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Where to set up adaptive and innovative R&D laboratories abroad?

Accounting for positive outcomes and direction of cross-national distance

Lorena M. D'agostino
University of Catania
Department of Political and Social Science
ldagosti@unict.it

Grazia D Santangelo
University of Catania
Department of Political and Social Science
graziasantangelo@gmail.com

Abstract
This study investigates the influence of cross-national economic and intellectual property rights (IPR) distance on the decision of setting up different types of research and development (R&D) laboratories abroad. Drawing on recent developments of research on cross-border distance, we suggest that cross-national economic distance positively influences the decision of setting up adaptive R&D laboratories due to the knowledge-exploiting mission of this type of laboratory that enables firms to profit from the opportunities different cross-national economic conditions offer. In addition, we propose that the decision of setting up innovative R&D laboratories critically depends on the direction of cross-national IPR distance. Firms are more (less) likely to set up innovative R&D laboratories in host countries with IPR regimes stronger (weaker) than in their home country as the knowledge-exploring mission of this type of laboratory is extremely sensitive to host country relative appropriability conditions. Innovative R&D laboratories need to greatly engage with local actors and, hence, are exposed to risks of technological leakages that firms originating in stronger IPR regimes may be unable to limit. Using data on R&D investments of world?s largest firms in 17 countries, we estimate gravity models and find support for our arguments.

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Introduction

Firms have greatly internationalized their research and development (R&D) activities over the last decades and increasingly differentiated between the knowledge-exploiting and knowledge-exploring mission of their foreign laboratories carrying out adaptive and innovative R&D, respectively (Cantwell & Mudambi, 2005, Dunning & Narula, 1995, Kuemmerle, 1997, 1999, Mansfield, Teece, & Romeo, 1979, Pearce & Singh, 1992, Shimizutani & Todo, 2008, Von Zedtwitz & Gassmann, 2002).

The heterogeneity of the mission of foreign R&D laboratories mirrors different location determinants, which traditionally relate to host country's economic conditions and formal institutions (i.e. intellectual property right (IPR) regimes) (Hakanson & Nobel, 1993, Ito & Wakasugi, 2007, Kumar, 1996, Odagiri & Yasuda, 1996, Patel & Vega, 1999, Vernon, 1966). Instead, distance factors have been regarded either as controls in the analyses of the internationalization of R&D (Ambos & Ambos, 2011, Granstrand, 1999)[i], or investigated as determinants of the decision of setting up homogeneous R&D activities abroad (Castellani, Jimenez, & Zanfei, 2013). In both cases, negative effects have been theoretically suggested and empirically documented, and emphasis has been placed on absolute cross-border distance factors, such as geographical and informal institutional distances. We, therefore, ask whether and how cross-national distance in economic and formal institutions (i.e. IPR regime) influences the decision of setting up different R&D laboratories abroad.

Based on recent developments of research on cross-border distance (Stahl & Tung, 2014, Zaheer, Schomaker, & Nachum, 2012), in relation to the decision of setting up different types of R&D laboratories abroad we challenge the absolute nature and overemphasized "dark" side of cross-national distance. Specifically, we suggest that the directionality of distance is relevant in relation to IPR as firms may avoid entering countries where intellectual property protection is less stringent than at home (Javorcik, 2004, Mansfield, 1995). We distinguish between distance in IPR protection between home and host country when the home country IPR regime is stronger/weaker than the host country (positive/negative IPR distance). We then argue that IPR distance between home and host countries may act as a push or pull factor of the decision of setting up innovative R&D laboratories depending on the directionality of distance. Positive (negative) IPR distance deters (facilitates) the location of innovative R&D laboratories abroad as it amplifies (reduces) the risks and associated costs of technological leakages, and, hence, creates adverse (favorable) conditions for the knowledge-exploring mission of this laboratory, which requires a great engagement with local actors. In addition, we suggest that what matters in relation to economic distance is the absolute distance between home and host as different conditions in terms of consumers' purchasing power and preferences as well as production may ultimately influence firm's location decisions (Hymer, 1976, Vernon, 1966, Zaheer, 1995). Hence, we argue that absolute economic distance acts as a pull factor of the decision of setting up adaptive R&D laboratories abroad as cross-country economic differences create opportunities of arbitrage that the knowledge-exploiting mission of this laboratory can reap by addressing the specificities of the host country's demand. In addition,

Using data of 397 R&D projects of 115 world's largest firms from 17 home countries targeting 37 destination countries over the period 2005-2011, we estimate gravity models and find support for our arguments.

Our study contributes to research on R&D internationalization by offering theoretical arguments and empirical evidence on the relation between different R&D activities and specific distance factors. In addition, we theoretically speculate and find empirical support for the relevance of the directionality as well as the "bright" side of cross-border distance. By confirming also the relevance of "dark" side of distance, we contribute to offer a more nuanced and balanced understanding of distance. Finally, we advanced research on cross-national distance by relating different R&D activities to distance factors others than geography and culture-related distance.

The study is organized as follows. Section 2 discusses the theoretical background. Testable hypotheses are developed in Section 3. The method is illustrated in Section 4 and the econometric results in Section 5. Finally, Section 6 concludes by discussing contributions and limitations.

Theoretical background

Cross-national distance has a great relevance for international activities as the firm's liability of foreignness increases with distance between home and host country (Zaheer, 1995). In this perspective, both cultural and/or geographical distance, used as "catch-all" measures of cross-national distance (Håkanson & Ambos, 2010), as well as cross-national distance, measured along multiple dimensions, adversely influence international operations (Berry, Guillén, & Zhou, 2010, Slangen & Beugelsdijk, 2010). Uncertainty increases with cross-national distance preventing information or knowledge to flow between countries, and, hence, raises the cost of doing business abroad. This applies also to cross-border R&D activities, which are negatively influenced by specific dimensions of cross-national cultural differences such as linguistic and religious distance, and geographical distance (Castellani, Jimenez, & Zanfei, 2013). Linguistic and religious distance act as inhibitors of cross-border investment decisions in the domain of R&D relative to manufacturing as these distance factors create barriers to communication and mutual understanding between the parties involved. In addition geographical distance has a negative impact on the decision of setting up R&D laboratories abroad, but relatively lower than manufacturing owing to the spiky nature of innovation, and to the unique ability of multinational enterprises (MNEs) to absorb and transfer knowledge on a global scale.

