

R&D internationalization and the strategic relevance of the institutional framework in host locations

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Abstract

The configuration of host national systems of innovation and the technological international networks established by multinational enterprises (MNE) can become key aspects for the internationalisation decision that may also concern knowledge related activities such as R&D. Through the combination of a theoretical model and empirical analysis, this paper shows to what extent institutional quality becomes a determinant factor for the attraction of foreign R&D activities, these latter being conditioned by the technological and productive capabilities of local contexts and the competitive pressures MNE face in foreign countries. Our contribution is a step further in the explanatory framework of R&D internationalisation and also provides new insights about what are the key reinforcement mechanisms for the attraction of new knowledge intensive investments.

Keywords: R&D internationalization; institutional framework; national system of innovation; technological networks; multinational enterprise.

1. Introduction

The determinant factors of foreign direct investment (FDI) and how firms take internationalisation decisions have been some predominant topics in the economics and international business (IB) literature fields. Different modelling efforts and the diversity of empirical works have driven the attention towards more complex problems such as the generation of knowledge in global basis and the dominant internationalisation mechanisms, as some seminal contributions show (Markusen, 1995; Dunning and Lundan, 2008a). According to the theoretical predictions and the available evidence, the traditional rationale of many governments to improve the attractiveness of their locations for MNE is based on the idea that these companies may generate potential positive impacts in terms of employment, trade and creation of value added, among other effects (Mansfield, 1968; Mansfield and Romeo, 1980; Markusen and Venables, 1999). A more updated vision of the relevant factors of foreign location attractiveness also considers the international impact of the increasing fragmentation of the value chain and the fact that foreign subsidiaries carry out not only production, distribution and sales but also science, technology and R&D activities in host countries (Mudambi, 2008; OECD, 2014; Athreye et al., 2014). The dominant MNE network conception (Ghoshal and Bartlett, 1990) and the individual competences of subsidiaries (Cantwell and Mudambi, 2005; Mudambi et al., 2014a) imply that those more autonomous and creative units within the MNE are also more involved in innovation activities abroad and this contributes to the enlargement of competitive advantages. This later effect increases the possibilities for the generation of positive impacts in terms of knowledge creation and diffusion in host location (Rugman and Verbeke, 2001). These arguments provide solid basis to our understanding of both the R&D internationalisation process and the potential effects of foreign subsidiaries in locations, providing a good reasoning frame to focus our research.

The complex relationship defined by R&D internationalisation and the features of host locations, such as the technological advance level, the entrepreneurial capacities and the institutional setting and its dynamics, are determinant aspects not only for higher FDI inflows but also for a higher diversity of activities carried out by foreign subsidiaries abroad. Therefore, a better understanding of the link between R&D internationalisation and the institutional set up of host economies implies to take also into account the

networking strategies of MNE in knowledge generation, an aspect that is integrated in the theoretical model and the empirical analysis developed in this paper. The contribution is to try to disentangle what are the most determinant factors in the relationship between the process of R&D internationalisation and the institutional quality of host countries, a relationship that conditions the competition that MNE face in the international generation of knowledge. Our proposal is based on the idea that this relationship responds to a combined action of the MNE that is also modulated by the technological performance of foreign subsidiaries and their links in international networks. This paper contributes twofold to the extant literature: firstly, we formally demonstrate how R&D internationalisation is conditioned by the institutional quality of host countries and secondly, we highlight the relevance of the technological international networks established by MNE in the decision of establishing R&D facilities abroad, an aspect that mitigates the effect of the institutional set up on the internationalisation of R&D. In addition, the findings will also permit to get new implications for the definition of policies addressed to enlarge the attractiveness of each location.

A relevant aspect in the firms' internationalisation processes nowadays is the growing performance of knowledge-intensive activities abroad. This is related to the increasing level of technological sophistication in many industries. The growth in knowledge intensity, together with the higher geographical dispersion of knowledge related activities in an increasing competition framework make the issue more complex than before. The presence of differences across countries in the level of technological development and the rising international disparities were positioned at the centre of the global expansion of R&D activities. At the same time, emerging economies have recently adopted a protagonist role due to their increased relevance in the two directions of FDI -receipts and emission-, an aspect included in the research agenda when considering R&D internationalisation (Athreye et al. 2014; Mudambi et al. 2014b). The increasing attractiveness of emerging economies has coincident with the irruption of emerging MNE (EMNE) in the international scenario. The access to new knowledge abroad is one of the key explanations of the EMNE internationalisation strategy while showing differences in knowledge sourcing regarding advanced MNE (Meyer, 2004; Cuervo-Cazurra, 2007; Ramamurti, 2012; Cuervo-Cazurra, 2012; Awate et al., 2015).

