Patent protection and foreign R&D investment location choices: inventor mobility and policy convergence

Citation for published version (APA):

Park, J., & Belderbos, R. (2022). Patent protection and foreign R&D investment location choices: inventor mobility and policy convergence. *Industrial and Corporate Change*, *31*(4), 1113-1136. https://doi.org/10.1093/icc/dtac018

Document status and date:
Published: 15/07/2022

DOI:
10.1093/icc/dtac018

Document Version:
Publisher's PDF, also known as Version of record

Document license:
Taverne

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy
If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

Download date: 26 Apr. 2024

Industrial and Corporate Change, 2022, **31**, 1113–1136
DOI: https://doi.org/10.1093/icc/dtac018
Advance access publication date: 12 April 2022
Original Article

Patent protection and foreign R&D investment location choices: inventor mobility and policy convergence

Jinhyuck (Joseph) Park[1,*] and René Belderbos[2,3,4]

[1]Strategy/Entrepreneurship Department, NEOMA Business School, 1 rue du Maréchal Juin, Mont-Saint-Aignan 76130, France. e-mail: joseph.park@neoma-bs.fr, [2]Department of Managerial Economics, Faculty of Economics and Business, Strategy and Innovation, KU Leuven, Naamsestraat 69, Leuven B-3000, Belgium. e-mail: rene.belderbos@kuleuven.be, [3]School of Business and Economics, Maastricht University, Tongersestraat 53, Maastricht 6211 LM, The Netherlands and [4]UNU-MERIT, Boschstraat 24, Maastricht 6211 AX, The Netherlands

*Main author for correspondence.

Abstract

We suggest two boundary conditions for the positive role of patent protection in attracting inward foreign R&D investments. Patent protection is less effective in limiting the leakage of nonpatented knowledge through interfirm mobility of employees, and a gradual strengthening of patent protection worldwide diminishes its effect as countries get closer to the intellectual property rights (IPR) frontier. We provide evidence in an empirical analysis of 3393 multinational firms' R&D location choices for 8015 greenfield R&D investments in 105 (potential) host countries, during 2003–2014. The relationship between R&D investment location choices and IPR protection is subject to declining marginal effects and negatively moderated by inventor mobility.

JEL classification: F2, O3

1. Introduction

The internationalization of R&D investments by multinational enterprises (MNEs) has become an important phenomenon in the global economy (e.g., Athukorala and Kohpaiboon, 2010; Harhoff *et al.*, 2014; Rahko, 2016; Belderbos *et al.*, 2017; Branstetter *et al.*, 2018; Kafouros *et al.*, 2018). The rise in cross-border R&D investments has been associated with an increasing geographic dispersion of technological capabilities, the availability of science and engineering personnel in lower-cost locations, and the need to conduct local R&D to adapt products to growing local markets in emerging economies. In particular, countries such as China and India have been increasingly popular destinations for R&D investments.

These trends have accentuated the hazards of conducting R&D in emerging economies due to weaker effective protection of intellectual property and its potential misappropriation by local firms. The recent trade conflict between the United States and China has been motivated by the alleged large-scale theft by Chinese firms of U.S. firms' technologies and intellectual property (USTR, 2018). Several surveys have shown that executives of MNEs view (weak) intellectual property (IP) protection as a challenge for R&D globalization (e.g., EIU, 2004; Potters *et al.*, 2017). Conducting R&D abroad has also been shown to increase the probability of IP infringement from local competitors (Schmiele, 2013).

Prior studies generally agree that MNEs take the protection of their intellectual property into account when deciding if and where to invest in foreign R&D activities. A strong IPR regime as exemplified by patent rights has been found to have positive effects on inward foreign (R&D) investments (Mansfield, 1994; Kumar, 1996; Lee and Mansfield, 1996; Smith, 2001; Branstetter *et al.*, 2006, 2007, 2011; Ito and Wakasugi, 2007; Belderbos *et al.*, 2008a, 2013). In this paper, we argue that, while patent rights are expected to have an important influence on cross-border R&D investments, there are important boundary conditions to the relationship between patent protection and inward R&D investments.

First, prior work has not considered that technological knowledge can have patented and nonpatented elements. Firms can prefer secrecy to patenting as patenting involves the disclosure of the invention (e.g., Cohen *et al.*, 2000). Important parts of knowledge can also be of a tacit nature rather than codified (Brusoni *et al.*, 2005). Tacit knowledge is more difficult to be transferred, absorbed, and utilized because it is highly context-dependent and personal (Polanyi, 1966; Szulanski, 1996). Because of the difficulties of codification, tacit knowledge is less effectively protected by patents.

While this is partially compensated by the generally lower spillovers inherent to tacitness, there is a key channel for the transfer of nonpatented and tacit knowledge: the interfirm mobility of firms' scientists and engineers, which allows for personal interaction and experience replication (Kim and Marschke, 2005; Agarwal *et al.*, 2009; Schmiele, 2013; Tambe and Hitt, 2014; Rahko, 2017). These risks of knowledge spillovers from foreign R&D operations of multinational firms to local firms are not easily combatted by stricter policies and enforcement related to patents, which focus on patented technologies. Hence, if a location is characterized by relatively strong mobility of (R&D) employees, patent protection is less likely to reduce IP hazards and increase a country's attractiveness to R&D investments. Building on the notion that effective IP protection requires safeguards for both patented and nonpatented knowledge protection, we argue that curbs on mobility and IPR protecting reinforce each other's effect on the attractiveness of a host country to R&D investments. Locations that provide both low mobility and strong IPR protection provide the most value to multinational investors aiming to appropriate value from their R&D investments.

Second, since the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) stipulating minimum standards for IPR protection has been implemented, many countries with weaker patent protection policies have narrowed the gap with countries at the patent protection frontier. Catching up may reduce the importance of a strengthening of IPRs, as this provides smaller relative gains to the investing MNEs. Hence, the marginal gains in a country's attractiveness to inward R&D investments may decline, the closer the country's IPR regime is to the IPR "frontier."

In this paper, we illustrate these patterns in a stylized model and test these predictions in an analysis of the relationship between patent protection and cross-border R&D investment location decisions by MNEs. We analyze the location choices for 8015 foreign R&D investments (2003–2014) by 3393 MNEs from 67 home countries across a set of 105 (potential) host countries. We rely on a composite patent protection index based on the Ginarte–Park index of patent rights and a legal enforcement index, to take into account both *de jure* and *de facto* protection of patents rights. R&D employee mobility intensities in potential host countries are measured by changes in patent inventor affiliations corrected for mobility within the same corporate group. Estimating "mixed" (random coefficient) logit models of location choice behavior allowing for investor preference heterogeneity, we find general support for the notion that the effects of strengthening effective patent rights on R&D investment location choices are smaller if host countries exhibit higher degrees of inventor mobility and if patent protection levels are closer to the IPR frontier.

Our paper contributes by connecting two different streams of literature that hitherto have been developed rather separately: the literature on patent protection and inward (R&D) investments (e.g., Mansfield, 1994; Kumar, 1996; Smith, 2001; Branstetter *et al.*, 2006; Ito and Wakasugi, 2007; Belderbos *et al.*, 2013), and the literature on inventor mobility studies (e.g., Almeida and Kogut, 1999; Agrawal *et al.*, 2006; Agarwal *et al.*, 2009; Tambe and Hitt, 2014; Castellaneta *et al.*, 2017) that has verified that mobility of inventors is a channel of knowledge spillovers increasing the risk of IP leakages to collocated firms. To the literature on patent protection, we show that its effectiveness in attracting R&D investment depends crucially on the degree to which a country exhibits employee mobility in R&D—which is an important new insight. To the literature on inventor mobility, we contribute the first analysis of cross-country heterogeneity in mobility rates—while extant studies have focused on mobility in a national context. We show that mobility has consequences not only for incumbent firms and knowledge spillovers but also for the likelihood that new R&D investments are attracted to a location. We suggest that distinguishing between types of technological knowledge and their different consequences for protection mechanisms and appropriation is an important extension for the broader literature on international technology transfer and IPR.

2. Background and theory

We provide further background to our research questions, drawing on the literature on IPR protection, knowledge characteristics, and mobility of (R&D) personnel. Building on these literatures, we develop a simple formal theoretical model of the bounded relationship between IPR protection in a host country and the probability that a multinational firm chooses that country as the location for its R&D investment. The model can be estimated empirically.

2.1 IPR protection, tacit knowledge, and interfirm personnel mobility

Studies have shown that interfirm mobility of personnel, in particular, scientists and engineers, is an important channel of (unintended) knowledge spillovers between firms (e.g., Almeida and Kogut, 1999; Agrawal *et al.*, 2006; Tambe and Hitt, 2014; Morescalchi *et al.*, 2015; Castellaneta *et al.*, 2017; Rahko, 2017). Breschi and Lissoni (2009) found that a part of the explanation of the localized nature of knowledge spillovers is that interfirm mobility of inventors occurs more frequently within than across regions. Studies have also suggested that hiring other firms' inventors and researchers is more likely if they are more productive (e.g., Hoisl, 2007; Palomeras and Melero, 2010) and that it has positive effects on firms' R&D productivity (Maliranta *et al.*, 2009), in particular, if they possess complementary knowledge (Song *et al.*, 2003).

Knowledge leakages abroad through personnel mobility is a particular concern for MNEs investing abroad having to deal with locally hired, and perhaps less loyal, personnel. An example is the misappropriation of knowledge of the U.S. SI group by the Chinese firm Sino Legend, related to the hiring of a former plant manager of the U.S. firm in Shanghai in 2007. The U.S. firm claimed that the theft of its resin formula had allowed the local rival to take its dominant market share in the Chinese market (APFC, 2014). Surveys of MNEs show that employee mobility abroad is a particular concern in the protection of proprietary knowledge and intellectual assets (Schmiele, 2013).[1] Given that mobile employees may transfer nonpatented knowledge or tacit knowledge that cannot easily be embedded in patents (Song *et al.*, 2003), knowledge leakage through personnel mobility is more difficult to counter by enforcing patent rights. Hence, heterogeneous employee mobility rates across countries and the associated hazards of knowledge leakage influence the effectiveness of patent protection in shielding against the misappropriation of knowledge and technological assets of MNEs abroad.

2.2 Convergence in IPR protection policies

Scholars have investigated the roles of IPR protection in relationship with trade, foreign direct investment (FDI), and R&D. The international trade literature has reported that strong patent rights stimulate imports (Maskus and Penubarti, 1995; Ivus, 2010) and exports (Maskus and Yang, 2013). Similarly, strong protection of IPR has been found to be associated with higher levels of inward FDI (e.g., Smith, 2001; Ushijima, 2013), in particular, in patent and technology-intensive sectors (Mansfield, 1994; Smarzynska Javorcik, 2004).

---

[1] A partial mitigation of knowledge dissipation through mobility may be possible if firms build up a tough reputation on patent enforcement (Kim and Marschke, 2005; Agarwal *et al.*, 2009; Ganco *et al.*, 2015), but measures such as noncompete clauses in employment contracts may be required to address this issue more directly (e.g., Garmaise, 2011; Marx *et al.*, 2009; Samila and Sorenson, 2011).