In an alternative perspective, cross-country distance "can be an asset, not just a liability" (Stahl & Tung, 2014, 2) as differences can be "an opportunity for arbitrage, complementarity and creativity" (Zaheer, Schomaker, & Nachum, 2012, 26).

Opposite to a strategy based on the exploitation of scale economies, which enables firms to profits from the replication of business models in similar contexts, arbitrage is the strategy of difference (Ghemawat, 2001). The idea is that cross-country differences, if exploited by means of alternative business models, can be relatively sustainable sources of competitive advantage. Traditionally, cross-country differences have been studies in terms of economic distance (Whitley, 1992) that relates to differences in consumers' purchasing power and preferences (for a review, see e.g. Berry, Guillén, & Zhou, 2010). Such differences (no matter the direction) bear critical implications to gain competitive advantage across countries and may positively influence firms entry (Zaheer, Schomaker, & Nachum, 2012). In particular, foreign R&D laboratories in economic may help profiting from economic differences by adapting to the differences and offering ad hoc solutions.

Cross-country distance can also create opportunities for complementarity and creativity. In relation to the decision of setting up foreign R&D laboratories such opportunities greatly depend on the relative strength of the formal institutions influencing the firm's ability to capture the rents generated by its innovation activities (Teece, 1986, p. 287). Firm's entry is usually deterred/facilitated when the IPR regime in the host country is weaker/stronger than in the home country (Javorcik, 2004, 19, Mansfield, 1995). A stronger IPR regime provides the owners of new knowledge and technology with the right to sue for infringement if another party attempts to use, sell, offer, import, or offer to import intellectual property into the country issuing the IPRs. Instead, such right may be fully lacking or ill specified in weaker IPR countries. The directionality of distance is then critical in the case of IPR regimes as a relative stronger IPR regime creates the conditions where opportunities for complementarity and creativity may flourish. Firms setting up R&D laboratories in relative stronger IPR regimes will face lower appropriability hazard, that is the hazard of technological leakages that originates from the difficulties of clearly specified IPRs (Teece, 1986), and, as a result, will be more willing to invest in the creation of new knowledge and technology locally as well as to tap into local knowledge and technological complementarities.

The debate on the influence of cross-national distance on foreign market entry is especially relevant in relation to the heterogeneity of the R&D activities firms may decide of setting up abroad

(Belderbos & Sleuwaegen, 2007, Kuemmerle, 1999, Shimizutani & Todo, 2008, Von Zedtwitz & Gassmann, 2002).

An established stream of research has proposed an array of classifications of foreign R&D activities (see Cantwell & Mudambi, 2005, for a review) that parallels the dichotomy exploitation-exploration (March, 1991). Exploitation is associated to "refinement, efficacy, selection and implementation" whereas exploration relates to "search, variation, experimentation and discover" (March, 1991, 102). Let alone the different labels, the conventional type of overseas R&D aims at adapting the MNE's knowledge, technology, products and processes to the local market. These adaptive R&D laboratories abroad are mainly based on the exploitation of knowledge developed at home to best achieve their market-driven mission (Ito & Wakasugi, 2007, Kuemmerle, 1999, Von Zedtwitz & Gassmann, 2002). A relative more recent type of overseas R&D laboratory is concerned with the development of new knowledge and, hence, is mainly based on the exploration of local expertise (Cantwell & Janne, 1999, Cantwell & Santangelo, 1999, Dunning, 2009, Dunning & Narula, 1995). The activity of innovative R&D laboratories is also extremely uncertain in nature as it typically concerns the development of pre-competitive and/or competitive knowledge that is critical to build and sustain the competitive advantage of the overall MNE. Although the number of more innovative R&D laboratories has increased in more recent years (Cantwell & Mudambi, 2005), adaptive R&D laboratories are still relevant in firms' R&D internationalization strategies (Belderbos & Sleuwaegen, 2007).In the next section we shall develop testable hypotheses on the influence of absolute economic distance and directional IPR distance on the probability of setting up adaptive and innovative R&D laboratories abroad. In particular, we shall argue that economic distance acts as a pull factor on the decision of setting up adaptive R&D laboratories, and IPR distance acts as a pull or push factor on the decision of setting up innovative R&D laboratories depending on the directionality of this specific cross-national distance.

Hypotheses Development

The influence of economic distance

Similar economic conditions in the home and host country enable firms to replicate their existing business model and enjoy the benefits of standardization (Ghemawat, 2001). Standardization across international markets faces major limitations when local tastes, preferences and consumption habits differ substantially across national boundaries (Boddewyn, Soehl, & Picard, 1986, Douglas & Wind, 1987). Hence, economic distance between two countries raises costs to adapt products to specific customer requirements and processes to specific production conditions in order to profit from differences (Ghemawat, 2001). Adaptation to distant economic conditions in the host country can hardly be achieved by maintaining operations at home despite the developments in information and communication technology (ICT) (Nachum, 2003, Zaheer & Manrakhan, 2001, Zaheer & Zaheer, 2001). ICT reduces the costs of communicating with and learning about customers and, hence, the need for local presence as far as more simple inexpensive products that do not require much customization or after-sales services are concerned (Zaheer & Manrakhan, 2001). Instead, firms need to acquire a presence in the host country to gain a full understanding of the local market demand for more sophisticated and less-standardized products and technologies (Zaheer & Manrakhan, 2001, Zaheer, Schomaker, & Nachum, 2012).

Clearly, the acquisition of a presence in a foreign country is not without a cost, but it may become an opportunity if firms possess proprietary knowledge that can be exploited in the host country (Caves, 1971, Hymer, 1976, Vernon, 1966) and, hence, profit from differences in order to gain competitive advantage. “Once a firm realizes it has a capability that could be used to satisfy demand in a foreign country it will evaluate different options for exploiting this capability” (Kuemmerle, 1999, 3). In particular, manufacturing facilities in economically distant host countries usually lack the expertise to adapt products and technologies to local demand conditions, as local adaptation requires the transfer of knowledge and prototypes from the firm's home country. Such a task is traditionally assigned to adaptive R&D laboratories (Kuemmerle, 1997). Adaptive R&D laboratories are able to bridge the cross-country economic distance by exploiting home country knowledge to adapt current products and/or technologies to local customer needs also through the support of sales and marketing activities, and technical services (Hakanson & Nobel, 1993, Kuemmerle, 1999, Odagiri & Yasuda, 1996).