The orchestrating role assigned to MNE is due to their networking ability for the generation and transmission of knowledge in an international basis, with the consequent effects of demonstration, imitation and possible spillover that can be seen as driving mechanisms of technological catch up in many developing countries (Cantwell, 1995; Athreye and Cantwell, 2007; Rugman and Doh, 2008). However, a set of factors limit the capacity of these effects, factors that respond to the combination of both the individual MNE decision and the spectrum of features in each host economy that make them more or less likely (Álvarez and Molero, 2005; Álvarez and Marin, 2010; Meyer et al., 2011; Marin and Sasidharan, 2010). The existence of absorptive capacities in host locations is required to maximise the positive impacts derived from the presence of foreign MNE in developing contexts (Borensztein et al., 1998; Meyer, 2004). Also institutional quality aspects such as the control of corruption may deter the MNE internationalisation decision, more crucially when knowledge generation activities such as R&D are in place. These arguments justify the appropriateness of a national system of innovation (NSI) approach to calibrate the set of elements that can make locations more attractive for MNE. According to this view, the institutional set up is one important pillar to explain innovation differences and possibilities across countries (Lundvall, 1992; 2007; Lundvall et al. 2002; 2009).

The theoretical implication of our research is the provision of a simple model that relates the R&D internationalisation decision of MNE with its most determinant factors. Such a model opens up a new perspective in the formal analysis of the global technological strategies of MNE with regard to the host institutional set up and is intended to motivate subsequent research on this topic. Through the empirical analysis we also show the relevance of both the institutional quality and the technological network of foreign subsidiaries in the global innovative activities of MNE. The statistical information used in the empirical analysis has been provided by the OECD on Measuring Globalisation; this source includes systematic information of the amount of R&D expenditure performed by MNE in foreign countries for 21 economies from 1996 to 2008. The information regarding institutional quality has been taken from the Worldwide Governance Indicators published by the World Bank, while information for other relevant factors has been provided by United Nations, OECD and World Bank databases.

The remaining of the paper is structured as follows. The next section is devoted to the theoretical background and the development of our research question. In the following section, we present some descriptive statistics built with available data from different international sources that provides the illustration of the intuition that serves as foundation for the development of the theoretical model, this later being presented in the subsequent section. Then we move to the specification of the econometric model and the discussion of results before we conclude providing some implications, limitations and suggestions for future research.

2. Theoretical background and research question

The economic explanation of the internationalisation process based on firms' heterogeneity predicts that more productive firms are usually more internationalised, and there are some factors defined at the level of host countries that also intervene in the decision. This is shown in few theoretical models that relate institutional aspects, such as corruption, and modes of entry in international markets (Helpman et al, 2004; Nockle and Yeaple, 2007; Markusen and Stähler, 2009; Javorcik and Wei, 2009). The relevance of location advantages is one of the most outstanding arguments found in the literature regarding the importance of the host national contexts in the explanation of the MNE' choice (Dunning, 1981; 2006; Markusen, 2002; Dunning and Lundan, 2008a) and empirical evidence show the pertinence of institutions and good governance in promoting growth and welfare, being mutual the influence between MNE and institutions: While the first would act as coordinators of a global system of value added activities, the second would be helpful for defining different modes of coordination (Dunning and Lundan, 2008b).

As a consequence, the firm's decision of entry into foreign markets is conditioned by a set of diverse societal and environmental aspects including both cultural and institutional factors of host economies (Kogut and Singh, 1988; Rosenzweig and Singh, 1991; Harzing, 1999; Davis et al., 2000; Dunning, 2006; Steven and Dykes, 2013). The institutional business literature has been mainly focused on legal and cultural aspects (Scott, 1981; 1983), but a larger punch of elements integrating the external environment in which subsidiaries operate in foreign contexts also includes technology, government regulations and the industrial structure (Rosenzweig and Singh, 1991; Davis et al., 2000). Some institutional aspects, such as the quality of public goods, property rights,

quality of judicial system, rule of law and control of corruption, act as support of firms operations in host locations. These elements could end up opening new opportunities for new MNE investments as well, even in culturally distant countries as it is the case of emerging economies (Hitt et al., 2006; Cuervo-Cazurra and Genc, 2011). The importance of corruption for the development of economic activity and its effect on FDI has also received an increasing amount of attention in the academic literature, revealing interesting differences when emerging countries are considered (Ledyeva et al., 2013; Hessami, 2014).