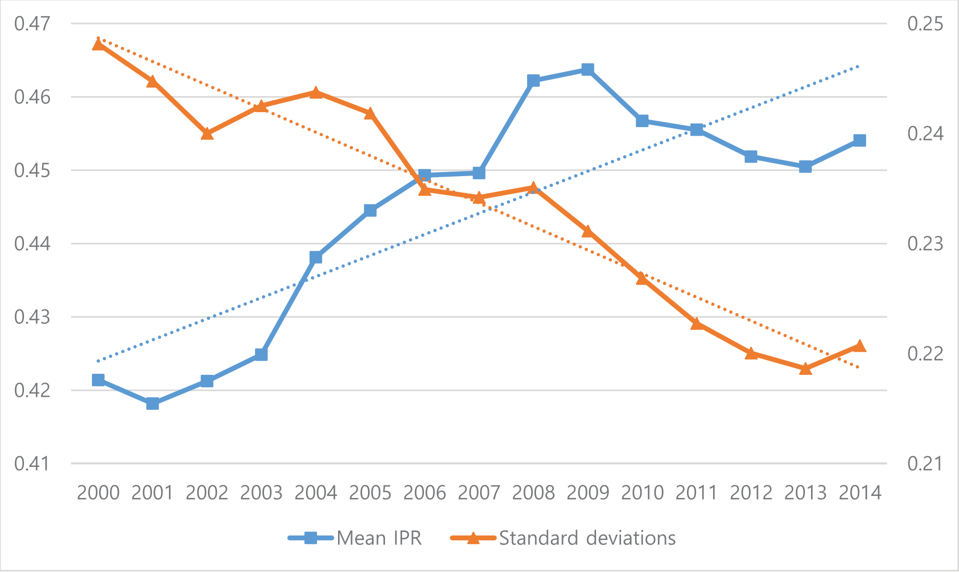

Figure 1. Global patent rights protection scores and their standard deviation

Prior studies generally agree that (cross-border) R&D activities are most sensitive to IPR protection, given their role in knowledge creation (e.g., Mansfield, 1994; Kumar, 1996). Branstetter *et al*. (2006) showed that patent policy reforms in host countries have positive effects on R&D expenditures and technology transfer to foreign affiliates by U.S. firms active in these host countries. Analyzing survey data on Japanese MNEs, Ito and Wakasugi (2007) concluded that R&D activities are directed toward countries with high patent protection.

A recent trend in global IPR is that many countries with weak IPR policies have progressed in narrowing the gap with developed countries at the patent protection frontier. A major influence has been the implementation of TRIPS agreement (Coriat *et al*., 2006; Park, 2008; Hamdan-Livramento, 2009; Kyle and McGahan, 2012). The implementation commenced as early as 1995, but developing countries were allowed transition periods until 2006 or even until 2013 (Yu, 2009). Figure 1 illustrates that the average patent right scores of the countries in our sample have generally increased over time (2000–2014) while the standard deviation has been decreasing, indicating a trend toward convergence at higher levels of protection.[2] The question rises whether IPR is still a distinctive characteristic favoring investment in one country over another if most countries have adopted more substantive IPR policies. Since the effect of a strengthening of IPR protection may depend on its initial level (Allred and Park, 2007), for countries lagging in IPR protection, a smaller gap with the IPR protection "frontier" may imply that a further increase in IPR protection provides smaller relative gains to the investing MNEs.

2.3 Research conjectures

In the Appendix, we illustrate the bounded relationships between IPR protection and the location choice for R&D activities by multinational firms in a simple formal model and derive the conjectures for research more formally. We start from the notion that technological knowledge has patented and nonpatented (e.g., tacit) dimensions. While part of the technological knowledge can be described and codified in patent documents and find protection in patent laws and enforcement, other technologies and the implementation and translation of technologies into innovation involve knowledge that is kept secret or that is tacit and noncodified (Cohen, *et al*., 2002).

---

[2] The patent protection scores combine formal patent protection statutes with an indicator of their actual enforcement (see Section 3).

Although tacit knowledge in general is more difficult to transfer, it can be transferred by face-to-face contacts and interactions between (R&D) personnel (e.g., Polanyi, 1966; Teece, 1986; Szulanski, 1996). Mobility of R&D workers, who have collaborated intensively in the R&D unit, then risks tacit knowledge outflows and misappropriation by other firms (Almeida and Kogut, 1999; Agrawal *et al.*, 2006; Morescalchi *et al.*, 2015), with patent protection providing little means to counteract this. Similarly, mobile personnel are the prime manner in which technological knowledge that is kept secret within the firm can spill over to other firms.

We conceptualize R&D location choice decisions as the challenge of MNEs to appropriate value from (profit from) their foreign R&D investment. We assume that the effective transfer or creation of technological knowledge abroad through the establishment of an R&D unit, T, has two elements, nonpatented knowledge and patented knowledge. Patented and nonpatented knowledge at least partially complement (reinforce) each other, for instance, because translating patented technologies into effective innovations often involves complementary skills or less codified practices drawing on tacit knowledge (e.g., Teece, 1986). The risks of knowledge spillovers and misappropriation by local firms are a negative function of patent protection and a positive function of mobility, where patent protection enhances the appropriation of patented knowledge and cubs on mobility enhance the appropriation of nonpatented knowledge. Following the distance to the frontier argument, the marginal appropriation benefits a firm derives from patent protection decline at higher levels of protection (protection closer to the global frontier). In formal terms, the profitability of R&D by firm i in country j can be expressed as

$$U_{ij} = \beta_0 \bar{w}_j + \beta_1 IPR_j - \beta_2 IPR_j^2 - \beta_3 MOB_j - \beta_4 IPR_j * MOB_j + \beta_5 IPR_j^2 * MOB_j + \varepsilon_{ij}$$

where U_{ij} are profits, $\bar{w}_j$ is a vector of local characteristics, IPR is the distance of IPR protection to the global frontier, MOB is mobility, and$\varepsilon_{ij}$are unobserved firm- and location-specific influences. The attractiveness of a location for R&D investment (the expected profits of the R&D investment) is a positive but declining function of IPR and a negative function of mobility while the positive linear effect of IPR is negatively moderated by mobility. It also follows that the declining marginal effect of IPR (the square term) is mitigated by mobility.[3]

If MNEs compare the different expected profits associated with R&D investment in the different host countries and choose the host country with the highest profits to locate its R&D there, it can be shown that under certain regular distributional properties of the error term in the profit function, the location choice decisions translate into a conditional logit model (e.g., Maddala, 1983: 60–61; Head *et al.*, 1995).

3. Data, variables, and empirical model

We test our predictions in an analysis of the relationship between patent protection and cross-border R&D investment location decisions by MNEs. We analyze the location choices for 8015 foreign R&D investments (2003–2014) by 3393 MNEs from 67 home countries across a set of 105 (potential) host countries. We identify the focal relationships from variations in patent protection and mobility across countries and within countries over time (e.g., changes in patent protection due to participation in the TRIPS agreement). We assume that an individual firm deciding on a location for a specific R&D project in a given year takes the existing state of IPR policies and mobility conditions in each country as given. We discuss the construction of variables and the empirical model below.

3.1 Global cross-border R&D investments

Our source of cross-border R&D investment data is the *FDI markets* database, which provides extensive data on greenfield cross-border FDI projects worldwide. The dataset draws on media information, firm reports, and various other sources regarding FDI (such as regional investment agencies). Information is available on types of FDI (among which R&D), destination countries,

---

[3] In other words, mobility is expected to shift the curve to the left (the linear term interaction) and to make the curve less steep (the quadratic term interaction). See Haans *et al.* (2016).

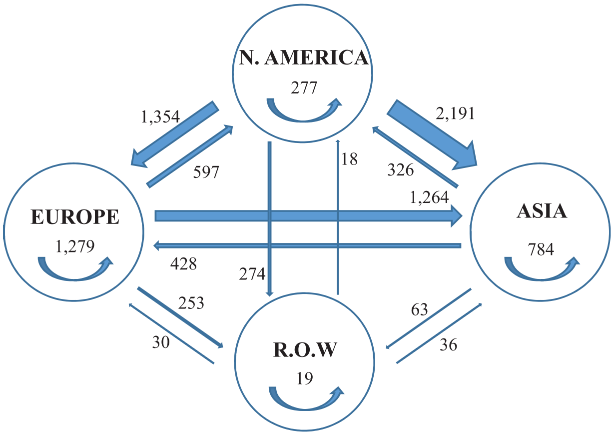

Figure 2. Number of cross-border R&D projects, inter-regional flows, 2003–2014.
Source: Authors' calculations based on the fDi Markets database.

and the origin of investing firms *FDI markets* claims to be representative of global greenfield FDI flows and has been widely used by international organizations such as the OECD, World Bank, and UNCTAD, and by scholars (e.g., Castellani *et al.*, 2013; Castellani and Pieri, 2013; Crescenzi *et al.*, 2013; see OECD, 2016 for more details). Our dataset covers FDI projects from 2003, the first year that the database records FDI information, to 2014.[4] We identified 8465 unique[5] cross-border projects of multinational firms as investments in R&D, which we could confirm by the associated project descriptions. Out of these, 450 projects in 31 countries could not be included in the analysis because the information on key variables such as IPR protection and some control variables was not available; we could include 106 different host countries as potential locations for R&D.[6] Since in the cross-border location choice model the home country is not included as a valid choice, the effective choice set includes 105 countries. As a result, 8015 cross-border R&D investments in 79 countries undertaken by 3393 multinational firms are maintained in the analysis. The number of observations in the conditional logit model is then technically the multiplication of countries in the choice set and the number of projects. As some, mostly less developed, host countries have missing information on a number of variables for early years in the sample (2003–2007 in particular), the average choice set for a focal firm includes a little under 92 countries, and we arrive at 734 271 observations.

Figure 2 describes the cross-regional flows of international R&D investment projects. The largest flows are from North America to Asia, North America to Europe, and from Europe to Asia while intra-European flows are also important. Table 1 shows the top 10 host countries and investing countries in terms of cross-border R&D investments. India has received the largest number of foreign R&D investments, followed by China, the United States, and the UK. U.S. firms account for the largest portion of worldwide R&D investments; before, German and Japanese firms' R&D investments are most frequent in the information & communication technology (ICT), electronics, pharmaceutical, chemical, and machinery industries.

We note the limitation of the use of FDI markets data in that there is no systematic information on the value of R&D investments or technology transfer, as for instance in Branstetter *et al.* (2006) or Kumar (2001). The advantage of the data lies in the detailed patterns of firm-level R&D

---

[4] Our license for the database covers 2014 as the last year of observation.

[5] If multiple projects by the same firm in the same host country in the same year were included, we treated this as one investment decision, as mixed logit models do not allow the inclusion of exact replications of observations. We found 728 not to be unique in this regard. We experimented with using the number of times an investment project by the same firm in the same year in the same country is reported as weight in the logit models but found no appreciable difference in the estimated coefficients.

[6] The countries excluded with the highest numbers of R&D investment projects are Taiwan (169 projects) and the UAE (77 projects). A comparison of the mean values of our focal variables *IPR* and *Mobility intensity* for the omitted and included projects did not reveal substantial differences, suggesting that the risk of selection bias is negligible.