Economic distance will hardly affect the probability of setting up innovative R&D laboratories in economically distant countries, as these laboratories are traditionally less concerns with the host country demand potential (Cantwell & Mudambi, 2005).

Hence, the probability of setting up an adaptive R&D laboratory abroad increases with the economic distance between home and host country.

H1: The high the economic distance between home and host country, the high the probability of setting up an adaptive R&D laboratory in the host country.

The influence of relative IPR distances

Despite the improvements in developing countries due to reforms in IPR regimes with the implementation of the WTO TRIPS agreement (Belderbos & Sleuwaegen, 2007), variation in the strength of IPR regimes remains substantial across developing and developed countries. Variation in the strength of IPR regimes is still an issue also when considering the group of developed countries. For example, the European Union (EU) IPR regime is still far to be fully harmonized across the EU member states (EPO, 2013, Javorcik, 2004). As a result, firms originating in countries with relatively strong IPR regimes avoid locating R&D in weaker IPR host countries unless firm-specific mechanisms have been developed to minimize the loss in case of technological leakages (Belderbos & Sleuwaegen, 2007, Zhao, 2006).

However, international R&D activities are not all equally sensitive to the relative strength of the IPR regime in the host country (Quan & Chesbrough, 2010). R&D laboratories carrying out innovative R&D activities abroad would be especially careful about technological leakages as these laboratories engage with local partners to explore local knowledge in order to develop pre-competitive and/or competitive knowledge, which is both highly uncertainty and expected to greatly contribute to the competitive advantage of the whole MNE. As a result, potential knowledge leakages in the host country from innovative R&D laboratories are especially harmful to the entire MNE since there is a lot at stake (Santangelo, 2012). Hence, the decision of setting up an innovative R&D laboratory is extremely sensitive to the relative appropriability conditions in the host country (Ito & Wakasugi, 2007, Von Zedtwitz & Gassmann, 2002).

Firms originating in relatively stronger IPR countries will be discouraged to set up innovative R&D laboratories in relatively weaker IPR countries due to the risks and associated costs of technological leakages when creating new knowledge as well as when exploring local knowledge in search of complementarity. Instead, firms originating in relatively weaker IPR countries will find appealing to set up an innovative R&D laboratory in a relatively stronger IPR regime when evaluating different location options as in a stronger IPR country they would be more protected when engaging with local partners to explore local knowledge. Although firms from weaker IPR countries are used to weak institutional conditions, a stronger IPR regime in the host country enables them to allocate they resources to fully explore host country knowledge and ease the acquisition of complementary technological assets they look for when expanding abroad (Luo & Tung, 2007).

A weaker IPR regime in the host country will hardly deter the decision of setting up adaptive R&D laboratories as this type of R&D laboratories tends to be conducted within a closed network between the headquarter and the affiliates of the MNE and, as a result, technological leakages are less likely (Ito & Wakasugi, 2007).

Hence, the probability of setting up innovative R&D laboratories decreases with the strength of the home IPR regime relative to the host country, and increases with the weakness of the home IPR regime relative to the host.

H2a: The stronger the IPR in the home country relative to the host country (positive IPR distance), the lower the probability of setting up an innovative R&D laboratory in the host country.

H2b: The weaker the IPR in the home country relative to the host country (negative IPR distance), the higher the probability of setting up an innovative R&D laboratory in the host country.

Data and sample

Our sample refers to 397 R&D investment projects made by 115 world's largest manufacturing and service firms (*Fortune Global 500*) headquartered in 17 countries and targeting 37 countries over the period 2005-2011. Information on such investments is drawn from *fDi Markets* database (latest access: August 2012), a database collecting worldwide greenfield FDI projects since 2003 on the basis of the announcement of the investment in media sources and company websites. The database provides information on the name and home location of the investing firm, and industry, main activity and destination of the investment projects. The 397 R&D investments were classified in two categories, *adaptive R&D* and *innovative R&D*, through a manual keyword search and an iterative procedure (see Appendix).

The 17 home countries count 15 OECD members by 2010 (Canada, Finland, France, Germany, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, South Korea, Sweden, Switzerland, the UK, and the US) and 2 emerging economies (China and Hong Kong). The 37 destination countries include OECD countries (Australia, Austria, Belgium, Canada, Chile, Denmark, Finland, France, Germany, Hungary, Ireland, Israel, Italy, Japan, Mexico, the Netherlands, Norway, Poland, Portugal, South Korea, Spain, Sweden, Switzerland, the UK, and the US) and post-transition, developing, and emerging countries (Brazil, China, Hong Kong, India, Lithuania, Philippines, Romania, Russia, Saudi Arabia, Singapore, Thailand, Vietnam) that either attract or originate at least the same number of R&D laboratories as OECD countries with the lowest involvement in bilateral investments according to our data source (for a similar procedure see also Castellani, Jimenez, & Zanfei, 2013). When we consider the full matrix of data, the total number of observations is 4,141 (i.e. 115 firms × (37 – 1) host countries + 1 home country as Luxembourg does not receive R&D investments). The number of observations in each model may be different from the theoretical 4,141 because some countries or sectors have no investments in R&D. In these cases, sector and country dummies (see below) perfectly predict these observations, which are thus dropped from the estimation sample.

Data on cross-country economic distance are drawn from the Berry, Guillén, and Zhou (2010) database (http://lauder.wharton.upenn.edu/ciber/research/faculty.php). Data on national IPR regimes refer to the index initially developed by Ginarte and Park (1997) and Park (2008). We also rely on different data sources to build our bilateral controls such as the CEPII, UNCTAD and the World Bank World Development Indicators (WDI) databases. Finally, we draw on additional firm-level information from the *Orbis* database by Bureau van Dijk, and company financial reports.