The relevance of local contexts has provided an extensive body of literature that underlines the potential effects of MNE in the provision of new production facilities, managerial practices and also technologies (Caves, 1974; Markusen, 1995; Haskel et al., 2002; Blomstrom and Kokko, 2003; Javorcik, 2004; Driffield & Love, 2007). The issue is that foreign subsidiaries do not only develop production, distribution and sales functions abroad but they also carry out science, technology and R&D activities, and this may derive into impacts for both the host location and the subsidiary as well. The possibilities of knowledge flows across borders may take place from the foreign units toward domestic firms and other agents, but also there can be potential reverse knowledge flows mainly when foreign firms look to tap into new knowledge in host locations (Cantwell, 1989; 1995; Barkema and Vermeulen, 1998; Frost, 2001; Piscitello, 2004; McCann and Mudambi, 2005; Singh, 2007; Yang et al., 2008). Overall, the size and direction of these effects must be clearly determined by the characteristics of the environment, the scientific and technological level of the domestic organizations and the regulatory and institutional set up, elements that differ between MNE from advanced countries and EMNE (Cantwell and Piscitello, 2002; 2005; Awate et al., 2015).

The national system of innovation (NSI) conceptual approach not only integrates these elements but also claims a very active role of the institutional framework in determining both the direction and the intensity of innovation as well as the interrelatedness with other socio-economic fields different than the productive system (Lundvall, 1992; Lundvall et al. 2002). This provides an analytical tool that gives support for carrying out international comparisons between national styles of management and innovation practices (Freeman, 1987; Lundvall, 1992; 2007; Nelson, 1993; Mowery and Oxley,

1995; Cantwell and Moleró, 2003). Moreover, in a context of increasing R&D internationalisation, it is plausible to think that this process may be strongly conditioned by the characteristics of the NSI in host economies (Pavitt and Patel, 1999; Patel and Vega, 1999). In this case, new efforts and more in-depth analysis of the factors related to institutional quality and its impact on R&D internationalisation carried out by MNE would be justified.

As Acemoglu et al. (2004) ascertain, the relevance of institutions for economic growth and development is due to their role in the provision of the incentives structure to societies and affect crucial aspects such as human and physical capital, technology and organization of production. It is well known that there is not a unique definition of institution but most of them highlights their role in shaping and regulating. Although the specific concept of institutions may adopt different meanings, the central place in the NSI approach is due to their role as facilitator of social coordination and as a determinant factor for long-run development (North, 1990; Alonso and Garcimartín, 2011). Not less to say that the interest in the topic has increased among both citizens and governments because of the importance of the implicit costs that are associated with “bad governance”.

Previous discussion lead us to analyse the role of host institutional stability in R&D internalisation according to the national systems of innovation (NSI) perspective. This is combined with the technological performance of foreign subsidiaries in a unique framework that is developed through a simple theoretical model and accompanied by an empirical work to contribute together to the explanation of R&D internationalisation. The assumption is that the features of the host location are conditional of MNE decisions and the institutional set up may act as a determinant aspect when this decision implies knowledge related activities such as science, technology and R&D. Previous contributions show that it is unlikely that firms would choose to locate knowledge-intensive activities in a country whose institutional characteristics limit their ability to appropriate rents (Cuervo-Cazurra et al., 2007). Meanwhile, recent modelling efforts and available evidence for emerging markets confirm that technological leakage from MNE can be more likely in those countries with a higher level of corruption and the cost of leakage increases with the technological sophistication of the companies (Javorcik and Wei, 2009). Therefore, assuming that technological sophistication is

positively correlated with the probability of entry by *greenfield* investment and negatively associated with the probability of joint-venture projects (Markusen, 1995; Javorcik and Wei, 2009), more technologically sophisticated industries are also more likely to internationalise R&D in host economies.

Moreover, the technological capabilities of host countries exert a direct influence in the attractiveness of foreign locations, mainly when technology-seeking is the driving force of the internationalisation MNE strategy (Erken and Kleijn, 2010; Athukorala and Kohpaiboon, 2010). In such a case, the location of R&D facilities abroad is usually oriented to tap into local knowledge and obtain benefits from knowledge spillovers to develop new products, not only for local markets but also for worldwide markets, which makes R&D a real global activity. In these situations, the role of institutions in the decision of R&D internationalisation gains in importance because the stronger the institutions of foreign locations are in terms of political stability and control of corruption, the more R&D will be performed by MNE in those locations (Doh et al., 2005; Veliyath and Sambharya, 2011).

Therefore, the research question addressed here takes into account the effect of institutional quality on the MNE decision of establishing R&D facilities abroad, paying special attention to the technological activity of both domestic and foreign firms in host countries. The question is stated as follows: *What is the relevance of institutional quality on the R&D internationalisation, conditional on the technological performance of foreign subsidiaries and their links in international networks?* The answer is provided through the development of both a theoretical model and an empirical analysis. Before proceeding with that, next section presents some descriptive that serve as illustration of the relevance of R&D internationalisation providing also the intuition for further developments.