Table 1. Cross-border R&D Investments: top host countries, investing countries, and industries

Top 10 Host countries	Projects[a]	Top 10 Investing countries	Projects[a]	Top 10 Industries	Projects[a]
India	1268	USA	3308	Software & IT services	2378
China	1096	Germany	784	Communications	767
USA	720	Japan	594	Pharmaceuticals	565
UK	568	UK	506	Chemicals	505
Germany	345	France	447	Semiconductors	470
Singapore	335	Switzerland	282	Industrial Machinery, Equipment & Tools	412
France	256	India	215	Automotive Components	361
Canada	221	China	200	Electronic Components	291
Spain	214	Netherlands	193	Business Services	281
Ireland	200	Canada	171	Biotechnology	252

Notes: [a]Projects is the number of R&D investments received, 2003–2014.

project decisions involving multiple home and host countries that can be uncovered. Studies that can rely on the information on the value of R&D or technology are in contrast typically restricted to analyze data of a single home country or analyze aggregate data. The broad coverage of home and host countries in our analysis allows us to determine the global boundary conditions of IPR protection.[7]

3.2 Patent protection and proximity to the frontier

The degree of patent protection in a country is measured by a composite index based on Ginarte and Park's patent right index (GP; Park, 2008) and *Legal System & Property Rights* scores in the *Economic Freedom of the World* report by the Fraser Institute. The GP index is widely used in the literature and is based on statutory information on patent laws. The index consists of five components: coverage, membership of international treaties, duration of protection, enforcement, and restrictions on patent rights, with the patent rights index taken as the unweighted sum. An often voiced criticism of the index is that a statutory indicator may not effectively capture the actual enforcement level of policies (Hu and Png, 2013; Maskus and Yang, 2013). Enforcement is an important consideration for MNEs. For instance, the US Trade Representative recently reported that even though China has introduced a round of revisions to their legal system and made a number of commitments to improve IPR protection, "foreign investors in China continue to voice concerns about lack of transparency, inconsistent enforcement of laws and regulations, weak IPR protection, corruption and a legal system that is unreliable and fails to enforce contracts and judgments" (USTR, 2017: 102). To improve the index, we follow recent works (Hu and Png, 2013; Maskus and Yang, 2013) by multiplying the GP index by a measure of enforcement of (patent) laws, the *Legal System & Property Rights* (LP) index. The *Legal System & Property Rights* index is a composite indicator provided by the Economic Freedom of the World report of the Fraser Institute, measuring "rule of law, security of property rights, an independent and unbiased judiciary, and impartial and effective enforcement of the law." This indicator consists of nine components based on executive and expert survey ratings extracted from the Global Competitiveness Report (World Economic Forum), the International Country Risk Guide (PRS Group), and Doing Business Reports of the World Bank. Utilizing such multiple sources increases the robustness of measurement and time-series information on a wide range of countries. Even though the GP index contains an element of the strength of enforcement opportunities embedded in a country's IP-related laws, it does not take into account the degree to which those laws are actually used in practice. In constructing the IPR indicator, both *de jure* and

---

[7] Using the available information on estimates of capital invested associated with the projects by FDI markets, we observed no differences in average project size between emerging economies such as India and China and developed countries such as the United States. In a supplementary analysis, we found no evidence that our findings are affected by heterogeneity in the size of projects.

de facto IP enforcement laws should be considered as strengthening each other, as with strong enforcement of rather weak laws, or with very weak enforcement of strong laws, the net effect on knowledge protection is likely to be limited. In the supplementary analysis section, we discuss that empirical findings are robust to the use of other (composite) IPR indicators, as long as actual enforcement is taken into account.

Reflecting our prediction concerning the declining marginal effect of augmenting patent protection if countries are closer to the global IPR frontier, our measure of patent protection indicates the proximity of a host country's patent laws and enforcement to the global IPR protection frontier. The convergence or catching-up effect of patent rights is examined by adding the squared term of the IPR indicator. The indicator is constructed as follows:

$$\mathrm{IPR} = \frac{\mathrm{GP\,(t)}}{Max\ GP\,(t)} * \frac{\mathrm{LP\,(t)}}{Max\ LP\,(t)} \tag{1}$$

GP and LP are normalized by the annual maximum value of each index, such that the composite index ranges from 0 to 1. The expression of GP and LP as an index relative to the maximum allows for an unbiased scaling and integration into the IPR index. Given that the GP index is constructed with 5-year time intervals, annual GP scores are linearly interpolated between two scores in a 5-year interval.

3.3 Interfirm inventor mobility intensity

We identify mobile inventors by using patent filing records on inventors and assignees using a methodology established in prior studies (Almeida and Kogut, 1999; Song *et al.*, 2003; Hoisl, 2007; Kim *et al.*, 2009; Marx *et al.*, 2009; Castellaneta *et al.*, 2017). If an inventor is listed on a patent record under assignee firm *A*, but previously was listed on patents filed by assignee firm *B*, then this inventor can be inferred to have moved to a new company. Inventors will generally possess nonpatented knowledge that can be used by rival firms to develop new patents. If such new patents are developed with the mobile inventor as the member of the research team in the firm that receives the mobile inventor, mobility will be identified. Mobile inventors who continue to develop technologies in their new firm environment leave a trace, and in this regard, the indicator of mobility is an appropriate measure of mobility likely to harm the interest of the firm losing the inventor.

One important issue in measuring inventor mobility is the disambiguation of inventor and assignee names. We used harmonized inventor and assignee data from the Crios-Patstat Database (Coffano and Tarasconi, 2014). This database is constructed by a team of researchers at Bocconi University, utilizing name harmonization techniques including correction of spelling errors and written format harmonization (e.g., J. Doe, John Doe, John DOE, JOHN DOE) while homonyms are further distinguished by standardized permanent addresses of inventors (Coffano and Tarasconi, 2014: 17–23). The database has been validated and used in several studies (e.g., Akcigit *et al.*, 2016; Corradini and De Propris, 2017; Conti *et al.*, 2018). While the data available provide information on both EPO and USPTO patents, we use EPO data because they are more reliable in terms of accurate information on addresses of inventors (Morrison *et al.*, 2017).

Since moves to a subsidiary of the same parent firm do not represent interfirm mobility, moving to an assignee with a similar name is not classified as mobility. To rule out that mobility to a subsidiary with a dissimilar name that is, however, controlled by the same parent firm, we further refined our inventor mobility data by using a recently constructed database of consolidated patent ownership by more than 8500 firms worldwide with at least 100 cumulative patents in 2017. Among the 1 620 199 EPO patents filed by firms during 2000–2014 used to construct our mobility measure, 73.1% are matched with the consolidated patent ownership data.[8] Correcting the mobility intensity indicator led to an average reduction in the overall mobility rate in the sample of 3% points, from 11.7% to 8.7%. To avoid possible overestimation of inventor moves,

---

[8] Although this is not a full coverage, the lack of a further consolidation effort for smaller firms is not likely to cause bias, as small firms with small patent holdings are less likely to own multiple (patent holding) subsidiaries and to exhibit potential intrafirm inventor mobility across such subsidiaries.

we also exclude patents with co-assignees (accounting for 7.6% of the patents) and only count one mobility occurrence per year per inventor (accounting for 0.7% of inventors).

The mobility count of a country is defined as the number of times inventors located in the country have changed assignees with different firm ownership during a year. Since identifying mobile inventors through the patent application history is not free from noise, in particular, in representing the timing of inventor mobility (Ge *et al.*, 2016), we use a 3-year moving window to aggregate mobility counts. As our focal variable, we use *Mobility intensity,* i.e., the mobility count divided by the total number of identified inventors in the country during each 3-year period. This is to avoid conflation of mobility with the size of innovative activity in a country and to measure more accurately the likelihood that foreign investors will be confronted with mobile inventors.[9]

If a country only has a few inventors listed on EP patents, which is the case for a number of less developed countries, mobility intensities cannot be calculated accurately enough with this methodology. To maintain these countries in the analysis, we add the dummy variable, *No information on mobility* to the models, which takes the value of 1 for a county in which there are fewer than 150 EP patents registered with host country inventors during the 3-year window. This applies to 51 countries, which together received about 3.5% of the R&D projects. Following our derived model (equation [3] in the Appendix), we add the linear term of mobility as well as the interaction terms with IPR and with its square term. We expect negative signs except for the interaction with the square term. We also include an interaction effect between IPR and *no information on mobility* to confirm that the mobility interaction effect is not driven by the lack of mobility data for the 51 countries. We note that we found consistent results even though we excluded these 51 countries from the choice set for the estimation in the supplementary analysis.

3.4 Control variables

We include a broad set of control variables in the location choice models. As the strength of a country's technological capabilities attracts foreign R&D investments (e.g., Kuemmerle, 1999; Belderbos, 2001; Alcácer and Chung, 2007; Harhoff *et al.*, 2014; Kafouros *et al.*, 2018), we control for annual *R&D intensity* (R&D expenditure over GDP) in a host country. The information is extracted from the World Bank Development Indicators (WBDI).[10] In addition, firms' sensitivity toward IP risk and their benefits from knowledge sourcing in foreign countries can also be a function of the local technological capabilities (Smith, 2001; Belderbos *et al.*, 2008a; Belderbos and Grimpe, 2020). Kafouros *et al.* (2012) observe that firms are more attracted to foreign knowledge pools if IPR protection is relatively weak, as weaker knowledge protection increases opportunities for knowledge sourcing. We interact the R&D intensity with the IPR variable to control for this influence. If the host country's R&D intensity is high, firms may be attracted to the country to source knowledge, with the role of patent rights less pronounced: a negative sign for the interaction effect may be expected.

As a large market size and growth potential of a host country are likely to attract FDI (Barrell and Pain, 1996; Kuemmerle, 1999), a host country's *GDP* (PPP; standardized in 2011 constant international dollar) and *GDP growth* are included. The information is extracted from WBDI. Since low wage levels of R&D workers may attract R&D investments (Kumar, 2001; Zhao, 2006; Belderbos *et al.*, 2009), a variable measuring the average annual dollar earnings of engineers (*R&D wage*) is included, using data from the UBS price and earning reports.[11] We follow prior FDI and R&D studies (Branstetter *et al.*, 2006, 2011) in including variables reflecting the openness of the potential host countries' economies. *Trade openness* is the sum of export and imports of goods and services as a share of GDP. *FDI promotion* indicates the extent to which

---

[9] Our calculated inventor mobility intensity (rate) compares relatively well with a survey of mobile inventors and their employment histories by Ge *et al.* (2016) for the United States. The average annual mobility rate of 11% (1975–2010) compares to 9.1% in our data (1977–2010).

[10] For 16 countries without such information, we predict this by countries' patent stock.

[11] The UBS data provide comparable information for 62 countries. We estimate engineers' annual wages of the countries with no information by regressing wages on GDP per capita and using the predicted values, as engineers' wages (annual earnings) and GDP per capita are highly correlated (the correlation coefficient is 0.87). The wages are for engineers in the electrical engineering sector with a university or technical college degree. This is the closest category in the UBS data related to R&D personnel.

a host country's policies are favorable to FDI. We construct this variable as the average score on Foreign ownership and Investment restrictions in the Global Competitiveness Report. The related questions are "How prevalent is foreign ownership of companies in your country?" and "How restrictive are regulations in your country relating to international capital flows?" Finally, a variable representing *Capital openness* is taken from Chinn and Ito (2006) and measures the extent to which capital account transactions are liberalized, based on statutory information.