Econometric analysis

Dependent variable

Our dependent variable is a binary indicator taking value 1 if a firm *i* headquartered in country *j* has at least 1 investment project in R&D activity *k* in the period 2005-2011 in country *z,* and 0 otherwise. We run separate regressions for *k* equal to *adaptive R&D* and *innovative R&D*. Adaptive R&D investments account for 2.7% of the sample, innovative R&D investments for 5.6%, Table 1 shows the number of R&D investments by firms and destination country, distinguished by adaptive and innovative R&D investments. More than 80% of firm-host pairs with positive R&D FDI register only one investment (both in the adaptive and innovative category), which suggests that measuring the probability of choosing a certain destination country with a binary variable bears a negligible loss of information.

Given the dichotomous nature of our dependent variable we estimated probit models. Moreover, since firms rarely invest in multiple years in the same country, we estimate data in cross-section.

[TABLE 1 ABOUT HERE]

Independent variables

To test hypothesis 1, we use the indicator of *economic distance* between each host and home country pair for the year 2004 developed by Berry, Guillén, and Zhou (2010). This is a synthetic indicator of four specific measures of economic differences across countries which international business literature has tended to focus on: income level (GPD per capita, 2000 US$), inflation (GDP deflator, % GDP), exports (exports of goods and services, % GDP) and imports (imports of goods and services, % GDP). As these measures "correlate with consumer purchasing power and preferences, macroeconomic stability, and the openness of the economy to external influences" (Berry, Guillén, & Zhou, 2010, , p. 464), the synthetic indicator offers a reliable measure of the difference between home and host country demand.

To measure IPR distance we draw on the index initially developed by Ginarte and Park (Ginarte & Park, 1997, Park, 2008), which provides a wide coverage of countries and years. The index is based on the evaluation of national patent laws in terms of coverage, membership in international treaties, provisions for loss of protection, enforcement mechanisms, and duration of protection. For each country, the index ranges from 0 to 5, and it is available every five years from 1960 to 2010 (latest updates available at http://www.american.edu/cas/faculty/wgp.cfm). We use the data from 2005, which refers to patent laws' updates occurred between 2000 and 2004, for each home and host country. First we calculate *IPR distance* as the difference in Ginarte and Park IPR index for each home-host country pair. In line with Tsang and Yip (2007) we allow explicitly for the direction of IPR distance to test hypotheses 2a and 2b. Specifically, we split *IPR distance* into two new variables: 1) *positive IPR distance* measured as ($IPR_j - IPR_z$) if $IPR_j \geq IPR_z$ and equal to 0 if $IPR_j < IPR_z$, and 2) *negative IPR distance* measured as ($IPR_z - IPR_j$) if $IPR_z \geq IPR_j$ and equal to 0 if $IPR_z < IPR_j$, where IPR_j is the Ginarte and Park IPR index of the home country and IPR_z of the host. The former is equivalent to *(IPR distance)* × dummy *lower IPR host* and the latter to (*IPR distance*) × dummy *higher IPR host. Positive* (*negative*) *IPR distance* indicates situations where the R&D investments originate in a home country with a stronger (weaker) IPR regime than the host country.

We control for other variables that may affect the bilateral investments following a gravity model (Anderson, 2011), which has been widely applied to the study of the determinants of FDI flows (e.g. Bevan & Estrin, 2004). In particular, we include a number of distance-related factors that might hinder or facilitate the establishment of foreign R&D investment projects. First we include, *geographical distance*, which is measured as the great circle distance (i.e. distance on the surface of a sphere) between geographical centers of countries (source: Berry, Guillén, and Zhou (2010)) (Fratianni & Oh, 2009). We also control for the fact that countries that share a borders are more likely to engage in bilateral investments (*shared borders*) (source: CEPII database http://www.cepii.fr/anglaisgraph/bdd/distances.htm). We introduce a variable for *time differences* (source: CEPII database), which might either favor the division of labor across countries through around-the-clock work or hamper real-time communication (Head, Mayer, & Ries, 2009, Stein & Daude, 2007). We also control for institutional similarities that reduce the cost of transactions and communications in foreign countries with the variables *colonial ties* and *common origin of legal system* (source: CEPII database) (Wei & Shleifer, 2000). In addition, we control for bilateral investment treaties (*BIT*), that reduce the uncertainty of operating in unfamiliar locations (Egger & Merlo, 2007), and the existence of regional trade agreements (*RTA*) that moderate barriers to trade and often include investment issues (MacDermott, 2007). *BIT* has been manually constructed using

UNCTAD data on bilateral investment treaties that entered into force before 1st January 2000 (http://www.unctad.org), the *RTA* variable is drawn from the CEPII dataset and takes value 1 if the country-pair belongs to a regional trade agreement up to 2004. Following Castellani, Jimenez, and Zanfei (2013), we also account for cultural and social differences that may inhibit communication and mutual understanding by introducing the variables *language distance* and *religious distance* as calculated by Dow and Karunaratna (2006). Lower distance in language means that people in home and host country speak the same or similar languages (e.g. the US and the UK), while higher distance signals countries with different or very dissimilar languages (e.g. France and China). To control for differences in the technological endowment when testing hypothesis 1, we consider the cross-country distance in technological endowment by introducing the variable *technological endowment distance* (i.e. the absolute home-host country distance in patent applications of residents per million inhabitants, which we draw from the WDI database).

We also include a number of firm-level controls that may explain the propensity to engage in foreign R&D investments. Firstly, we account for the propensity of a firm to invest in foreign R&D (*R&D internationalization*) with the total number of R&D investment in the period 2003-2004. We also introduce a variable that accounts for the firm's *experience in host non-R&D activities* measured by the firm's number of non-R&D investments in the host country in the period 2003-2004, as the presence of non-R&D activities in a country may subsequently influence the decision of co-locating specific types of R&D laboratories (Kuemmerle, 1997). We also control for firm *size* with the firm's two-year average sales in 2003-2004.

Finally, we control for *sectoral concentration* by means of a Herfindahl–Hirschman index for the investments of each firm. The index is based on the firm's share of R&D investments in 2003-2004 in each different sector and ranges from 0 (no investments) to 1 (investments in only one sector) (Castellani, Jimenez, & Zanfei, 2013). We also introduce sectoral fixed-effects based on six of NACE Rev. 2 sectors (i.e. Mining and quarrying; Manufacturing; Electricity, gas, steam and air conditioning supply; Transportation and storage; Information and Communication; Professional, scientific and technical activities).

Table 2 lists the variables, data sources and period of reference, and the relative descriptive statistics. Table 3 reports the correlation matrix.