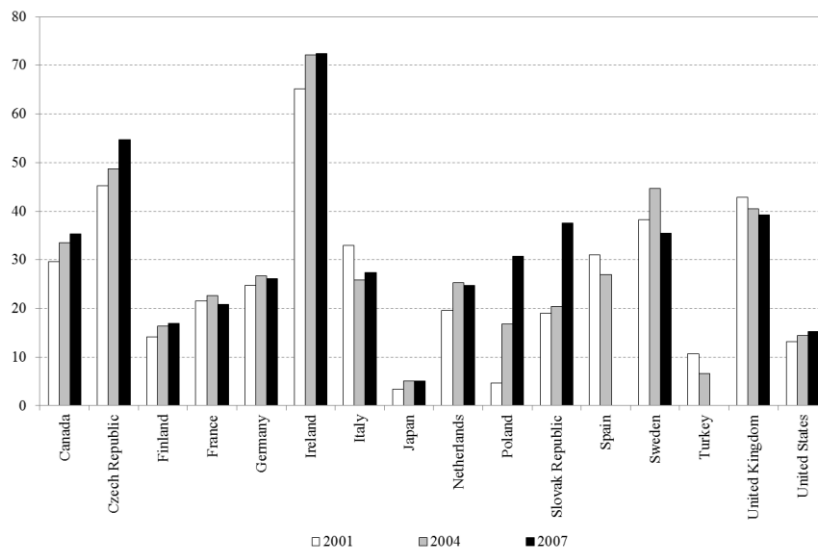
3. R&D Internationalisation: Some descriptive statistics

The contribution of R&D performed by subsidiaries to total business R&D expenditures reveals a high diversity among countries when the sample includes both advanced as well as some emerging economies from Eastern Europe¹, an aspect shown in Figure 1 for some selected years according to data availability. The existence of international

¹ The lack of information in some years is due to the discontinuities in time series for some countries.

differences is notable attending the highest values corresponding to some countries such as Ireland and the Czech Republic that are well positioned in terms of foreign R&D performed in their locations. On the other hand, United States and Japan are the developed countries in which foreign firms contribute less to total business R&D expenditures. Although the evolution of the R&D performed by foreign MNE shows the existence of a more dynamic behaviour of R&D internationalisation in some middle-income transition economies between 2001 and 2007, it is more stable in more developed economies.

Figure 1. R&D performed by MNC



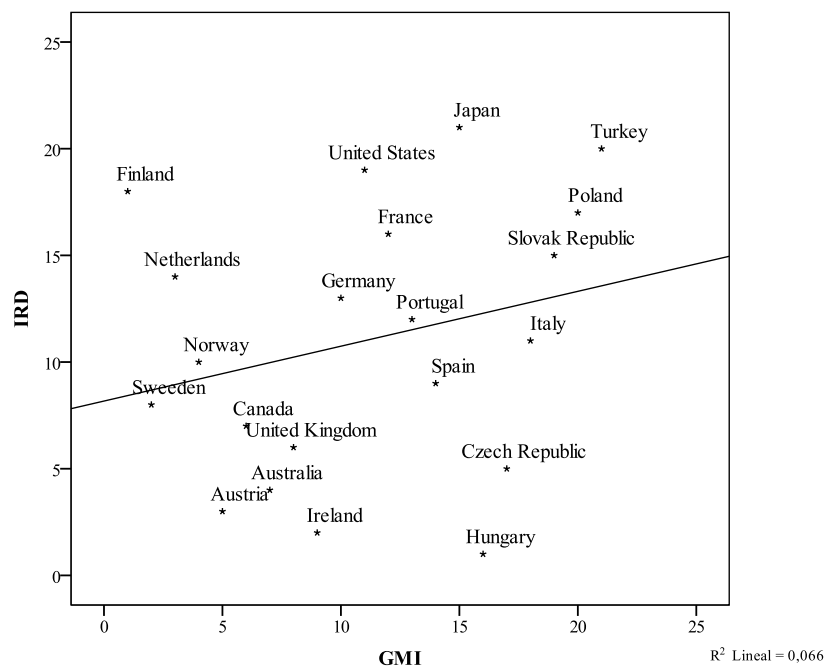
Source: Own elaboration with data from OECD Statistics on Measuring Globalisation.

