	(5.43)	(15.89)
Foreign Coll.	-0.1167***	-0.2319***	-0.0788***	-0.1108***
	(-3.37)	(-7.24)	(-2.77)	(-5.60)
R&D*For.Coll	0.3392***	0.4696***	0.1817***	0.1574***
	(6.77)	(9.87)	(4.29)	(5.41)
Time Dummies	Yes	Yes	Yes	Yes
Sector Dummies	Yes		Yes	
Observations	2504	2504	2504	2504
R^2	0.354	0.613	0.649	0.473
Firm clusters		120		120

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Column I - OLS with firm growth, column II - fixed effects with firm growth,
column III - OLS with profitability, column IV - fixed effects with profitability.

these relationships. The evidence suggests that the capability to imitate and absorb knowledge is a necessary stepping stone for the acquisition of more sophisticated competencies required to operate closer to the technology frontier. To our knowledge, this is the first work to show evidence of the effect of international co-patenting on Indian manufacturing firms.

Our main contribution to the extant literature addresses the fact that—as pointed out by Giuliani et al. (2016)—previous works have mostly concentrated on more conventional means

Table 6: Foreign R&D collaboration and firm performance: the role of absorptive capacity (Patents*Foreign Coll as moderator)

	Sales Growth OLS	Sales Growth FE	Profitability OLS	Profitability FE
Log Sales	-0.0052***	-0.1094***	0.0009	-0.0543***
	(-2.73)	(-13.93)	(0.57)	(-15.57)
Log Age	-0.0504***	0.4247***	-0.0214***	-0.1356***
	(-10.77)	(11.39)	(-5.63)	(-8.03)
Investment Intensity	-0.0051	0.0656***	0.0666***	-0.0365***
	(-1.27)	(9.49)	(20.32)	(-12.32)
Log Leverage	-0.0030	0.0632***	-0.0228***	-0.0161***
	(-1.08)	(8.80)	(-9.79)	(-5.29)
Log Cash Balance	0.0047***	0.0075***	-0.0043***	-0.0151***
	(3.63)	(3.57)	(-4.13)	(-16.99)
Profitability Growth	0.2490***	0.2055***	0.6601***	0.1862***
	(6.82)	(6.06)	(22.59)	(13.04)
R&D Intensity	-0.0110	0.0049	0.0013	0.0966***
	(-1.47)	(0.42)	(0.20)	(15.98)
Foreign Coll.	-0.0272**	-0.0515***	-0.0714***	-0.0328***
	(-2.54)	(-4.93)	(-8.27)	(-7.33)
Patents*Foreign Coll.	0.2238***	0.0827***	0.2117***	0.0507***
	(15.45)	(5.30)	(17.68)	(7.49)
No. of patents	0.0016***	0.0004	0.0019***	0.0033***
	(5.74)	(0.61)	(8.37)	(12.84)
Time Dummies	Yes	Yes	Yes	Yes
Sector Dummies	Yes		Yes	
Observations	2504	2504	2504	2504
R^2	0.248	0.315	0.526	0.727
Firm clusters		120		120

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Column I - OLS with firm growth, column II - fixed effects with firm growth,
column III - OLS with profitability, column IV - fixed effects with profitability.

of technology transfer such as imports, exports, and FDI (Lall, 1992; Archibugi and Pietrobelli, 2003; Lall and Narula, 2004). In contrast, we consider technology transfer through international R&D collaborations. The dynamics of knowledge transfer in a research collaboration are quite different from the processes of building the necessary organisational capabilities for the mere imitation of knowledge produced elsewhere. Furthermore, and as pointed out by Amsden (2009), the accumulation of technological and managerial capabilities usually occurs within domestic firms rather than within subsidiaries of foreign-owned firms. It is likely that this is because while multinational corporations are an important source of capital investment, very little technological transfer takes place between subsidiaries since most of the tacit forms of knowledge reside (and most R&D activities take place) in the headquarters of firms that are mostly located in developed countries (Cimoli et al., 2009). By considering co-patenting activities—a proxy for direct R&D collaborations—we are able to better capture the transfer of a type of knowledge that goes far beyond the mere development of skills for how to operate machinery produced in developed countries.

The evidence presented in this work expands our knowledge of the microeconomics underlying knowledge accumulation, highlighting that technological development is gradual and that even complex and dynamic organisations close to the frontiers of technology build on their existing technological capabilities to climb the 'ladder of knowledge complexity' (Dosi et al., 2019).