[TABLE 2 AND 3 ABOUT HERE]

Results

Table 4 and 5 show the estimation results from the probit regressions for the probability of setting up adaptive and innovative R&D laboratories, respectively. As most variables vary only by source–

destination country pair, each country pair will enter the sample multiple times, depending on how many firms come from the same home country. As a consequence, the residuals from the regressions will cluster by country pair, and the standard errors of the country-pair-specific explanatory variables could be substantially underestimated. To alleviate this issue, we report standard errors clustered by country pair.

Hypothesis 1 is tested in Models 1 and 2, which are reported in Table 4, where the probability of setting up adaptive and innovative R&D laboratories, respectively, is estimated as function of *economic distance*, a set of controls, and sectoral fixed-effects. In addition, in these models, we include home and host country fixed-effects to be able to focus on the role of bilateral determinants. The probability that a firm will locate specific types of R&D facilities in a given country depends on several location-specific characteristics, as well as on the higher propensity of some countries to invest abroad. Country fixed-effects do not allow us to identify any specific effect of home- or host-country characteristics but ensure that the effect of distance-related variables on cross-country investments is not confounded by some unobservable home- or host-country characteristic.

[TABLE 4 ABOUT HERE]

To test hypothesis 2a and 2b, we replace *IPR distance* with the directional measures. In Table 5, Models 3 to 8 report the estimates of the probability of setting up adaptive and innovative R&D laboratories, as function of firstly *positive IPR distance* (Model 3 and 4), then *negative IPR distance* (Model 5 and 6), and finally both (Model 7 and 8). In these models, we did not include host country fixed-effects, as these would erode the effects of the IPR directional distances (Cuervo-Cazurra, 2006, Stein & Daude, 2007, Wei, 2000).

[TABLE 5 ABOUT HERE]

For both sets of models we calculate the variance inflation factors and obtain values below the conventional threshold of 10. Multicollinearity is not an issue.

Model 1 shows that *economic distance* is positively and significantly associated to the probability of setting up adaptive R&D laboratories ($p<0.05$). The higher the differences in *economic distance*, the more likely are firms to establish R&D laboratories aiming at adapting products, process, and technologies to local tastes and market demand. Instead, *economic distance* does not seem to influence the probability of setting up innovative R&D laboratories in Model 2. Hypothesis 1 is supported.

Models 4 and 8 illustrate that *positive IPR distance* is negatively and significantly associated ($p<0.01$) to the probability of setting up innovative R&D laboratories abroad. Hypothesis 2a is supported. Models 6 and 8 show that *negative IPR distance* is positively and significantly associated to the probability of setting up innovative R&D laboratories abroad ($p<0.01$). Hypothesis

2b is supported. Instead, differences in IPR regimes do not significantly affect the probability of setting up adaptive R&D laboratories as shown in Models 3, 5 and 7.

To support empirically our argument that economic distance is absolute in nature and direction does not matter in relation to this specific distance factor, we calculate economic distance when the home country is more (less) wealthier than the host country (*positive* (*negative*) *economic distance*) and re-run our analysis. Since for each country pair no individual country index is available for the *economic distance* measure developed by Berry, Guillén, and Zhou (2010), we proceed in two steps to capture the directionally of this measure. First, we classified each home and host country based on the World Bank classification of countries by income (http://data.worldbank.org/about/country-and-lending-groups) and calculated a dummy *lower income host* equal 1 if the home is classified in a higher income group than the host and a dummy *higher income host* equal 1 if the home is classified in a lower income group than the host. Second, we built two variables: *positive economic distance* that equals *economic distance* × *lower income host*, and *negative economic distance* that equals *economic distance* × *higher income host*. *Positive* (*negative*) *economic distance* would be equal to the variable *economic distance* when the home country has a higher (lower) income than the host country. This way of proceeding is based on the idea that a country income is usually related to other country macroeconomic indicators and, hence, perceived as a fairly good indicator of the overall country economic conditions. In addition, this way of proceeding allows us not to distance too much from the indicator used in the main estimations. Thus, we replace these measures with *economic distance* in the main estimations and obtain no significant results. That is, directional economic distances seem not to matter on the decision of setting up R&D laboratories abroad.

We also run a number of robustness tests to validate our findings and rule out alternative explanations.

In our main estimation we analyze *adaptive R&D* and *innovative R&D* as independent events. However, the decision of setting up a new adaptive (innovative) R&D laboratory in a country may be facilitated/deterred by the presence of an innovative (adaptive) R&D laboratory in the same country. We are not interested in assessing how the decision of setting up a type of R&D laboratory affects the location decision of the other type. Rather, we are interesting in ruling out that the interdependence between different types of R&D laboratories changes the impact of the relevant distance factors on the probability of setting up each type of R&D laboratory abroad. To this end, we estimate a bivariate probit model in which the probability of setting up adaptive R&D laboratory is estimated jointly with the probability of setting up innovative R&D laboratory. The ρ coefficient suggests that the error terms of the two equations are indeed correlated. However, for the purpose of our analysis the signs and significance of the main results are confirmed. As a further robustness check along these lines, we ran a standard univariate probit of the probability of setting up *adaptive (innovative) R&D*, and introduce a dummy that takes value 1 if a firm has previously established *innovative* (*adaptive*) R&D. Our main results are confirmed.

To rule out alternative explanations in relation to hypothesis 1, we replace *economic distance* with a *demographic distance* indicator. In principle, differences in population growth rate and composition between home and host country may well offer opportunities to exploit home country knowledge and influence the decision of setting up adaptive R&D laboratories abroad. To this end, we draw on the *demographic distance* indicator developed by Berry, Guillén, and Zhou (2010), which is based on life expectancy, birth rate, shares of population under 14, and share of population above 65. We then rerun Models 1 and 2 and *demographic distance* fails to yield significant results. In addition, to rule out alternative explanations in relation to hypotheses 2a and 2b, we rerun Models 3 to 8 and exclude from the analysis R&D investment projects in ICT service sectors as knowledge in these sectors is modular (Brusoni & Prencipe, 2001) and, as a result, intellectual property protection in these sectors may follow logics not related to IPR regimes (Zhao 2006). Our main results are confirmed. Finally,

The estimations of these robustness checks are not reported but available upon request.