Although from a static perspective a negative association between institutional quality and the internationalisation of R&D seems to be, there is also a positive path that can influence a higher international expansion of technology. This is shown by the smooth positive relationship between the rank positions of countries in terms of the contribution of MNE to national business R&D expenditures and the good governance, this latter measured by the Governance Matter Indicator² (Figure 2). In particular, the top positions in terms of institutional quality are represented by a set of well ranked

² Although the analytical treatment of institutions encloses some methodological problems associated to the measurement of government performance, the Governance Matter Indicator developed by Kauffmann et al. (2007; 2010) is generally accepted in research and has been recently renamed as Worldwide Governance Indicators.

countries such as Austria, United Kingdom, Ireland and Canada that are also well positioned in terms of the innovative activities carried out by foreign subsidiaries. However, the rank order is lower regarding the contribution of R&D performed in foreign contexts by MNE in those economies with a worse relative performance in good governance, such as Turkey, Poland and the Slovak Republic. The smooth relationship between the two indicators is mainly due to the fact that larger rank differences are shown in several Eastern and Southern European economies -Hungary, Czech Republic and Spain- and, on the other side of the coin, in some north European countries such as Finland and Netherlands.

Figure 2. Relationship of countries' rank order according to foreign R&D and the institutional indicator



Source: Own elaboration with data from OECD Statistics on Measuring Globalisation and World Bank Worldwide Governance Indicators.

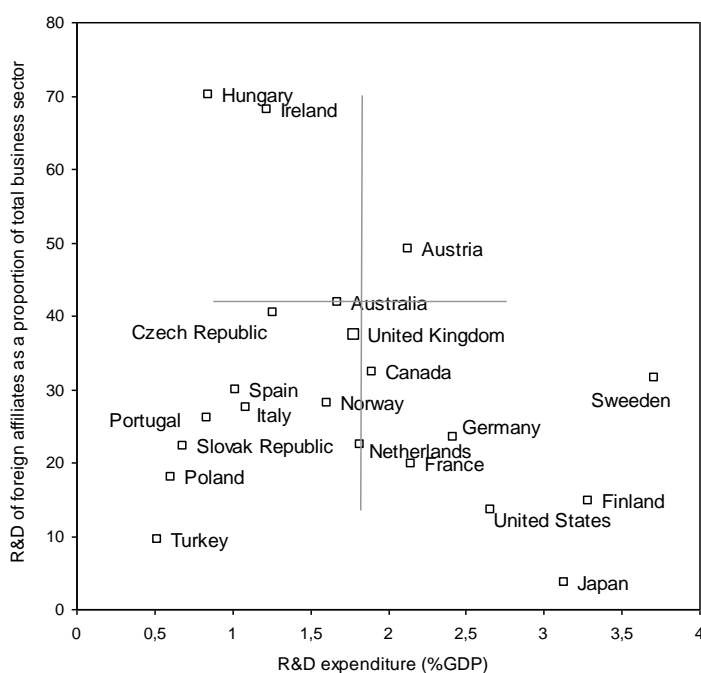
Our point of departure is the theoretical prediction of a positive relation between the MNE location choice and the presence of good governance in host economies. However, the GMI is a complex measure of institutional stability that includes six different indicators: voice and accountability, political stability and absence of violence,

government effectiveness, regulatory quality, rule of law and control of corruption³. This would allow us a more in-depth analysis and specially in terms of corruption since the direction of this relationship can become negative when R&D activities are involved because the fear to knowledge leakage in foreign contexts. The cost of leakage suggests a MNE preference for the internationalisation of core activities such as R&D, instead of subcontracting them in host economies, the choice being justified as a form to impede not desirable knowledge spillover effects, as it was described in the previous section.

A second motivation to carry out this analysis is the fact revealed by the international comparison of the existing relationship between R&D activities performed by foreign MNE, and the R&D national efforts of host economies. The scatter plot in Figure 3 does not reveal a well-defined relationship between the two indicators. Nonetheless, the R&D internationalisation variable does not necessarily show the highest values in those more advanced NSI. There is a set of countries where the internationalisation of R&D achieves higher values although R&D expenditure represents only around 1% of their GDP; this is the case for Hungary and Ireland, and in a lesser extent for a set of Southern and Eastern European countries -Czech Republic, Spain, Poland, Portugal and Turkey-. As already known, some of these countries are living struggling moments due to the consequences of the World financial crisis and they share some features such as the lack of macro stability in spite of being part of the European Union block or candidates, as it is the case of Turkey. On the other hand, some countries are around the median value of R&D effort, but the R&D performed by foreign MNE does not represent more than 40% of the total business R&D in the country. A particular group of countries are the technological leaders, which are positioned in the bottom right of the graph revealing the scarce importance of the R&D carried out by foreign firms in these locations. The relative importance of the R&D performed by foreign subsidiaries is not so relevant in those economies with a more advanced NSI, this latter aspect usually implying a more stable institutional framework. Therefore, it might be thought that national technological capabilities discourage R&D activities by foreign MNE in these locations and mitigate the effect of institutional quality on R&D internationalisation.