Our findings bear fundamental policy implications. No doubt, the processes of knowledge accumulation and industrial development require public policies that help build technological and organisational learning. Firms differ greatly with respect to their stage of capability development. This is particularly true in developing countries, where an optimal policy mix should consider such heterogeneity. As Cirera and Maloney (2017) point out, for firms that are in a lower stage of development, policy should ensure ease of access to foreign technology, initiate programmes to stimulate knowledge transfer, and nurture the organisational capabilities that allow them to absorb technology from advanced countries. However, as sectors move towards the technological frontier, firms tend to be more complex and sophisticated. As this process unfolds, policy should involve building instruments that help firms in supporting big R&D projects, where they can learn to seize technological and organisational opportunities.

Even though our work focuses on a sample of Indian manufacturing firms, we believe that the evidence presented might also hold true for firms in other developing countries. Future research should investigate this possibility by focusing on data from other countries going through various stages of economic development.

References

AITKEN, B. J. AND A. E. HARRISON (1999): "Do domestic firms benefit from direct foreign investment? Evidence from Venezuela," *American Economic Review*, 89, 605–618.

ALNUAIMI, T., J. SINGH, AND G. GEORGE (2012): "Not with my own: Long-term effects of cross-country collaboration on subsidiary innovation in emerging economies versus advanced economies," *Journal of Economic Geography*, 12, 943–968.

AMESSE, F. AND P. COHENDET (2001): "Technology transfer revisited from the perspective of the knowledge-based economy," *Research Policy*, 30, 1459–1478.

AMSDEN, A. H. (2009): "Nationality of firm ownership in developing countries: who should 'crowd out' whom in imperfect markets," in *Industrial policy and development: the political economy of capabilities accumulation.*, ed. by M. Cimoli, G. Dosi, and J. Stiglitz, Oxford University Press, 470–506.

ARCHIBUGI, D. AND C. PIETROBELLI (2003): "The globalisation of technology and its implications for developing countries: Windows of opportunity or further burden?" *Technological Forecasting and Social Change*, 70, 861–883.

BARNEY, J. (1991): "Firm resources and sustained competitive advantage," *Journal of Management*, 17, 99–120.

BARTZ-ZUCCALA, W., P. MOHNEN, AND H. SCHWEIGER (2018): "The role of innovation and management practices in determining firm productivity," *Comparative Economic Studies*, 60, 502–530.

BELDERBOS, R., M. CARREE, B. DIEDEREN, B. LOKSHIN, AND R. VEUGELERS (2004): "Heterogeneity in R&D cooperation strategies," *International Journal of Industrial Organization*, 22, 1237–1263.

Belderbos, R., B. Cassiman, D. Faems, B. Leten, and B. Van Looy (2014): "Co-ownership of intellectual property: Exploring the value-appropriation and value-creation implications of co-patenting with different partners," *Research Policy*, 43, 841–852.

Bertrand, O. and M. J. Mol (2013): "The antecedents and innovation effects of domestic and offshore R&D outsourcing: The contingent impact of cognitive distance and absorptive capacity," *Strategic Management Journal*, 34, 751–760.

Blalock, G. and P. J. Gertler (2005): "Foreign direct investment and externalities: The case for public intervention," *Does foreign direct investment promote development*, 73–106.

——— (2009): "How firm capabilities affect who benefits from foreign technology," *Journal of Development Economics*, 90, 192–199.

Borensztein, E., J. De Gregorio, and J.-W. Lee (1998): "How does foreign direct investment affect economic growth?" *Journal of International Economics*, 45, 115–135.

Bottazzi, G., A. Secchi, and F. Tamagni (2014): "Financial constraints and firm dynamics," *Small Business Economics*, 42, 99–116.

Branstetter, L., G. Li, and F. Veloso (2014): "The rise of international coinvention," in *The changing frontier: Rethinking science and innovation policy*, University of Chicago Press, 135–168.

Cassiman, B. and R. Veugelers (2002): "R&D cooperation and spillovers: some empirical evidence from Belgium," *American Economic Review*, 92, 1169–1184.

——— (2006): "In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition," *Management Science*, 52, 68–82.

Cheung, K.-y. and L. Ping (2004): "Spillover effects of FDI on innovation in China: Evidence from the provincial data," *China Economic Review*, 15, 25–44.

Cimoli, M., G. Dosi, and J. E. Stiglitz (2009): *Industrial policy and development: The political economy of capabilities accumulation*, Oxford University Press.

Cirera, X. and W. F. Maloney (2017): *The innovation paradox: Developing-country capabilities and the unrealized promise of technological catch-up*, The World Bank.

Coad, A., N. Mathew, and E. Pugliese (2020): "What's good for the goose ain't good for the gander: heterogeneous innovation capabilities and the performance effects of R&D," *Industrial and Corporate Change*, 29, 621–644.

——— (2021): "Positioning firms along the capabilities ladder," *UNU-MERIT Working Paper Series*.