The empirical models control for the *Corporate tax rate* (e.g., Basile *et al.*, 2008), with the tax information extracted from *KPMG's online Corporate tax rates table.*[12] Given that we investigate R&D investments, which require highly educated workers, the average years of tertiary schooling, extracted from Barro and Lee (2013), are used to measure *Tertiary Education*. Both geographic and language distances between a home country and a host country could make a potential host country less attractive for FDI (e.g., Belderbos *et al.*, 2017). *Geographic distance* is the great circle distance between the capital cities of the host and home country. We use the index of a common language (*Common language*) between host and home countries provided by Melitz and Toubal (2014). This index is based on whether the two countries share common official and native languages, and to what extent their native languages are linguistically similar. Finally, new R&D projects are more likely to be directed toward a country in which firms have already invested (Belderbos *et al.*, 2017). Prior investment of investing firms is represented by a dummy variable, *Prior investment* taken from the *FDI markets* database. This indicator takes the value 1 if the firm has recorded any types of FDI investments in the host country prior to the focal R&D project, otherwise 0.

We also include controls for government and institutional characteristics. We include the "*Regulation Efficiency*" index from the Economic Freedom of the World report by the Fraser Institute as an indicator of government efficiency. This is a composite indicator relying on 15 different indices related to government regulations and administrative efficiency. The higher the score is, the more administratively efficient the government is, and the lower the regulatory burden is for enterprises. We include an indicator of a country's *Corruption* level, taking the Corruption Perception Index provided by Transparency International, which is based on expert and business surveys.

The variables that are interacted in the empirical models (IPR, Mobility intensity, R&D intensity) are demeaned, such that the estimated coefficients reflect their effects in the mean of the moderating variables. Table 2 presents descriptive statistics of the variables and information on the top and bottom host countries in terms of IPR protection and mobility. As expected, patent protection is generally stronger for developed countries than for less developed countries. Low mobility intensities can also be a feature of less developed countries while the main industrialized countries are not among the top 10 countries with limited inventor mobility. Mean, standard deviations, and correlations are included in Table 3.

3.5 Empirical model

We estimate the conditional logit specification of our derived model. This specification is in line with prior literature on FDI location choice (e.g., Coughlin *et al.*, 1991; Chung and Alcácer, 2002; Basile *et al.*, 2008), which has used discrete choice models such as conditional and mixed logit models to relate the probability that a firm chooses a certain location among a set of potential locations to relevant locational characteristics. The conditional logit model is appropriate when data pertain to individual firm decisions, as is the case in our analysis. The focus on firm decisions at the microlevel, rather than the macrolevel analysis of investments between home and host countries, has the advantage that firm-level factors that vary by location, such as the presence of a firm's earlier investments in the host country, can be taken into account. The discrete choice model is identified by differences in choice (country) characteristics confronting the choosers (firms). Firm characteristics that do not vary by location, such that firm or industry effects cannot

---

[12] For nine countries, no information is available in the KPMG data. In this case, we imputed the corporate tax rates by using tax rates on commercial profits from the WBDI. We note that we are unable to control for R&D tax credits (e.g., OECD, 2016) as data on the b-index are only available for a small subset of countries and years.

Table 2. IPR protection and interfirm inventor mobility intensity: country rankings

	IPR top 10	IPR lowest 10	Mobility intensity top 10	Mobility intensity lowest 10
1	Finland	Bangladesh	Chile	Lithuania
2	Denmark	Angola	Hong Kong	Turkey
3	Germany	Burundi	Jordan	Luxembourg
4	Netherlands	Madagascar	Ukraine	Mexico
5	Norway	Chad	Slovakia	Brazil
6	Sweden	Haiti	China	Hungary
7	Canada	Guyana	Norway	Singapore
8	Switzerland	Venezuela	Australia	Greece
9	Austria	Togo	Japan	Poland
10	United Kingdom	Pakistan	Israel	India

Note: The country rankings are based on average scores of the indicators, 2003–2014.

be included in conditional logit models, as their value would be identical across choices such that they would drop out of the equation (McFadden, 1973).

We adopt a generalized form of the conditional logit model allowing for heterogeneity in investor preferences by estimating random coefficients (e.g., Revelt and Train, 1998; Train, 2003; Hole, 2007). Unlike the conditional logit model, the mixed logit model allows for unknown heterogeneous investor preferences and correlated error terms across locations, e.g., spatial correlation (Alcácer *et al.*, 2018). The estimated coefficients have a mean component that is unbiased across observations, and a random component that reflects variations between observations.

Formally, let $X_{j,t-1}$ be the vector of location-specific characteristics and $Z_{j,t-1}$ a subset of these, and θ_f a vector of randomly distributed weights with zero mean with density $g\left(\theta_f\right)$, then the probability of locating in country j can be formalized as[13]

$$P_j = \int \frac{\exp\left(\beta X_{j,t-1} + \theta_f Z_{j,t-1}\right)}{\sum_n^J \exp(\beta X_{n,t-1} + \theta_f Z_{n,t-1})} g\left(\theta_f\right) d\left(\theta_f\right) \tag{2}$$

The probability that a firm chooses location j from among the set of locations J depends on the relative locational attributes and the coefficients β, but the estimations of these coefficients vary due to the weights θ_f assigned to the different traits. The mixed logit probability is essentially a weighted average of the conditional logit function. The dependent variable is a dummy variable taking the value 1 for the host country that is chosen as the location for the R&D investment; else zero.

In order to obtain the mixed logit probability, the integral of the multiplication of the conditional probability with the density function needs to be calculated. As there is no closed-form solution for the mixed logit probability, coefficients are generated by numerical simulation. We take 50 draws and follow prior work by assuming that the weights are normally distributed. Since there are no *a priori* expectations about which coefficients have random components, we regard all coefficients as random,[14] with $Z_{l,t-1}$ identical to $X_{l,t-1}$ (Revelt and Train, 1998; Chung and Alcácer, 2002; Basile *et al.*, 2008). We report the mean components and the significant random components.

Given that the marginal effects on the probability of investment are not directly reflected in the coefficients of the conditional and mixed logit models, we follow the conventional method to calculate relative magnitudes of effects by examining *odds ratios*: the effect of an explanatory variable on the proportional increase in the probability that a certain location is chosen for R&D investments rather than another. These effects can be calculated by exponentiating the coefficients (e.g., Alcácer and Chung, 2007; Alcácer and Delgado, 2016). We note that given a large number

---

[13] This equation is a generalized version of equation (4) in the Appendix.

[14] Stata mixlogit command allows us to estimate maximum 20 random coefficients. Given that we have 22 coefficients to estimate, we estimate standard coefficients for *no information on mobility* and its interaction term, as we found these coefficients to have insignificant random components in more concise models.

Table 3. Correlation coefficients, means, and standard deviations

	Variable	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	IPR	0.03	0.22																
2	Mobility intensity	0.04	0.40	0.59															
3	R&D intensity	0.03	0.94	0.73	0.48														
4	GDP	26.05	1.69	0.42	0.45	0.36													
5	R&D wage	10.08	0.49	0.87	0.53	0.65	0.39												
6	FDI promotion	1.84	0.24	0.49	0.21	0.22	0.07	0.37											
7	Capital openness	0.64	0.37	0.57	0.23	0.32	0.09	0.59	0.48										
8	Trade openness	90.93	66.38	0.29	0.18	0.08	−0.18	0.41	0.32	0.23									
9	Corporate tax rate	2.70	0.64	−0.12	−0.11	0.05	0.16	−0.21	−0.00	−0.18	−0.34								
10	Prior FDI	0.08	0.27	0.13	0.13	0.10	0.25	0.10	0.04	0.02	0.00	0.01							
11	Common language	0.18	0.17	0.33	0.15	0.17	0.02	0.37	0.20	0.35	0.07	−0.01	0.01						
12	Geographic distance	8.71	0.81	−0.28	−0.13	−0.21	−0.08	−0.28	−0.07	−0.19	−0.09	0.11	−0.03	−0.27					
13	Tertiary education	0.54	0.41	0.67	0.47	0.59	0.39	0.72	0.18	0.45	0.19	−0.19	0.11	0.29	−0.21				
14	GDP growth	3.76	3.61	−0.28	−0.14	−0.24	−0.09	−0.33	0.09	−0.22	0.01	0.05	−0.02	−0.16	0.18	−0.27			
15	Corruption	1.50	0.69	−0.84	−0.45	−0.69	−0.18	−0.77	−0.45	−0.49	−0.30	0.11	−0.05	−0.37	0.18	−0.56	0.23		
16	Regulation Efficiency	1.94	0.15	0.61	0.36	0.34	0.05	0.54	0.57	0.55	0.38	−0.20	0.05	0.30	−0.13	0.44	−0.10	−0.59	
17	No information on mobility	0.53	0.50	−0.68	−0.60	−0.62	−0.51	−0.64	−0.23	−0.25	−0.12	0.00	−0.17	−0.15	0.19	−0.48	0.20	0.53	−0.34

Note: All correlation coefficients are significant at the 5% level. IPR, mobility intensity, and R&D intensity are demeaned. GDP, R&D wage, FDI promotion, geographic distance, corruption, and regulation efficiency are expressed in a natural logarithm.

of choice possibilities (105 foreign countries) in our analysis, the average predicted probability of a specific country being chosen for investment is 0.011 (with a standard deviation of 0.028), such that the odds ratios refer to limited changes in absolute choice probabilities.

4. Empirical results

Table 4 shows the results of the mixed logit models. Model 1 shows the results without the focal variables. We add the focal variable, *IPR* in model 2. The coefficient of IPR in model 2 is positive and significant at the 0.1% level. It can be calculated that the odds that a host country is chosen as the location for an R&D investment increases by 62.9% due to a standard deviation increase in IPR protection. The mobility intensity has a negative sign and is significant at the 0.1% level, with the coefficient implying a 14.6% decrease in the odds of receiving an R&D investment due to a standard deviation increase in the mobility intensity.

In models 3–5, the square term of IPR protection and the interaction term between the IPR protection variable and mobility intensity are included in turn while model 5 includes all variables. The quadratic term of IPR is negative and significant, confirming the declining marginal effects of patent protection if countries' patent rights are closer to the frontier. The interaction with mobility intensity is also negative and significant, implying that higher interfirm mobility of inventors weakens the positive effect of patent protection in line with our predictions. The interaction term between the quadratic IPR and mobility intensity is positive in model 5, as predicted in our theoretical model.

We tested for the presence of declining marginal returns by examining whether the inflection point is in the sample range, and if so, whether the slope of the parabola after the inflection point is significantly negative (Haans *et al.*, 2016). As the marginal effects of IPR vary in the level of mobility intensity in the model, we conduct this test at three different levels of mobility intensity (mobility intensity at the mean minus a standard deviation, mobility intensity at the mean, and mobility intensity at the mean plus a standard deviation). We did not find significantly negative slopes after the inflection point, confirming that the IPR parabola is consistent with declining marginal effects rather than being inverted-U shaped.[15]

We also assess the economic significance of the effects of patent protection on foreign R&D investments. The marginal effects of IPR protection depend on the level of protection and the degree of mobility in the potential host country. In Figure 3, we depict these varying marginal effects, expressed as odds ratios based on the results of model 5. The baseline graph shows the effects of a standard deviation increase in IPR protection—in terms of the proportional increase in the odds that a host country is chosen for investment—at the mean intensity of mobility. The other two graphs depict the effects of IPR protection in case host country mobility is high (a standard deviation higher than the mean), or low (a standard deviation lower than the mean), respectively. In the baseline of mean mobility, the effect of a standard deviation increase in IPR protection in terms of increasing the odds that a country is chosen for R&D investment declines from 214% ($P = 0.000$) in case of low IPR scores to 13% ($P = 0.552$) in case of high IPR scores. In the case of low mobility, this range is between 515% ($P = 0.000$) and –4% ($P = 0.847$), while for high mobility, the range reduces to between 61% ($P = 0.030$) and 32% ($P = 0.159$). The figure illustrates that the effects of patent protection on investment location choice depend importantly on the level of IPR and the mobility intensity of host countries.