³ For the elaboration of each component of the GMI for each country, 352 indicators are collected exhaustively from different sources such as international organisations and rating agencies, cross-country and over-time comparisons being allowed.

Figure 3. R&D internationalisation and R&D national effort



Source: Own elaboration with data from OECD Statistics on Measuring Globalisation.

4. Theoretical model: A minimalist formalization

A formal cost-benefit environment reflecting the main incentives of MNE to internationalise their R&D activities allows us to deal analytically with the research question defined in this paper. The foundations of the formal model are built on the theoretical and descriptive bases provided in previous sections regarding institutional quality and the technology capabilities of host countries. Furthermore, the FDI stock of the host country confers a dynamic perspective to the environment that may be used in formal developments of the model (Mudambi, 1995). Consequently, the basis for a Bayesian game setting are established here, linking the current paper to the formal literature on entry modes, local technological development, institutional factors and knowledge spillovers (Sanna-Randaccio and Veugelers, 2007; Javorcik and Wei, 2009; Alvarez et al., 2015).

The main variables defining the profits of MNE as well as the incentives to internationalise their R&D activities are given by the following:

- (i) Institutional quality of the host economy (level of corruption): γ

(ii) National technology capacities of the host economy: θ

The institutional quality variable has been introduced to account for the level of corruption in host countries to explain R&D internationalisation. It serves the dual purpose of linking this paper with previous research in this area and contributing to the extant knowledge about the effect of corruption on the kinds of activities carried out by MNE internationally.

The resulting profit obtained by a MNE absent a formal dynamic structure is given by

$$\pi(\gamma, \theta) = TI(\gamma, \theta) - TC(\gamma, \theta) \quad (1)$$

where $TI(\cdot)$ and $TC(\cdot)$ stand for the total income received and total cost faced by the MNE, respectively.

Consider now a standard Euclidean space with θ defined on the x-axis and γ on the y-axis. The variable on the z-axis should be the dependent one, in this case, the R&D internationalisation incentives of MNE are based on the profits obtained. This structure provides a cost-benefit analysis environment with the highest income level, and, therefore, internationalisation incentives, reached at (1, 0), while the lowest income level is obtained at the exact opposite point, i.e. (0, 1). Clearly, the crossing of the total income and cost functions will delimit the resulting internationalisation areas.

The following assumptions may be imposed on the total income function based on the arguments derived from the previous section

$$\frac{\partial TI}{\partial \gamma} < 0; \quad \frac{\partial TI}{\partial \theta} > 0; \quad \frac{\partial^2 TI}{\partial \gamma \partial \theta} \geq 0 \quad (2)$$

That is, the income derived from the internationalisation of the R&D activities of the MNE depends negatively on the corruption faced within the host country and positively on the local technological capacities, while their combined effect may be either positive or negative. This latter effect lacks importance within the current environment but

should regain it when defining the Bayesian game determined by the type of competitors faced by the subsidiaries of the MNE as well as the amount of FDI activities previously performed in the host country.

A similar approach can be used to define the total costs faced by MNE when internationalising their R&D:

$$\frac{\partial TC}{\partial \gamma} > 0; \quad \frac{\partial TC}{\partial \theta} < 0; \quad \frac{\partial^2 TC}{\partial \gamma \partial \theta} \geq 0 \quad (3)$$

The intuition is identical to the total income case with the corresponding reversal in signs accounted for.

We introduce now a third variable, the level of FDI previously existing in the host country, which will be denoted by ψ . In the current setting, ψ may have, at least theoretically, either a positive or a negative effect on the incentives of MNE to internationalise their R&D activities. The effect would be positive if ψ behaves as a signal of the country openness to the international economy. However, the effect may be negative when related to corruption and the capacity of the subsidiaries that have already entered the country to create local contacts that favour them relative to any new entrant. The resulting dependent variables follow:

(i) Institutional quality of the host economy (level of corruption): $\gamma(\psi)$

(ii) National technology capacities of the host economy: $\theta(\psi)$

To reflect the capacity of subsidiaries, we will concentrate on the “moving behind” effect derived from the stock of FDI existing in the host country. As we emphasize below, when determining the internationalisation of R&D activities, this effect may be complemented by those of the FDI already performed by the own MNE within the host country together with its innovative networks established internationally and the subsequent potential knowledge spillovers that may occur.