Conclusions

The increasing internationalization of R&D activities has paralleled a differentiation of the mission of foreign R&D laboratories. The location decisions of R&D laboratories with different missions have attract a great deal of research. In particular, the determinants of the decision of setting up different R&D laboratories abroad have been mainly investigated in terms of host country economic conditions and IPR regime. In relation to foreign R&D laboratories geographical and cultural distance-related factors have been treated as controls or accounted without disentangling the mission of the foreign R&D laboratory. Inspired by recent research on cross-national distance reminding that "international management is management of distance" (Zaheer, Schomaker, & Nachum, 2012, 19), we investigate whether cross-national economic and IPR distance influence the decision of setting up adaptive and innovative R&D laboratories abroad.

Using data on world largest firms investing in adaptive and innovative R&D laboratories abroad in 37 countries over the period 2003-2011, our findings offer evidence of the multidimensionality of distance in relation to heterogeneous international R&D activities (Berry, Guillén, & Zhou, 2010, Zaheer, Schomaker, & Nachum, 2012). As adaptive and innovative R&D activities respond to different strategic missions, we argue that the decision of setting up different

R&D units abroad depends on distance factors specific to the mission of the R&D laboratory. Knowledge exploitation opportunities in economically distant host countries make appealing the setting up of adaptive R&D laboratories. The risks (opportunities) of appropriating the outcome of knowledge exploration in weaker (stronger) IPR host countries deter (encourage) the setting up of innovative R&D laboratories.

Our study advances research on R&D internationalization by offering theoretical arguments and supporting empirical evidence on the relevance of specific cross-national distance factors influencing the decision of setting up different types of R&D laboratories.

First, in relation to the location decision of adaptive and innovative R&D laboratories we argue and show that some forms of cross-national "are absolute ..., other forms of distance are not as well delineated (Zaheer, Schomaker, & Nachum, 2012, 19). In particular, we offer conceptual arguments and empirical evidence on the absolute nature of economic distance and the directionality of formal institutional distances, such as IPR. Economic distance emphasizes cross-country differences and similarities. No matter whether adaptive R&D activities are planned from more or less wealthier countries, differences in economic conditions will offer opportunities for exploiting home country knowledge to profit from differences. Instead, cross-country distance in IPR regime matters when evaluating different location options where to set up innovative R&D laboratories. The costs and opportunities to explore local knowledge will be markedly different in host countries with an IPR regime more or less stringent than the home country.

Second, in the relation to the location decision of different foreign R&D laboratories we suggest a positive view on distance (Stahl & Tung, 2014, Zaheer, Schomaker, & Nachum, 2012). Our arguments and findings highlight that distance may well have a positive influence on the firms' location decision of specific R&D activities. This is the case of the positive influence of economic distance on the probability of setting up adaptive R&D laboratories as different economic conditions offer opportunities to profit from cross-national differences by exploiting home country knowledge. This is also the case of the positive influence of IPR distance when the host IPR regime is stronger than the home. Favorable host country appropriability conditions ease the location of innovative R&D laboratories, as the knowledge exploration mission of these laboratories requires a greater engagement with local partners that increase the risks of technological leakages. However, we also propose a more nuanced and balanced understanding of distance (Zaheer, Schomaker, & Nachum, 2012) by also confirming that distance factors may have a "dark" as well as the "bright" side discussed above. In particular, we suggest that IPR distance may discourage firms to set up innovative R&D laboratories abroad when the appropriability hazard is greater in the host country than in the home country, that is in weaker IPR host countries. Firms looking for host countries where setting up their innovative R&D laboratories will rather avoid weaker IPR host countries as in these environments the risks of technological leakages would be higher when engaging with local partners to explore host country knowledge.

Finally, we also contribute to research on cross-national distance, which has been widely studied traditionally in connection to the location of less value-creating activities and more recently also to more value-creating activities, such as R&D. To this research we offer theoretical arguments and empirical evidence on the influence of specific distance factors on different type of foreign R&D activities by speculating on distance factors others than geographical and culture-related distances.

The limitations of our study set the avenue for future. To keep the coding of the international R&D laboratories manageable we restrict our analysis to investments of the world largest firms, for which firm-level data are also usually more readily available. As a result, the conclusions that can be drawn from our analysis refer to very large firms, which traditionally devote great resources in collecting information and scanning the globe for opportunities to exploit proprietary knowledge and/or explore host country knowledge. Smaller firms may not have such resources and such a shortage may reflect on their decision when internationalizing their R&D activities. Hence, research focusing on smaller firms may reveal different patterns than the ones we find and may be worth pursuing. Our analysis also focuses on greenfield investments. However, we know internationalization is also strongly pursued through merger and acquisitions (M&As). Hence it would be interesting to replicate the study on M&A data to compare the results. Notwithstanding these caveats, we believe our study adds to the scientific discussion on distance and internationalization, and hope it will offer inspiration for future research.

Appendix

The classification of the foreign R&D laboratories according to the type of activity undertaken is based on a procedure initially developed in D'Agostino and Santangelo (2012a) and further revisited in D'Agostino and Santangelo (2012b). First, a survey of existing studies on R&D internationalization that provided a classification of R&D activities (e.g. Dunning & Narula, 1995, Pearce & Singh, 1992) was conducted. From this literature, crucial keywords for two types of R&D laboratories were identified: adaptive and innovative. Through a manual keyword-scanning of the description of the R&D investment available in the *fDi Markets* database in the period 2003-2011, an R&D laboratory was classified as *adaptive* if the R&D laboratory carries out adaptation of existing products and processes to differentiated consumers or "customer" demands, or provides "support" to local sales operations and "technical services"; and as *innovative* if it carries out "basic", "fundamental", "scientific", "frontier technology" research or "development" works and searches for "solutions" in terms of new products and processes. In case the description was incomplete or inconclusive the research was expanded to online information, such as business news databases and company websites. All cases were coded independently by two researchers and the two researchers' classifications then compared. In case of disagreement, each researcher further expanded the information on the R&D investment project independently and the results were compared eventually. The process was carried on until a complete match was achieved. To ensure that each R&D laboratory is assigned to only one of the two categories, the few cases in which the R&D laboratory performs multiple R&D activities (13%) were classified as an innovative R&D laboratory because the co-occurrence of innovative and adaptive R&D may reflect an upgrading of the laboratory's capacities towards more complex tasks (Ronstadt, 1978). Over the period 2005-2011 our analysis focuses on 397 R&D investment projects. This figure accounts for 86% of the R&D investment projects made by world's largest firms in these years due to incomplete data both at firm- and country-level. Of the 397 R&D investment projects 121 (31%) are classified as adaptive and 273 (69%) as innovative. This is consistent with the evidence that R&D laboratories are recently internationalized more for innovative than adaptive motives (Belderbos & Sleuwaegen, 2007).