We observe that the control variables generally have the expected signs. R&D investments are more likely in countries with strong technological capabilities (high R&D intensity) across all models, as observed in prior studies (e.g., Kuemmerle, 1999; Alcácer and Chung, 2007; Belderbos *et al.*, 2017; Kafouros *et al.*, 2018). *GDP* has the expected positive impact, *R&D wage* is negative and significant, and *FDI promotion* and *Trade openness* have significantly positive coefficients.

---

[15] See Haans *et al.* (2016). The estimated slope after the inflection point is negative but not significant (ß = -1.99, $P = 0.127$) when mobility intensity is at one standard deviation below the sample mean, or when mobility intensity is at the mean (ß = -0.78; $P = 0.477$). When mobility intensity is at a standard deviation above the mean, the inflection point is beyond the sample maximum and no negative slope is observed within the sample.

Table 4. Heterogeneous effects of patent protection on foreign R&D location choice

	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**	**Model (5)**
IPR		2.217***	3.398***	2.644***	3.679***
		(0.227)	(0.326)	(0.220)	(0.519)
IPR*IPR			−4.549***		−5.119***
			(0.900)		(1.121)
IPR*Mobility intensity				−2.035***	−5.090***
				(0.333)	(0.762)
IPR*IPR*Mobility intensity					10.239***
					(2.134)
Mobility intensity	−0.514***	−0.717***	−0.697***	−0.384***	−0.298***
	(0.040)	(0.043)	(0.043)	(0.068)	(0.078)
R&D intensity	0.270***	0.490***	0.376***	0.441***	0.444***
	(0.025)	(0.042)	(0.047)	(0.044)	(0.057)
Log(GDP)	0.942***	0.916***	0.916***	0.911***	0.915***
	(0.018)	(0.020)	(0.019)	(0.019)	(0.024)
Log(Wage)	−2.125***	−2.239***	−2.224***	−2.227***	−2.187***
	(0.103)	(0.110)	(0.108)	(0.108)	(0.139)
Log(FDI Openness)	1.774***	1.524***	1.665***	1.695***	1.669***
	(0.144)	(0.135)	(0.149)	(0.164)	(0.169)
Capital Openness	0.217*	0.071	0.050	0.116	0.124
	(0.095)	(0.094)	(0.095)	(0.097)	(0.095)
Trade Openness	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Corporate Tax	−0.236***	−0.143***	−0.125***	−0.084**	−0.134**
	(0.032)	(0.029)	(0.031)	(0.031)	(0.045)
Firm's Prior Investment	1.201***	1.111***	1.099***	1.107***	1.051***
	(0.068)	(0.062)	(0.061)	(0.075)	(0.064)
Common Language	1.502***	1.538***	1.586***	1.571***	1.625***
	(0.104)	(0.103)	(0.098)	(0.103)	(0.147)
Log(Geographic distance)	−0.180***	−0.149***	−0.154***	−0.146***	−0.145***
	(0.021)	(0.020)	(0.019)	(0.023)	(0.020)
Tertiary education	0.367***	0.309***	0.362***	0.290***	0.250***
	(0.051)	(0.053)	(0.053)	(0.052)	(0.057)
GDP growth	0.012*	−0.003	−0.004	−0.001	−0.001
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Log(Corruption)	−0.100*	0.035	−0.041	0.040	−0.036
	(0.044)	(0.062)	(0.055)	(0.056)	(0.058)
Log(Regulation Efficiency)	1.201***	1.187***	0.992***	1.201***	1.046***
	(0.153)	(0.157)	(0.161)	(0.157)	(0.167)
No info on mobility	−1.348***	−0.806***	−0.662***	−0.616***	−0.470***
	(0.074)	(0.069)	(0.071)	(0.071)	(0.080)
IPR*R&D intensity		−1.289***	−0.874***	−1.242***	−0.978***
		(0.138)	(0.167)	(0.137)	(0.183)
IPR*No info on mobility		3.267***	1.965***	2.544***	0.585
		(0.328)	(0.425)	(0.378)	(0.578)
#. host countries (mean/max)	92/105	92/105	92/105	92/105	92/105
#. firms	3393	3393	3393	3393	3393
#. R&D projects	8015	8015	8015	8015	8015
Simulated Log-likelihood	−25 743.7	−25 539.8	−25 516.8	−25 520.8	−25 509.2
Wald chi^2	7194.4***	7502.0***	8120.8***	7747.2***	6833.2***
Observations	734 271	734 271	734 271	734 271	734 271

Notes: Results of mixed (random parameter) logit models. All coefficients except those for No info on mobility and its interaction are treated as random components. The standard deviations of the random parameters are reported in the online Appendix. Clustered standard errors at the firm level in parentheses: $^{***}P < 0.001$,
$^{**}P < 0.01$,
$^{*}P < 0.05$.

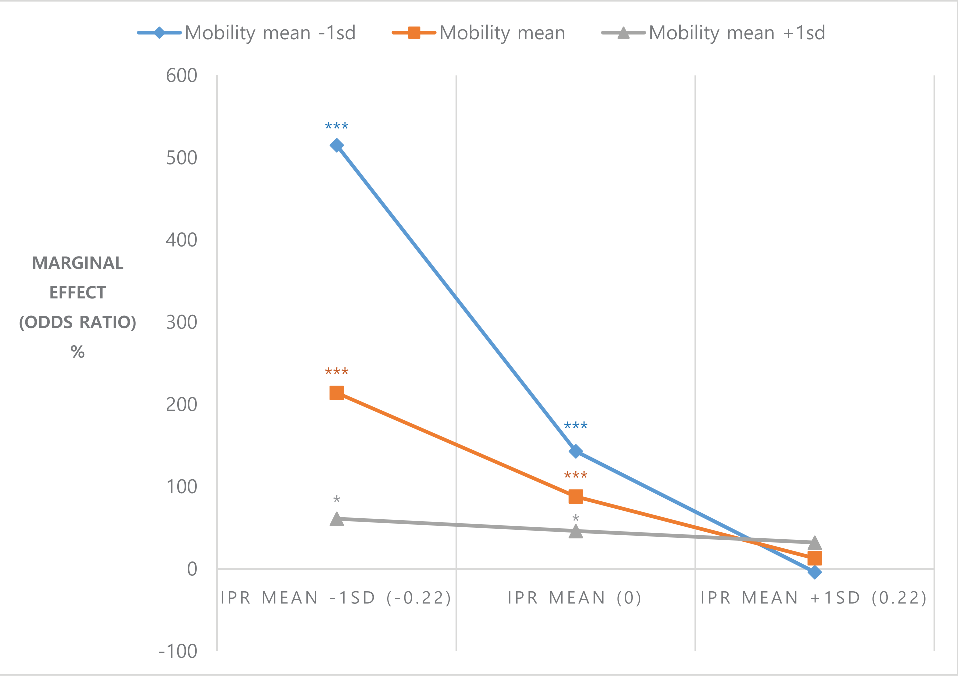

Figure 3. Marginal effects: The effect of patent protection on the increase in the odds of a country being chosen for R&D investment, as a function of inventor mobility intensity.
Notes: Odds ratios are based on exponentiated coefficients and a standard deviation increase in IPR. Statistical significance of estimated effects is expressed in asterisks: *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$.

Capital openness and *Corporate tax rate* show the expected signs but the former is not significant in the full model. The significantly positive coefficient on *Prior investment* confirms previous findings that R&D projects are more likely to be directed toward a country in which firms have existing operations. *Common language* and *tertiary education* increase the probability of hosting foreign R&D while *geographic distances* reduce it, in line with expectations. As expected, *Corruption* deters R&D investments whereas government efficiency (*Regulation Efficiency*) attracts them. The latter effect is not significant in the main model, which might be ascribed to high correlations with other variables (such as *IPR* and *R&D intensity*). Presumably, due to the same reason, *GDP growth* is not significant in the full specification. We note that two insignificant variables are significant in the control-only model with the expected signs.

The interaction between *IPR* and *R&D intensity* is negatively significant. This suggests that in countries with strong R&D and knowledge resources, foreign investors are less sensitive to IPR, since they may focus more on local knowledge sourcing than knowledge creation. *No information on mobility* has a negative and significant coefficient with the full specification, which may be expected as this dummy variable captures whether a country has only a few patent applications and is technologically little developed. The interaction of IPR with *No information on mobility* is negative but insignificant in the full model.

4.1 Robustness tests

We conducted a number of supplementary analyses to examine the robustness of our findings, results, and details, which are relegated to an Appendix separately made available. First, mobility data derived from patent data may lack precision due to the difficulty to identify inventors with homonyms as identical or different persons.[16] We therefore further examined the sensitivity of the mobility data to see if results hold after we apply a rough correction based on the expected occurrences of name similarities. In countries with greater ethnic homogeneity (e.g., in Korea or Japan), family names also have much greater homogeneity and namesakes are more difficult to disentangle from mobile inventors. Using the ethnic fractionalization score of Alesina *et al*. (2003) and Drazanova (2020), we distinguish between countries with high (higher than the median) and low ethnic homogeneity. In the sensitivity analysis, we observe consistent significant effects of mobility intensity for high- and low-homogeneity countries, but the mobility intensity interaction effect is smaller for the high-homogeneity countries. This suggests that the mobility intensity measure may, indeed, be less precisely measured and overestimate mobility in countries with greater name similarities while support for our conjectures remains strong. We also found consistent effects if we left out the countries from the empirical model for which no mobility measure could be constructed, if we constructed mobility intensity measures based on USPTO data rather than EPO data, if we used a 5-year window rather than a 3-year window to calculate mobility intensities, and if we increase the threshold for exclusion of mobility intensity measures (no information on mobility) to 250 patents.

Second, we examined whether there is evidence that firms first compare similar countries for investment, such that not all country location choices are equal substitutes. Such a notion can be tested empirically by estimating nested logit models (Disdier and Mayer, 2004), distinguishing "nests" of more comparable countries. We estimated a model distinguishing low-income, middle-income, and high-income countries. The empirical results did not readily suggest that such group-specific comparisons are prevalent. Although middle-income countries (which include India and China) were found to be significantly more attractive, the hypothesis that the nested logit model was a significant improvement over the conditional logit model was not supported ($P = 0.585$). We also found consistent results in an alternative nested logit model when host countries are grouped in geographical regions (i.e., Asia vs. Europe vs. America vs. Africa). No systematic differences across groups were observed, and again the hypothesis that this model is to be preferred over a conditional logit model was not supported ($P = 0.457$).

Third, we explored alternative measures for the strength of IPR protection. If we omit one of the five dimensions from the Ginarte–Park index (the legal provisions for enforcement) and then recalculate the IPR index, we obtain similar but statistically slightly weaker results. This is not unexpected because the "enforcement" part in the GP index is representing the legal means to enforce while the legal systems index that we use to enhance the measure of IPR strength represents the actual use of these legal means, making the combined indicator the strongest.[17] Similarly, statistically weaker results are found if we use (full) GP index only. In contrast, if we use the legal systems (LP) indicator only or combine the GP indicator with an alternative indicator of practical enforcement, the Impartial Courts index, we again find highly consistent results. The Impartial Courts index from the Global Competitiveness Report survey asking executives to assess the degree of impartiality and quality of the legal system for private businesses. We conclude that a practical enforcement correction on legal IPR indicators is important to reflect the strength of the IPR regime as it is likely to be assessed by MNEs.