Thus, the higher the amount of FDI existing in the host country, the higher the “moving behind” effect faced by MNE. This effect may be interpreted as a signal indicating the existence of a (technologically) developed market within the host country that ameliorates the corruption pressures exerted over the subsidiaries and allows them to create better links within the host national system of innovation. Therefore,

$$\frac{\partial \gamma}{\partial \psi} < 0 \quad (4)$$

Note that higher value of γ represents an increment in corruption and, therefore, on the costs faced by MNE. As a result, the existence (and increment) of a stock of FDI weakens the effect of the corruption variable.

Similarly, when considering the development of the technological capabilities of the host economy we should have:

$$\frac{\partial \theta}{\partial \psi} > 0 \quad (5)$$

Thus, a higher stock of FDI existing in the host country implies that the connections with the national system of innovation are stronger and easier to develop by MNE.

The resulting effect of ψ on the income function of MNE can be summarized as follows:

$$\frac{\partial TI}{\partial \psi} = \frac{\partial TI}{\partial \gamma} \frac{\partial \gamma}{\partial \psi} + \frac{\partial TI}{\partial \theta} \frac{\partial \theta}{\partial \psi} > 0 \quad (6)$$

with

$$\frac{\partial TI}{\partial \gamma} \frac{\partial \gamma}{\partial \psi} > 0 \quad (7)$$

and

$$\frac{\partial TI}{\partial \theta} \frac{\partial \theta}{\partial \psi} > 0 \quad (8)$$

The total cost function follows a similar intuition when accounting for the effect of ψ on the variables θ and γ

$$\frac{\partial TC}{\partial \psi} = \frac{\partial TC}{\partial \gamma} \frac{\partial \gamma}{\partial \psi} + \frac{\partial TC}{\partial \theta} \frac{\partial \theta}{\partial \psi} < 0 \quad (9)$$

The payoffs obtained by MNE depend on the value of the variable ψ since it conditions the influence of both corruption and the development level of the national innovation system on the incentives of MNE to internationalise their R&D activities.

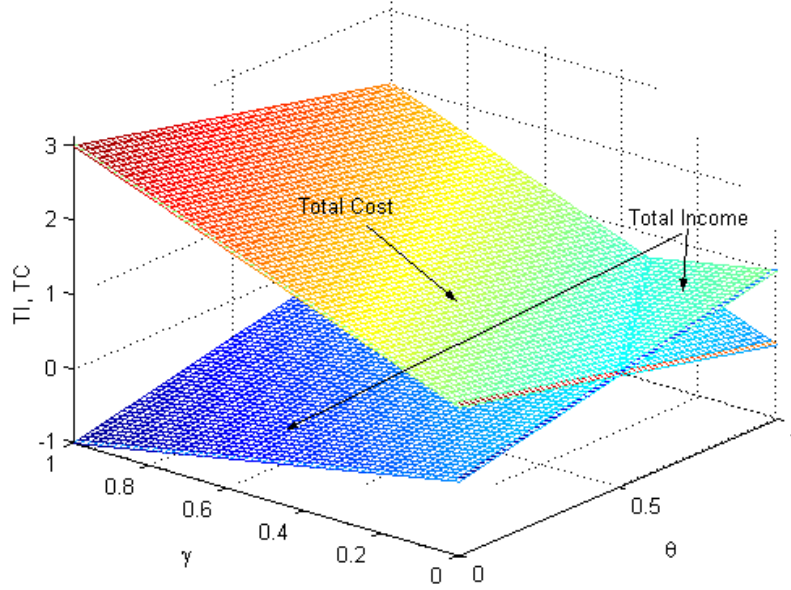
This analysis sets the basis for a more complex environment where strategic interactions determining the amount of R&D that MNE perform in the host country would depend on

- (i) The level of FDI already existing in the country, following a similar analysis to the setting described above.
- (ii) The potential knowledge spillovers to the local system, a function of the technological development of the country.
- (iii) The level of corruption in the host country.
- (iv) The capacity of competitors to absorb the knowledge spilled, which, at the same time depends on the corruption and technological development levels of the host country.

Figure 4 present a basic numerical example, which is also used to highlight the analytical tractability gained when defining the entire strategic structure in terms of the variable ψ . The income and cost functions represented in Figure 4 are given by

$$\begin{aligned} TI(\gamma, \theta) &= \theta - \gamma \\ TC(\gamma, \theta) &= 2\gamma - \theta + 1 \end{aligned} \quad (10)$$

Figure 4. Total Income and Total Cost functions determining the internationalisation incentives of MNE.