Cohen, D. (1998): "Toward a knowledge context: Report on the first annual UC Berkeley forum on knowledge and the firm," *California Management Review*, 40, 22–39.

Cohen, W. M. and D. A. Levinthal (1990): "Absorptive capacity: A new perspective on learning and innovation," *Administrative Science Quarterly*, 128–152.

De Jong, J. P. and M. Freel (2010): "Absorptive capacity and the reach of collaboration in high technology small firms," *Research Policy*, 39, 47–54.

Dosi, G., N. Mathew, and E. Pugliese (2019): "What a firm produces matters: diversification, coherence and performance of Indian manufacturing firms," Tech. rep., LEM Working Paper Series.

European Patent Office (2020): "EPO PATSTAT Database," Spring edition.

Evans, D. S. (1987): "The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries," *Journal of Industrial Economics*, 35, 567–81.

Fabrizio, K. R. (2009): "Absorptive capacity and the search for innovation," *Research Policy*, 38, 255–267.

Fagerberg, J. and B. Verspagen (2002): "Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation," *Research Policy*, 31, 1291–1304.

Filippetti, A., M. Frenz, and G. Ietto-Gillies (2017): "The impact of internationalization on innovation at countries' level: the role of absorptive capacity," *Cambridge Journal of Economics*, 41, 413–439.

Fu, X. and Y. Gong (2011): "Indigenous and foreign innovation efforts and drivers of technological upgrading: evidence from China," *World Development*, 39, 1213–1225.

Fu, X., C. Pietrobelli, and L. Soete (2011): "The role of foreign technology and indigenous innovation in the emerging economies: technological change and catching-up," *World Development*, 39, 1204–1212.

Girma, S. (2005): "Absorptive capacity and productivity spillovers from FDI: a threshold regression analysis," *Oxford Bulletin of Economics and Statistics*, 67, 281–306.

Giuliani, E., A. Martinelli, and R. Rabellotti (2016): "Is co-invention expediting technological catch up? A study of collaboration between emerging country firms and EU inventors," *World Development*, 77, 192–205.

Glas, A., M. Hübler, and P. Nunnenkamp (2016): "Catching up of emerging economies: the role of capital goods imports, FDI inflows, domestic investment and absorptive capacity," *Applied Economics Letters*, 23, 117–120.

Glass, A. J. and K. Saggi (1998): "International technology transfer and the technology gap," *Journal of Development Economics*, 55, 369–398.

Griffith, R., S. Redding, and J. V. Reenen (2004): "Mapping the two faces of R&D: Productivity growth in a panel of OECD industries," *The Review of Economics and Statistics*, 86, 883–895.

Griffith, R., S. Redding, and J. Van Reenen (2003): "R&D and absorptive capacity: theory and empirical evidence," *Scandinavian Journal of Economics*, 105, 99–118.

Hagedoorn, J. (2003): "Sharing intellectual property rights—an exploratory study of joint patenting amongst companies," *Industrial and Corporate Change*, 12, 1035–1050.

Kafouros, M. and M. Aliyev (2016): "Institutions and foreign subsidiary growth in transition economies: The role of intangible assets and capabilities," *Journal of Management Studies*, 53, 580–607.

Kafouros, M., J. H. Love, P. Ganotakis, and P. Konara (2020): "Experience in R&D collaborations, innovative performance and the moderating effect of different dimensions of absorptive capacity," *Technological Forecasting and Social Change*, 150, 119757.

Keller, W. (1996): "Absorptive capacity: On the creation and acquisition of technology in development," *Journal of Development Economics*, 49, 199–227.

——— (2010): "International trade, foreign direct investment, and technology spillovers," in *Handbook of the Economics of Innovation*, Elsevier, vol. 2, 793–829.

Khachoo, Q., R. Sharma, and M. Dhanora (2018): "Does proximity to the frontier facilitate FDI-spawned spillovers on innovation and productivity?" *Journal of Economics and Business*, 97, 39–49.

Khan, Z., R. Rao-Nicholson, and S. Y. Tarba (2018): "Global networks as a mode of balance for exploratory innovations in a late liberalizing economy," *Journal of World Business*, 53, 392–402.

Kim, C. and J. Song (2007): "Creating new technology through alliances: An empirical investigation of joint patents," *Technovation*, 27, 461–470.

Kim, C.-S. and A. C. Inkpen (2005): "Cross-border R&D alliances, absorptive capacity and technology learning," *Journal of International Management*, 11, 313–329.

Kneller, R. (2005): "Frontier technology, absorptive capacity and distance," *Oxford Bulletin of Economics and Statistics*, 67, 1–23.

Lall, S. (1992): "Technological capabilities and industrialization," *World Development*, 20, 165–186.