Finally, we found consistent results for subsamples of investments in high-tech and low-tech industries, when we omit 27 countries that did not receive any investment, and if we control for potential effects of size heterogeneity effects in R&D projects. We also found consistent results in an analysis of a combined sample of R&D entries through mergers and acquisitions (M&A) and greenfield investments, but weaker results when we examined the observations on locations of technology-oriented M&As only. The latter may be due to the different motives that may be behind M&A, including the need to do business in a certain country despite its IPR regime.

---

[16] In addition, Frake (2017) notes that patenting by individual researchers may make them more easily mobile, but this may apply not too differently across countries.

[17] The correlation between the enforcement part in GP and the effective legal system score from the Frasier Institute is 0.62, smaller than the correlation between the overall GP index and the effective legal system score (0.72). This suggests that the legal systems indicator does, indeed, bring in an additional element in measuring effective IPR regimes.

5. Conclusions

This study examines the heterogeneous effects of patent protection on multinational firms' foreign R&D location choices. Considering that the benefits of firms' local R&D depend on appropriating benefits of both patented and nonpatented technologies, we derive the prediction that the effectiveness of patent rights protecting patented technologies is reduced by stronger mobility of local R&D personnel associated with the leakage of tacit and nonpatented knowledge. In addition, we predict that the marginal effect of patent protection on R&D investment location choices is declining when a country's IPR policies get closer to the global IPR frontier. Drawing on a large set of cross-border R&D investment data and a patent protection indicator that also considers the actual enforcement of patent rights, we confirm that high levels of interfirm inventor mobility deter foreign R&D and reduce the effect of patent protection on R&D investment location choices while the marginal effects of patent protection are declining at higher levels. The estimated IPR effects and the moderating influences are economically significant, with effect sizes decreasing or increasing strongly depending on the existing level of IPR protection relative to the IPR protection frontier and host countries' inventor mobility.

Our findings are consistent with the notion that technology transfer and firms' aims to appropriate the fruits of (international) R&D involve two types of knowledge that are complementary in nature: patented technological knowledge, and technological knowledge that is kept secret or more tacit in nature. Firms need to be able to build on both types of knowledge to exploit technological knowledge in marketable innovations, but patent rights are only able to provide effective protection to patented and patentable technological knowledge. While the limitations of patent rights have been discussed in the literature on R&D and appropriation (e.g., Cohen *et al.*, 2002), this notion has not been considered in the literature on international R&D and IPR regimes (e.g., Branstetter *et al.*, 2006; Belderbos *et al.*, 2008a,b, 2013). We show that the effectiveness of patent protection for attracting R&D investment depends crucially on the degree to which a country exhibits employee mobility in R&D. We suggest that distinguishing between types of technological knowledge and their different consequences for protection mechanisms and appropriation is an important extension for the broader literature on international technology transfer and IPR.

Our paper also contributes to the literature on interfirm employee mobility (e.g., Song *et al.*, 2003; Hoisl, 2007; Breschi and Lissoni, 2009; Maliranta *et al.*, 2009; Palomeras and Melero, 2010; Tambe and Hitt, 2014; Cheyre *et al.*, 2015; Ganco *et al.*, 2015; Rahko, 2017) by showing that such mobility can reduce the effectiveness of patent protection policies. We contribute an analysis of cross-country heterogeneity in mobility rates and show that mobility has consequences not only for incumbent firms and knowledge spillovers but also for the probability that new R&D investments are attracted to a location. This aspect has until now remained underexposed since the prior literature has tended to focus on mobility in a single country. Our findings provide support for the suggestion in prior studies (Garmaise, 2011; Marx *et al.*, 2009; Samila and Sorenson, 2011; Castellaneta *et al.*, 2017) that under high employee mobility, other policies than patent rights enforcement, such as trade secret protection and enforcement of anticompete clauses in employment contracts may be more effective to combat misappropriation of knowledge and technologies. Our analysis could not be extended to trade secret protection, because of current data restrictions, with country data on such protection only available for a limited number of (OECD) countries (Lippoldt and Schultz, 2014). Clearly, studying these complementary IPR protection policies in the context of MNEs and international R&D is a fruitful avenue for future research.

Our study also contributes to the literature on technology asymmetry in FDI (e.g., Shaver and Flyer, 2000; Alcácer and Chung, 2007; Belderbos *et al.*, 2008a,b; Ushijima, 2013; Driffield *et al.*, 2016). Our results also showed that there are differences in responses to IPR policies in a function of the technological capabilities and R&D intensity of host counties, a notion that has received attention in prior literatures on patent systems and growth (Allred and Park, 2007; Kim *et al.*, 2012). While the focus of our paper has been on the appropriation of MNEs' knowledge abroad, knowledge sourcing considerations render IPR protection less important. Such heterogeneity is likely to become more important due to the rise of MNEs based in emerging economies and their investments in countries with stronger technological capabilities.

Our results suggest a number of policy implications. Policy makers should be aware that the effectiveness of patent protection policies in attracting FDI may be reduced in function of the degree of catching up with IPR policies in developed countries. Second, patent protection is less effective if it is accompanied by high employee mobility rates of R&D personnel. This implies that attention also needs to be paid to regulations on trade secrets protection and enforcement of anticompetition clauses in employment contracts, as these can play a complementary role in attracting R&D investments. Third, patent protection is less of an issue if a host country with strong technological capabilities seeks to attract R&D investments by firms with a knowledge sourcing objective.

We note an important caveat to our findings, if these are to be interpreted as informing on host country policies that can attract R&D investments to foster innovation and growth. Given that a strong IPR regime is inherently preventing IP misappropriation from a potential knowledge outflow from foreign R&D activities, the net social benefits of increasing IPR protection are *a priori* unclear. Weaker patent rights and greater mobility of inventors are not only an IP threat for foreign investors but also represent channels for knowledge spillovers to local firms (e.g., Song *et al.*, 2003; Maliranta *et al.*, 2009; Tambe and Hitt, 2014). For host countries, strengthening IPR policies may pose a trade-off between attracting foreign R&D investments (including those from the most technologically capable firms), and a lower likelihood that each of these investments produces wider benefits to the local economy.

Our study has a number of limitations, of which we mention the most salient ones. First, our data on cross-border greenfield R&D investment projects did not contain the accurate information on the value of R&D investments or technology transfer, as for instance in Branstetter *et al.* (2006) or Kumar (2001). The advantage of our approach is the analysis of detailed patterns of firm-level R&D project decisions involving multiple home and host countries while studies that can rely on the information on the value of R&D or technology are restricted to analyze data of single home country or analyze aggregate data. The broad coverage of home and host countries in our analysis allows us to determine the global boundary conditions of IPR protection. Although we found no evidence that our findings are affected by heterogeneity in the size of projects, future research should endeavor to pair broad coverage with the information on the value of R&D investment. This would also help to draw more precise implications as to the effects of policy.

Second, we relied on estimates of mobility of R&D personnel across host countries derived from inventor and assignee information in patent data, which is known to be noisy (Ge *et al.*, 2016; Frake, 2017). Preferably, mobility estimates involve inventor surveys and web-mining techniques to gather self-reported profiles (e.g., Serrano and Ziedonis, 2018); but at this moment, it is not feasible to do this on a large scale and in a cross-country setting. Third, we conceptualized R&D investment location decisions as individual decisions by multinational firms, which take into account whether there is a prior R&D unit in the country. Yet, multinational firms may take their entire global portfolio of R&D units into account when deciding on new R&D investment locations in a complex trade-off between scale, redundancy, and diversity (Kim, 2015; Kafouros *et al.*, 2018; Belderbos, De Michiel, Lokshin, 2022). Future research could further develop such a portfolio approach to global R&D, in which preferably also a distinction is made between research on the one hand and development activities on the other hand (e.g., Kuemmerle, 1999; Belderbos *et al.*, 2009).

Fourth, our analysis abstracted from specific measures firms could take with the aim to limit knowledge spillovers. Greater control over foreign R&D units by assigning home country employees and managers, and segmentation of tasks across geographically dispersed R&D sites for international R&D projects have been proposed as organizational mechanisms to reduce effective knowledge spillovers between collocated firms (Alcácer and Zhao, 2012; Nandkumar and Srikanth, 2016; Berry, 2017; Belderbos, Kazimierczak, Goedhuys, 2021; Belderbos *et al.*, 2021b). In general, foreign affiliates have different means at their disposal, such as a greater reliance on secrecy, to seek to contain knowledge outflows (e.g., De Faria and Sofka, 2010; Veugelers and Cassiman, 2004). Future work should take into account potential heterogeneity in the relationship between R&D internationalization and IPR environments due to differences in firms' organizational strategies.

Finally, although at our detailed level of analysis focusing on individual firms' decisions on R&D locations IPR policies can be taken as exogenous, at a broader and longer-term level, large-scale MNE investments in a host country can influence such policies, as well as its technological capabilities and mobility patterns. Foreign R&D investment, IPR protection, mobility, and technology development will influence each other in more complex ways. These complex relationships will remain an important subject of future research.

Acknowledgments

The authors made equal contributions to this research. The authors wish to thank two anonymous reviewers, Pierre Mohnen, John Hagedoorn, Katrin Hussinger, Keun Lee, Boris Lokshin, and participants at the 5th Technology & Innovation Community Meeting (Leuven), the 4th Geography of Innovation Conference (Barcelona), and seminars at UNU-MERIT for comments on earlier drafts. René Belderbos acknowledges financial support from the Research Foundation Flanders (FWO) under grant No. G075520N. Jinhyuck (Joseph) Park acknowledges support from UNU-MERIT.

Supplementary data

Supplementary materials are available at *Industrial and Corporate Change* online.

References

Agarwal, R., M. Ganco and R. H. Ziedonis (2009), 'Reputations for toughness in patent enforcement Implications for knowledge spillovers via inventor mobility,' *Strategic Management Journal*, **30**(13), 1349–1374.

Agrawal, A., I. Cockburn and J. McHale (2006), 'Gone but not forgotten: knowledge flows, labor mobility, and enduring social relationships,' *Journal of Economic Geography*, **6**(5), 571–591.

Akcigit, U., S. Baslandze and S. Stantcheva (2016), 'Taxation and the international mobility of inventors,' *American Economic Review*, **106**(10), 2930–2981.

Alcácer, J. and W. Chung (2007), 'Location strategies and knowledge spillovers,' *Management Science*, **53**(5), 760–776.

Alcácer, J., W. Chung, A. Hawk and G. Pacheco-de-Almeida (2018), 'Applying random coefficient models to strategy research: identifying and exploring firm heterogeneous effects,' *Strategy Science*, **3**(3), 533–553.

Alcácer, J. and M. Delgado (2016), 'Spatial organization of firms and location choices through the value chain,' *Management Science*, **62**(11), 3213–3234.

Alcácer, J. and M. Zhao (2012), 'Local R&D strategies and multilocation firms: the role of internal linkages,' *Management Science*, **58**(4), 734–753.