Table 1 – Frequency and percentage of R&D laboratories, by firms-host country

Number of investments	Adaptive R&D		Innovative R&D	
	Frequency	Percentage	Frequency	Percentage
0	3855	97.32	3808	94.42
1	91	2.3	189	4.69
2	12	0.3	25	0.62
3	3	0.08	10	0.25
4	0	0	1	0.02
Total	3961	100	4033	100

Table 2 – Variable description and descriptive statistics

Variable	Description	Source	Time	Mean	SD	Min	Max
Adaptive R&D	Adaptive R&D laboratory	fDi Markets	2005-2011	0.03	0.16	0	1
Innovative R&D	Innovative R&D laboratory	fDi Markets	2005-2011	0.06	0.23	0	1
Economic distance	Dyadic distance in economic dimension	Berry, Guillén et al. 2010	2004	8.63	12.77	0.05	72.56
IPR distance	Distance in Ginarte and Park IPR index (absolute value)	Ginarte and Park (1997) and online updates	2005	0.61	0.57	0	2.39
Positive IPR distance	Positive distance in Ginarte and Park IPR index	Ginarte and Park (1997) and online updates	2005	0.58	0.59	0	2.39
Negative IPR distance	Negative distance in Ginarte and Park IPR index	Ginarte and Park (1997) and online updates	2005	0.03	0.09	0	0.8
Geographical distance	Logarithm of great circle distance between geographical centers of country *j* and country *z* (km)	Berry, Guillén et al. 2010	-	8.53	0.97	5.28	9.87
Shared borders	Whether country *j* and country *z* share a border	CEPII	-	0.08	0.27	0	1
Time difference	Time difference between country *j* and z (hours)	CEPII	-	5.61	3.56	0	11.58
Colonial ties	Whether country *j* and country *z* have ever had a colonial link	CEPII	-	0.07	0.26	0	1
Common origin of legal system	Whether country *j* and country *z* have a common legal origin	CEPII	-	0.21	0.41	0	1
BIT	Whether country *j* and country *z* have signed a Bilateral Investment Treaty whose date of entry in force is before 1st January 2000	UNCTAD	2000	0.18	0.39	0	1
RTA	Whether country *j* and country *z* are part of a Regional Trade Agreement	CEPII	2004	0.32	0.47	0	1
Language distance	Distance in language factor	Dow and Karunaratna (2006)	-	-0.22	1.10	-3.87	0.53
Religious distance	Distance in religion factor	Dow and Karunaratna (2006)	-	-0.32	1.00	-1.55	1.53
Technological endowment distance	Logarithm of distance in patent applications by residents, per million inhabitants, between country *j* and country *z*.	WDI	2003-2004	6.00	1.21	0.07	7.95
R&D internationalization	Logarithm of R&D FDI by firm *i* (2-year sum)	fDi Markets	2003-2004	0.07	0.30	0	2.64
Experience in host non-R&D activities	Logarithm of non-R&D FDI by firm *i* in country *z* (2-year sum)	fDi Markets	2003-2004	0.23	0.47	0	3.47
Size	Logarithm of firm sales (2-year average)	Orbis	2003-2004	10.30	0.88	7.75	12.42
Sectoral concentration	Herfindahl–Hirschman index of sectoral concentration by R&D FDI (2-year sum)	fDi Markets	2003-2004	0.39	0.45	0.00	1

Table 3 – Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Economic distance	1																	
2	IPR distance	0.260 ***	1																
3	Positive IPR distance	0.264 ***	0.987 ***	1															
4	Negative IPR distance	-0.078 ***	-0.130 ***	-0.285 ***	1														
5	Geographical distance	0.265 ***	0.311 ***	0.325 ***	-0.157 ***	1													
6	Shared borders	-0.122 ***	-0.099 ***	-0.103 ***	0.042 ***	-0.549 ***	1												
7	Time difference	0.164 ***	0.198 ***	0.208 ***	-0.100 ***	0.878 ***	-0.416 ***	1											
8	Colonial ties	-0.050 ***	-0.045 ***	-0.044 ***	0.000	0.036 **	0.015	0.073 ***	1										
9	Common origin of legal system	0.167 ***	0.099 ***	0.099 ***	-0.024	0.049 ***	0.190 ***	0.093 ***	0.124 ***	1									
10	BIT	0.159 ***	0.080 ***	0.083 ***	-0.037 **	-0.036 **	-0.091 ***	-0.116 ***	-0.021	-0.107 ***	1								
11	RTA	-0.069 ***	-0.261 ***	-0.267 ***	0.093 ***	-0.734 ***	0.407 ***	-0.739 ***	-0.125 ***	0.071 ***	0.04 **	1							
12	Language distance	-0.007	0.122 ***	0.117 ***	0.003	0.028 *	-0.268 ***	-0.023	-0.335 ***	-0.527 ***	0.176 ***	-0.14 ***	1						
13	Religious distance	0.244 ***	0.304 ***	0.308 ***	-0.086 ***	0.369 ***	-0.230 ***	0.270 ***	-0.119 ***	0.066 ***	0.027 *	-0.319 ***	0.227 ***	1					
14	Technological endowment distance	0.037 **	0.136 ***	0.150 ***	-0.117 ***	0.383 ***	-0.109 ***	0.344 ***	-0.026 *	-0.041 ***	-0.058 ***	-0.400 ***	0.180 ***	0.399 ***	1				
		***	***	***	***	***	***	**			***	***	***	***	***				
15	R&D internationalization	0.034 **	0.018	0.016	0.010	0.052 ***	-0.009	0.058 ***	0.017	0.036 **	-0.011	-0.042 ***	-0.066 ***	0.054 ***	0.003	1			
16	Experience in host non-R&D activities	-0.017	0.008	0.005	0.02	0.006	0.021	-0.011	0.028 *	-0.008	0.041 ***	-0.069 ***	-0.028 *	0.068 ***	0.052 ***	0.248 ***	1		
17	Size	0.011	0.006	0.012	-0.04 **	0.024	-0.010	0.025	-0.036 **	-0.023	-0.020	-0.041 ***	0.043 ***	0.033 **	0.171 ***	0.051 ***	0.224 ***	1	
18	Sectoral concentration	-0.024	-0.008	-0.015	0.042 ***	0.015	-0.015	0.014	0.006	-0.013	0.027 *	-0.032 **	0.023	0.054 ***	0.060 ***	0.148 ***	0.062 ***	0.042 ***	1