Lall, S. and R. Narula (2004): "Foreign direct investment and its role in economic development: do we need a new agenda?" *The European Journal of Development Research*, 16, 447–464.

Lawson, B., D. Krause, and A. Potter (2015): "Improving supplier new product development performance: the role of supplier development," *Journal of Product Innovation Management*, 32, 777–792.

Li, X. (2011): "Sources of external technology, absorptive capacity, and innovation capability in Chinese state-owned high-tech enterprises," *World Development*, 39, 1240–1248.

Lu, Y., Z. Tao, and L. Zhu (2017): "Identifying FDI spillovers," *Journal of International Economics*, 107, 75–90.

Mingyong, L., P. Shuijun, and B. Qun (2006): "Technology spillovers, absorptive capacity and economic growth," *China Economic Review*, 17, 300–320.

Montobbio, F. and V. Sterzi (2011): "Inventing together: exploring the nature of international knowledge spillovers in Latin America," in *Catching up, spillovers and Innovation Networks in a Schumpeterian Perspective*, Springer, 81–117.

——— (2013): "The globalization of technology in emerging markets: a gravity model on the determinants of international patent collaborations," *World Development*, 44, 281–299.

Muscio, A. (2007): "The impact of absorptive capacity on SMEs' collaboration," *Economics of Innovation and New Technology*, 16, 653–668.

Narula, R. and A. Marin (2003): "FDI spillovers, absorptive capacities and human capital development: evidence from Argentina," *MERIT-Infonomics Research Memorandum Series*.

Nelson, R. R. and S. Winter (1982): *An evolutionary theory of economic change*, Harvard University Press.

Nooteboom, B., W. Van Haverbeke, G. Duysters, V. Gilsing, and A. Van den Oord (2007): "Optimal cognitive distance and absorptive capacity," *Research Policy*, 36, 1016–1034.

Phene, A., K. Fladmoe-Lindquist, and L. Marsh (2006): "Breakthrough innovations in the US biotechnology industry: the effects of technological space and geographic origin," *Strategic Management Journal*, 27, 369–388.

Quéré, M. (2003): "Knowledge dynamics: biotechnology's incursion into the pharmaceutical industry," *Industry and Innovation*, 10, 255–273.

Riccobono, F., M. Bruccoleri, and G. Perrone (2015): "External knowledge sourcing for R&D activities: antecedents and implications of governance mode choice," *Technology Analysis & Strategic Management*, 27, 142–160.

Sasidharan, S. (2006): "Foreign direct investment and technology spillovers: Evidence from the Indian manufacturing sector," *Available at SSRN 881528.*

Savino, T., A. Messeni Petruzzelli, and V. Albino (2017): "Search and recombination process to innovate: a review of the empirical evidence and a research agenda," *International Journal of Management Reviews*, 19, 54–75.

Schumpeter, J. A. (2017): *Theory of economic development*, Routledge.

Seo, R., J. Edler, and S. Massini (2021): "Can entrepreneurial orientation improve R&D alliance performance? An absorptive capacity perspective," *R&D Management*, https://doi.org/10.1111/radm.12473.

Smarzynska Javorcik, B. (2004): "Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages," *American Economic Review*, 94, 605–627.

Sultana, N. and E. Turkina (2020): "Foreign direct investment, technological advancement, and absorptive capacity: A network analysis," *International Business Review*, 29, 101668.

Tether, B. S. (2002): "Who co-operates for innovation, and why: an empirical analysis," *Research Policy*, 31, 947–967.

Vishwasrao, S. and W. Bosshardt (2001): "Foreign ownership and technology adoption: evidence from Indian firms," *Journal of Development Economics*, 65, 367–387.

Weitzman, M. L. (1998): "Recombinant growth," *The Quarterly Journal of Economics*, 113, 331–360.

Winter, S. G. (1987): "Knowledge and Competences as Strategic Assets," in *The Competitive Challenge: Strategy and Organization for Industrial Innovation and Renewal*, ed. by D. J. Teece, Ballinger.

Zahra, S. A. and G. George (2002): "Absorptive capacity: A review, reconceptualization, and extension," *Academy of Management Review*, 27, 185–203.

Zahra, S. A. and J. C. Hayton (2008): "The effect of international venturing on firm performance: The moderating influence of absorptive capacity," *Journal of Business Venturing*, 23, 195–220.

Zhang, Y., H. Li, Y. Li, and L.-A. Zhou (2010): "FDI spillovers in an emerging market: the role of foreign firms' country origin diversity and domestic firms' absorptive capacity," *Strategic Management Journal*, 31, 969–989.

Zhou, X., M. Shan, and J. Li (2018): "R&D strategy and innovation performance: the role of standardization," *Technology Analysis & Strategic Management*, 30, 778–792.

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