Alesina, A., A. Devleeschauwer, W. Easterly, S. Kurlat and R. Wacziarg (2003), 'Fractionalization,' *Journal of Economic Growth*, **8**(2), 155–194.

Allred, B. B. and W. G. Park (2007), 'Patent rights and innovative activity: evidence from national and firm-level data,' *Journal of International Business Studies*, **38**(6), 878–900.

Almeida, P. and B. Kogut (1999), 'Localization of knowledge and the mobility of engineers in regional networks,' *Management Science*, **45**(7), 905–917.

APFC (Asia Pacific Foundation of Canada). (2014), 'Intellectual property rights challenges facing foreign and Canadian businesses in China: a survey of literature,' Report, APFC, (October). Vancouver.

Athukorala, P. C. and A. Kohpaiboon (2010), 'Globalization of R&D by US-based multinational enterprises,' *Research Policy*, **39**(10), 1335–1347.

Barrell, R. and N. Pain (1996), 'An econometric analysis of US foreign direct investment,' *The Review of Economics and Statistics*, **78**(2), 200–207.

Barro, R. J. and J. W. Lee (2013), 'A new data set of educational attainment in the world, 1950-2010,' *Journal of Development Economics*, **104**, 184–198.

Basile, R., D. Castellani and A. Zanfei (2008), 'Location choices of multinational firms in Europe: the role of EU cohesion policy,' *Journal of International Economics*, **74**(2), 328–340.

Belderbos, R. (2001), 'Overseas innovations by Japanese firms: an analysis of patent and subsidiary data,' *Research Policy*, **30**(2), 313–332.

Belderbos, R., F. De Michiel. and B. Lokshin (2022), 'R&D in foreign subsidiaries at or below the global R&D frontier,' *Working paper*, Management International Review.

Belderbos, R., K. Fukao and T. Iwasa (2009), 'Foreign and domestic R&D investment,' *Economics of Innovation and New Technology*, **18**(4), 369–380.

Belderbos, R. and C. Grimpe (2020), 'Learning in foreign and domestic value chains–The role of opportunities and capabilities,' *Industrial and Corporate Change*, **29**(6), 1431–1450.

Belderbos, R., M. Kazimierczak and M. Goedhuys (2021a), 'Trademarks, patents, and the appropriation strategies of incumbents: the scope of new firm formation in European regions,' *Regional Studies*, **56**(2), 210–226.

Belderbos, R., B. Leten and S. Suzuki (2013), 'How global is R&D? Firm-level determinants of home-country bias in R&D,' *Journal of International Business Studies*, **44**(8), 765–786.

Belderbos, R., B. Leten and S. Suzuki (2017), 'Scientific research, firm heterogeneity, and foreign R&D locations of multinational firms,' *Journal of Economics & Management Strategy*, **26**(3), 691–711.

Belderbos, R., E. Lykogianni and R. Veugelers (2008a), 'Strategic R&D location in European manufacturing industries,' *Review of World Economics*, **144**(2), 183–206.

Belderbos, R., E. Lykogianni and R. Veugelers (2008b), 'Strategic R&D location by multinational firms: spillovers, technology sourcing, and competition,' *Journal of Economics and Management Strategy*, **17**(3), 759–779.

Belderbos, R., J. Park and M. Carree (2021b), 'Do R&D investments in weak IPR countries destroy market value? The role of internal linkages,' *Strategic Management Journal*, **42**(8), 1401–1431.

Berry, H. (2017), 'Managing valuable knowledge in weak IP protection countries,' *Journal of International Business Studies*, **48**(7), 787–807.

Branstetter, L., R. Fisman, C. F. Foley and K. Saggi (2007), 'Intellectual property rights, imitation, and foreign direct investment: theory and evidence,' (No. w13033). National Bureau of Economic Research.

Branstetter, L., R. Fisman, C. F. Foley and K. Saggi (2011), 'Does intellectual property rights reform spur industrial development?' *Journal of International Economics*, **83**(1), 27–36.

Branstetter, L. G., R. Fisman and C. F. Foley (2006), 'Do stronger intellectual property rights increase international technology transfer? Empirical evidence from U.S. firm-level panel data,' *Quarterly Journal of Economics*, **121**(1), 321–349.

Branstetter, L. G., B. G. Glennon and J. B. Jensen (2018), "The IT Revolution and the Globalization of R&D," *NBER Working Paper No. 24707*.

Breschi, S. and F. Lissoni (2009), 'Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows,' *Journal of Economic Geography*, **9**(4), 439–468.

Brusoni, S., O. Marsili and A. Salter (2005), 'The role of codified sources of knowledge in innovation: empirical evidence from Dutch manufacturing,' *Journal of Evolutionary Economics*, **15**(2), 211–231.

Castellaneta, F., R. Conti and A. Kacperczyk (2017), 'Money secrets: how does trade secret legal protection affect firm market value? Evidence from the uniform trade secret act,' *Strategic Management Journal*, **38**, 834–853.

Castellani, D., A. Jimenez and A. Zanfei (2013), 'How remote are R&D labs? Distance factors and international innovative activities,' *Journal of International Business Studies*, **44**(7), 649–675.

Castellani, D. and F. Pieri (2013), 'R&D offshoring and the productivity growth of European regions,' *Research Policy*, **42**(9), 1581–1594.

Cheyre, C., S. Klepper and F. Veloso (2015), 'Spinoffs and the mobility of US merchant semiconductor inventors,' *Management Science*, **61**(3), 487–506.

Chinn, M. D. and H. Ito (2006), 'What matters for financial development? Capital controls, institutions, and interactions,' *Journal of Development Economics*, **81**(1), 163–192.

Chung, W. and J. Alcácer (2002), 'Knowledge seeking and location choice of foreign direct investment in the United States,' *Management Science*, **48**(12), 1534–1554.

Coffano, M. and G. Tarasconi (2014), 'CRIOS-Patstat database: sources, contents and access rules,' *CRIOS Working Paper, (1)*, Center for Research on Innovation, Organization and Strategy.

Cohen, W. M., A. Goto, A. Nagata, R. R. Nelson and J. P. Walsh (2002), 'R&D spillovers, patents and the incentives to innovate in Japan and the United States,' *Research Policy*, **31**(8–9), 1349–1367.

Cohen, W. M., R. R. Nelson and J. P. Walsh (2000), 'Protecting their intellectual assets: appropriability conditions and why US manufacturing firms patent (or not),' *NBER working paper No. w7552*. National Bureau of Economic Research.

Conti, C., M. L. Mancusi, F. Sanna-Randaccio, R. Sestini and E. Verdolini (2018), 'Transition towards a green economy in Europe: innovation and knowledge integration in the renewable energy sector,' *Research Policy*, **47**(10), 1996–2009.

Coriat, B., F. Orsi and C. d'Almeida (2006), 'TRIPS and the international public health controversies: issues and challenges,' *Industrial and Corporate Change*, **15**(6), 1033–1062.

Corradini, C. and L. De Propris (2017), 'Beyond local search: bridging platforms and inter-sectoral technological integration,' *Research Policy*, **46**(1), 196–206.

Coughlin, C. C., J. V. Terza and V. Arromdee (1991), 'State characteristics and the location of foreign direct investment within the United States,' *The Review of Economics and Statistics*, **73**, 675–683.

Crescenzi, R., C. Pietrobelli and R. Rabellotti (2013), 'Innovation drivers, value chains and the geography of multinational corporations in Europe,' *Journal of Economic Geography*, **14**(6), 1053–1086.

De Faria, P. and W. Sofka (2010), 'Knowledge protection strategies of multinational firms—A cross-country comparison,' *Research Policy*, **39**(7), 956–968.

Disdier, A. C. and T. Mayer (2004), 'How different is Eastern Europe? Structure and determinants of location choices by French firms in Eastern and Western Europe,' *Journal of Comparative Economics*, **32**(2), 280–296.

Drazanova, L. (2020), 'Introducing the Historical Index of Ethnic Fractionalization (HIEF) dataset: accounting for longitudinal changes in ethnic diversity,' *Journal of Open Humanities Data*, **6**(1), 1–8.

Driffield, N., J. H. Love and Y. Yang (2016), 'Reverse international knowledge transfer in the MNE: (Where) does affiliate performance boost parent performance?' *Research Policy*, **45**(2), 491–506.

Economist Intelligence Unit (EIU). (2004), 'Report. Scattering the seeds of invention: the globalisation of research and development (September).' London, UK, New York, Hong Kong.

Frake, J. (2017), 'Signals or shackles: how patents affect inventor mobility and entrepreneurship,' *Working paper*, University of Maryland.

Ganco, M., R. H. Ziedonis and R. Agarwal (2015), 'More stars stay, but the brightest ones still leave: job hopping in the shadow of patent enforcement,' *Strategic Management Journal*, **36**(5), 659–685.

Garmaise, M. J. (2011), 'Ties that truly bind: noncompetition agreements, executive compensation, and firm investment,' *Journal of Law, Economics, and Organization*, **27**(2), 376–425.

Ge, C., K. W. Huang and I. P. Png (2016), 'Engineer/scientist careers: patents, online profiles, and misclassification bias,' *Strategic Management Journal*, **37**(1), 232–253.

Haans, R. F., C. Pieters and Z. L. He (2016), 'Thinking about U: theorizing and testing U-and inverted U-shaped relationships in strategy research,' *Strategic Management Journal*, **37**(7), 1177–1195.

Hamdan-Livramento, I. M. (2009), 'How compliant are developing countries with their TRIPS obligations?' *(No. CEMI-WORKINGPAPER-2009-001)*.

Harhoff, D., E. Mueller and J. Van Reenen (2014), 'What are the channels for technology sourcing? Panel data evidence from German companies,' *Journal of Economics & Management Strategy*, **23**(1), 204–224.

Head, K., J. Ries and D. Swenson (1995), 'Agglomeration benefits and location choice: evidence from Japanese manufacturing investments in the United States,' *Journal of International Economics*, **38**, 223–247.

Hoisl, K. (2007), 'Tracing mobile inventors—the causality between inventor mobility and inventor productivity,' *Research Policy*, **36**(5), 619–636.

Hole, A. R. (2007), 'Estimating mixed logit models using maximum simulated likelihood,' *Stata Journal*, **7**(3), 388–401.

Hu, A. G. and I. P. Png (2013), 'Patent rights and economic growth: evidence from cross-country panels of manufacturing industries,' *Oxford Economic Papers*, **65**(3), 675–698.

Ito, B. and R. Wakasugi (2007), 'What factors determine the mode of overseas R&D by multinationals? Empirical evidence,' *Research Policy*, **36**(8), 1275–1287.

Ivus, O. (2010), 'Do stronger patent rights raise high-tech exports to the developing world?' *Journal of International Economics*, **81**(1), 38–47.

Kafouros, M., P. J. Buckley and J. Clegg (2012), 'The effects of global knowledge reservoirs on the productivity of multinational enterprises: the role of international depth and breadth,' *Research Policy*, **5**(41), 848–861.

Kafouros, M., C. Wang, E. Mavroudi, J. Hong and C. S. Katsikeas (2018), 'Geographic dispersion and co-location in global R&D portfolios: consequences for firm performance,' *Research Policy*, **47**(7), 1243–1255.

Kim, J., S. J. Lee and G. Marschke (2009), 'International knowledge flows: evidence from an inventor-firm matched data set,' in R. Freeman & D. Goroff (eds), *Science and Engineering Careers in the United States: An Analysis of Markets and Employment*. University of Chicago Press: Chicago and London, pp. 321–348.