* p<0.10, ** p<0.05, *** p<0.01. No. of obs. 4033

Table 4 – Probit estimations

Dependent variable	Model 1	Model 2
	Adaptive R&D	Innovative R&D
Economic distance	0.052**	0.007
	(0.020)	(0.016)
IPR distance	-0.050	0.395
	(0.297)	(0.349)
Geographical distance	-0.227**	-0.171*
	(0.105)	(0.088)
Shared borders	-0.027	0.188
	(0.339)	(0.182)
Time difference	0.018	-0.009
	(0.032)	(0.033)
Colonial ties	-0.230	-0.002
	(0.256)	(0.154)
Common origin of legal system	-0.177	0.405***
	(0.208)	(0.134)
BIT	0.103	0.252
	(0.185)	(0.205)
RTA	-0.187	-0.643***
	(0.261)	(0.221)
Language distance	-0.085	0.061
	(0.090)	(0.070)
Religious distance	-0.069	-0.044
	(0.095)	(0.127)
Technological endowment distance	0.011	0.032
	(0.069)	(0.064)
R&D internationalization	1.305***	2.330***
	(0.120)	(0.195)
Experience in host non-R&D activities	0.305***	0.031
	(0.108)	(0.107)
Size	-0.130*	0.059
	(0.070)	(0.059)
Sectoral concentration	-0.078	-0.597***
	(0.153)	(0.128)
Sector fixed-effects	Yes	Yes
Home-country fixed-effects	Yes	Yes
Host-country fixed-effects	Yes	Yes
Number of observations	2764	3809
Wald (chi2) prob.	0	0
Log pseudolikelihood	-259	-407
Number of home-host clusters	345	440

* p<0.10, ** p<0.05, *** p<0.01. Standard errors are clustered by home-host country pairs.

Table 5 – Probit estimations

Dependent variable	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	Adaptive R&D	Innovative R&D	Adaptive R&D	Innovative R&D	Adaptive R&D	Innovative R&D
Economic distance	0.010***	0.001	0.010***	0.001	0.010***	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Positive IPR distance	0.004	-0.472***	-	-	0.005	-0.463***
	(0.107)	(0.100)			(0.107)	(0.100)
Negative IPR distance	-	-	0.196	1.782***	0.197	1.737***
			(0.589)	(0.587)	(0.587)	(0.586)
Geographical distance	-0.049	-0.134	-0.043	-0.190**	-0.044	-0.115
	(0.098)	(0.083)	(0.093)	(0.086)	(0.099)	(0.083)
Shared borders	0.018	-0.029	0.021	-0.118	0.020	-0.048
	(0.291)	(0.207)	(0.289)	(0.224)	(0.291)	(0.207)
Time difference	-0.046	0.036	-0.050*	0.045	-0.049	0.014
	(0.030)	(0.033)	(0.029)	(0.030)	(0.032)	(0.033)
Colonial ties	0.091	0.168	0.091	0.155	0.092	0.153
	(0.232)	(0.177)	(0.232)	(0.194)	(0.232)	(0.179)
Common origin of legal system	-0.302	0.273**	-0.298	0.174	-0.300	0.299**
	(0.217)	(0.126)	(0.207)	(0.133)	(0.219)	(0.126)
BIT	-0.057	0.068	-0.052	0.043	-0.053	0.154
	(0.159)	(0.148)	(0.159)	(0.145)	(0.159)	(0.150)
RTA	-0.375**	-0.389**	-0.388**	-0.330**	-0.386**	-0.437**
	(0.172)	(0.167)	(0.177)	(0.147)	(0.179)	(0.175)
Linguistic distance	-0.099	-0.083*	-0.097	-0.129***	-0.098	-0.072
	(0.078)	(0.047)	(0.073)	(0.050)	(0.079)	(0.047)
Religious distance	0.275***	0.137*	0.281***	0.095	0.281***	0.175**
	(0.074)	(0.073)	(0.072)	(0.065)	(0.076)	(0.075)
Host technological endowment	0.056	-0.027	0.048	-0.031	0.049	-0.053
	(0.057)	(0.050)	(0.055)	(0.053)	(0.056)	(0.049)
R&D internationalization	1.228***	2.220***	1.227***	2.180***	1.227***	2.220***
	(0.100)	(0.172)	(0.100)	(0.178)	(0.100)	(0.172)
Experience in non-R&D activities	0.636***	0.240**	0.633***	0.239**	0.633***	0.228**
	(0.095)	(0.096)	(0.096)	(0.100)	(0.096)	(0.099)
Size	-0.183***	0.009	-0.182***	0.015	-0.183***	0.009
	(0.060)	(0.054)	(0.061)	(0.055)	(0.060)	(0.055)
Sectoral concentration	-0.069	-0.513***	-0.070	-0.514***	-0.070	-0.522***
	(0.138)	(0.116)	(0.138)	(0.119)	(0.138)	(0.118)
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Home-country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Host-country fixed effects	No	No	No	No	No	No
Number of observations	3961	4033	3961	4033	3961	4033
Wald (chi2) prob.	0	0	0	0	0	0
Log pseudolikelihood	-294	-446	-294	-450	-294	-442
Number of home-host clusters	450	472	450	472	450	472

* p<0.10, ** p<0.05, *** p<0.01. Standard errors are clustered by home-host country pairs.

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[i] A notable exception is the stream of research explicitly investigating the differences between host and home country technological endowment (Almeida, 1996, Cantwell & Janne, 1999, Cantwell & Santangelo, 1999, Dunning, 2009).