Kim, J. and G. Marschke (2005), 'Labor mobility of scientists, technological diffusion, and the firm's patenting decision,' *RAND Journal of Economics*, **36**(2), 298–317.

Kim, M. (2015), 'Geographic scope, isolating mechanisms, and value appropriation,' *Strategic Management Journal*, **36**(2), **37**(4), 623–815.

Kim, Y. K., K. Lee, W. G. Park and K. Choo (2012), 'Appropriate intellectual property protection and economic growth in countries at different levels of development,' *Research Policy*, **41**(2), 358–375.

Kuemmerle, W. (1999), 'The drivers of foreign direct investment into research and development: an empirical investigation,' *Journal of International Business Studies*, **30**, 1–24.

Kumar, N. (1996), 'Intellectual property protection, market orientation and location of overseas R&D activities by multinational enterprises,' *World Development*, **24**(4), 673–688.

Kumar, N. (2001), 'Determinants of location of overseas R&D activity of multinational enterprises: the case of US and Japanese corporations,' *Research Policy*, **30**(1), 159–174.

Kyle, M. K. and A. M. McGahan (2012), 'Investments in pharmaceuticals before and after TRIPS,' *The Review of Economics and Statistics*, **94**(4), 1157–1172.

Lee, J. Y. and E. Mansfield (1996), 'Intellectual property protection and US foreign direct investment,' *The Review of Economics and Statistics*, **78**, 181–186.

Lippoldt, D. and M. Schultz (2014), 'Uncovering trade secrets- an empirical assessment of economic implications of protection for undisclosed data', *OECD Trade Policy Papers, No. 167*, OECD Publishing, Paris.

Maddala, G. S. (1983), *Limited Dependent and Qualitative Variables in Econometrics*. Cambridge University Press: Cambridge.

Maliranta, M., P. Mohnen and P. Rouvinen (2009), 'Is inter-firm labor mobility a channel of knowledge spillovers? Evidence from a linked employer–employee panel,' *Industrial and Corporate Change*, **18**(6), 1161–1191.

Mansfield, E. (1994), 'Intellectual property protection, foreign direct investment, and technology transfer,' *Discussion Paper no. 19*, International Finance Corporation, Washington, DC.

Marx, M., D. Strumsky and L. Fleming (2009), 'Mobility, skills, and the Michigan non-compete experiment,' *Management Science*, **55**(6), 875–889.

Maskus, K. E. and M. Penubarti (1995), 'How trade-related are intellectual property rights?' *Journal of International Economics*, **39**(3), 227–248.

Maskus, K. E. and L. Yang (2013), 'The impacts of post-TRIPS patent reforms on the structure of exports,' *RIETI Discussion Paper Series, 13-E-030 (No. 13030)*.

McFadden, D. (1973), 'Conditional logit analysis of qualitative choice behavior,' in P. Zarembka (ed.), *Frontiers in Econometrics*. Academic Press: New York, pp. 105–142.

Melitz, J. and F. Toubal (2014), 'Native language, spoken language, translation and trade,' *Journal of International Economics*, **93**(2), 351–363.

Morescalchi, A., F. Pammolli, O. Penner, A. M. Petersen and M. Riccaboni (2015), 'The evolution of networks of innovators within and across borders: evidence from patent data,' *Research Policy*, **44**(3), 651–668.

Morrison, G., M. Riccaboni and F. Pammolli (2017), 'Disambiguation of patent inventors and assignees using high-resolution geolocation data,' *Scientific Data*, **4**, 170064.

Nandkumar, A. and K. Srikanth (2016), 'Right person in the right place: how the host country IPR influences the distribution of inventors in offshore R&D projects of multinational enterprises,' *Strategic Management Journal*, **37**(8), 1715–1733.

OECD. (2016), 'Where to locate innovative activities in global value chains: does co-location matter?' *OECD Science, Technology and Industry Policy Papers, No. 30*, OECD Publishing, Paris.

Palomeras, N. and E. Melero (2010), 'Markets for inventors: learning-by-hiring as a driver of mobility,' *Management Science*, **56**(5), 881–895.

Park, W. G. (2008), 'International patent protection: 1960–2005,' *Research Policy*, **37**(4), 761–766.

Polanyi, M. (1966), *The Tacit Dimension*. Doubleday Anchor: New York.

Potters, L., N. Grassano and A. Tübke (2017), 'Report. The 2017 EU survey on industrial R&D investment trends,' EUR 28871 EN. European Union. (print).

Rahko, J. (2016), 'Internationalization of corporate R&D activities and innovation performance,' *Industrial and Corporate Change*, **25**(6), 1019–1038.

Rahko, J. (2017), 'Knowledge spillovers through inventor mobility: the effect on firm-level patenting,' *The Journal of Technology Transfer*, **42**(3), 585–614.

Revelt, D. and K. Train (1998), 'Mixed logit with repeated choices: households' choices of appliance efficiency level,' *The Review of Economics and Statistics*, **80**(4), 647–657.

Samila, S. and O. Sorenson (2011), 'Noncompete covenants: incentives to innovate or impediments to growth,' *Management Science*, **57**(3), 425–438.

Schmiele, A. (2013), 'Intellectual property infringements due to R&D abroad? A comparative analysis between firms with international and domestic innovation,' *Research Policy*, **42**(8), 1482–1495.

Serrano, C. J. and R. Ziedonis (2018), 'How redeployable are patent assets? Evidence from failed startups,' *(No. w24526)*. National Bureau of Economic Research.

Shaver, J. and F. Flyer (2000), 'Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States,' *Strategic Management Journal*, **21**(12), 1175–1193.

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**(3), 605–627.

Smith, P. J. (2001), 'How do foreign patent rights affect US exports, affiliate sales, and licenses?' *Journal of International Economics*, **55**(2), 411–439.

Song, J., P. Almeida and G. Wu (2003), 'Learning–by–Hiring: when is mobility more likely to facilitate interfirm knowledge transfer?' *Management Science*, **49**(4), 351–365.

Szulanski, G. (1996), 'Exploring internal stickiness: impediments to the transfer of best practice within the firm,' *Strategic Management Journal*, **17**(S2), 27–43.

Tambe, P. and L. M. Hitt (2014), 'Job hopping, information technology spillovers, and productivity growth,' *Management Science*, **60**(2), 338–355.

Teece, D. J. (1986), 'Profiting from technological innovation: implications for integration, collaboration, licensing and public policy,' *Research Policy*, **15**(6), 285–305.

Train, K. (2003), *Discrete Choice Methods with Simulation*. Cambridge University Press: Cambridge.

Ushijima, T. (2013), 'Patent rights protection and Japanese foreign direct investment,' *Research Policy*, **42**(3), 738–748.

USTR. (2017), 'Report. 2016 report to congress on China's WTO compliance,' United States Trade Representative, (January). Washington, DC.

USTR. (2018), 'Report. Update concerning China's acts, policies and practices related to technology transfer, intellectual property, and innovation,' United States Trade Representative, (November). Washington, DC.

Veugelers, R. and B. Cassiman (2004), 'Foreign subsidiaries as channel of international technology diffusion: some direct firm level evidence from Belgium,' *European Economic Review*, **48**, 455–476.

Yu, P. K. (2009), 'The objectives and principles of the TRIPS agreement,' *Houston Law Review*, **46**, 797–1046.

Zhao, M. (2006), 'Conducting R&D in countries with weak intellectual property rights protection,' *Management Science*, **52**(8), 1185–1199.

Appendix An illustrative model of IPR protection and R&D location choice

Assume that the effective transfer or creation of technological knowledge abroad through the establishment of an R&D unit, *T*, has two elements, nonpatented knowledge *Tnp* and patented knowledge *Tp*. Nonpatented and patented at least partially complement (reinforce) each other, for instance, because translating patented technologies into innovation often involves less codified practices drawing on tacit knowledge and complementary knowledge kept secret (e.g., Teece, 1986). Hence, knowledge transfer or creation associated with local R&D can be described as

$$T = Tnp + Tp + Tp * Tnp \tag{1}$$

with the latter term indicating that the effective use of patented (nonpatented) knowledge often requires drawing on nonpatented (patented knowledge) as well. The risks of knowledge spillovers and misappropriation by local firms are a negative function of patent protection (*IPR*) and a positive function of mobility (*MOB*). Spillovers of *Tp* depend on patent protection while spillovers of *Tnp* depend on mobility. Spillovers hamper appropriation of R&D investments by the firm. Let *APj* represent the value that the multinational firm can appropriate from the technology *T* developed through local R&D in country *j*. For simplicity, we assume that the magnitudes of *Tp* and *Tnp* are fixed and cannot easily be adjusted. Then, if the appropriation of *Tp* depends on IPR protection, and appropriation of *Tnp* depends on mobility, *APj* can be expressed as

$$APj = f\left(IPR_j\right) + g\left(MOB_j\right) + f\left(IPR_j\right) * g(MOB_j) \tag{2}$$

where f is a function describing the relationship between appropriation benefits of *Tp* due to patent protection and g is a function describing the relationship between appropriation benefits of *Tnp* due to mobility.

The appropriation benefits a firm derives from patent protection, $f\left(IPR_j\right)$, depends on the distance of *IPRj* with respect to the IPR frontier, as argued above. This implies that the marginal effect of IPR protection on appropriation benefits declines at higher levels of protection. Hence, function f has the following properties: $f'(IPR) > 0, f''(IPR) < 0$. We choose a simple specification for *f(IPR)* that corresponds with these properties: $f(IPR) = IPR - IPR^2$. Forg(MOB), we assume a linear relationship: $g'(\mathrm{MOB}) < 0$, $g''(\mathrm{MOB}) = 0$.

Firm i receives profits U_{ij} by investing in R&D in location j. U_{ij} is a positive function of appropriation benefits *AP*. *Uij* is also a positive function of other benefits of local R&D related to increased access to the local market, cost reductions of hiring able scientists at lower wages, etc., captured by a vector $\bar{w}_j$. Finally, profits are a function of unobserved firm- and location-specific influences, ε_{ij}. Substituting for f and g in (2) and adding coefficients leads to the following expression for profits:

$$U_{ij} = \beta_0 \bar{w}_j + \beta_1 IPR_j - \beta_2 IPR_j^2 - \beta_3 MOB_j - \beta_4 IPR_j * MOB_j + \beta_5 IPR_j^2 * MOB_j + \varepsilon_{ij} \tag{3}$$

It follows that the attractiveness of a location for R&D investment (the expected profits of investing in a location) is a positive but declining function of IPR and a negative function of mobility. The positive effect of IPR is negatively moderated by mobility while the declining marginal effect of IPR (the square term) is mitigated by mobility.

We assume that the multinational firms compare the different profits associated with R&D investment in the different host countries and choose the host country with the highest expected profits to locate its R&D there. It can be shown that if the terms ε_{ij} are independent and have certain regular distributional properties, the location choice decisions translate into a conditional logit model (e.g., Maddala, 1983: 60–61) with the probability that location j is chosen expressed as the relative utility compared to the sum of the profits of all locations:

$$P_{i,j} = \frac{\exp\left(U_{i,j}\right)}{\sum_n^J \exp\left(Ui, n\right)} \tag{4}$$

We estimate the conditional logit model of equation (4). We allow for investor heterogeneity and relax the assumption of error term independence by applying the generalized random parameter form of the conditional logit model (Section 3).