The domain of these functions is delimited by $\gamma, \theta \in [0,1]$. The resulting R&D internationalisation area determined by $TI > TC$ is illustrated in Figure 5. At the same time, the dependence of the variables within both these functions on ψ , allows us to define the corresponding incentive structure on the values taken by ψ . For example, assume that

$$\gamma = \frac{1}{\psi + 1} \text{ and } \theta = 2\psi \quad (11)$$

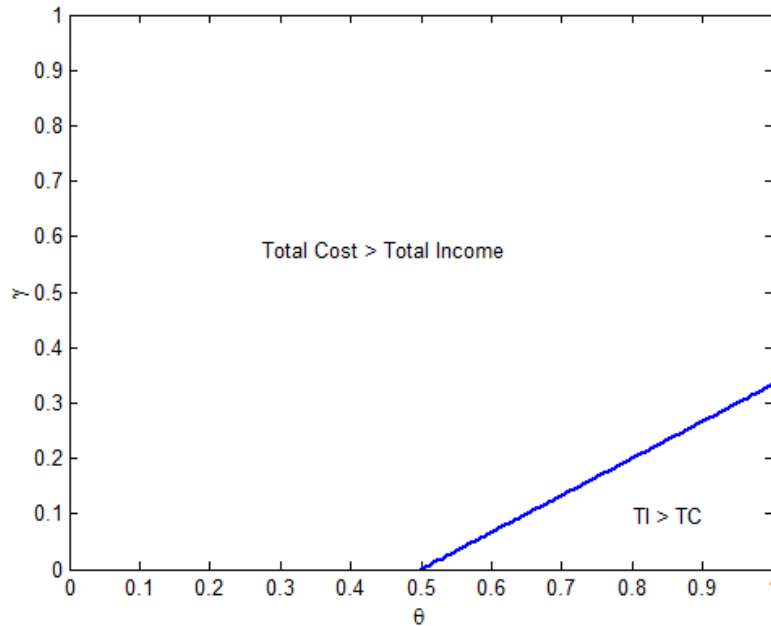
In this case, the income and cost functions introduced above become

$$\begin{aligned} TI(\gamma, \theta) &= 2\psi - \frac{1}{\psi + 1} \\ TC(\gamma, \theta) &= \frac{2}{\psi + 1} - 2\psi + 1 \end{aligned} \quad (12)$$

This model can be easily solved for $\psi \in [0,1]$, leading to a cut-off value of $\psi = 0.87$, which determines the relative level of FDI required for MNE to internationalise their R&D activities within the host country. The substitution implemented simplifies the

analysis when accounting for additional variables, which allows for a more complex structure to be considered when examining empirically the formal strategic environment as it is suggested in the next section.

Figure 5. Total Income and Total Cost-induced R&D internationalisation areas.



5. The econometric model: Specification and discussion of results

5.1. Specification of the model

Given the potential relationship between R&D internationalisation and the features of NSI in host countries, and particularly their institutional quality, we analyse empirically in this section the theoretical model previously described. The specification of the econometric model is also based on a set of well-known factors found in theoretical and empirical background, and it includes several aspects that have not been explicitly considered in previous analysis trying to disentangle more carefully some particular insights regarding our research question. The general model can be then broadly defined as follows:

$$\text{IRD} = f(\text{Inst_Qual}, \text{Nat_Tech}, O)$$

where, IRD represents the internationalisation of R&D, Inst_Qual represents the institutional quality, Nat_Tech represents national technological capabilities and O refers to a set of other factors.

The dependent variable is the internationalisation of R&D (IRD) and it is defined as the R&D performed by foreign subsidiaries in host countries as a proportion of the total business R&D in there. The option of this measure of R&D intensity is due to the fact that it reflects the potential positive impacts derived from the most sophisticated activities carried out by foreign subsidiaries in terms of catching up and knowledge spillovers, and it highlights the relevance of the R&D internationalisation for host economies and the potential implications for governments to attract these kinds of activities.

Regarding independent variables, the first one relates to institutional quality (Inst_Qual) and it includes an indicator of good governance. Although the number of potential institutional indicators is broader with regard to Governance Matter Indicator, a single indicator integrates this block: Control of Corruption⁴. This selection has been made because of its increasing role in the agenda of international institutions and national governments as well as to avoid collinearity problems that are associated with the joint consideration of different institutional variables. Besides, control of corruption reflects the governmental environment and the lower risk of rapid change, which is directly related to the respect of intellectual property rights and to appropriability regimes since property protection becomes a problematic issue in more corrupt countries (Doh et al., 2005; Javorcik and Wei, 2009).

The second block of explaining factors refers to the national technology capabilities (Nat_Tech) and it is represented by a set of indicators related to the NSI (Lundvall et al. 2009; Fagerberg and Srholec, 2009). Technological indicators such as R&D expenditures and patents were the main candidates. However, only the later is included in the estimation to avoid endogeneity and collinearity problems. Moreover, the inclusion of patents reflects not only the technological capability of host countries but also the appropriability regimes characterising local contexts. On the other hand, the

⁴ According to the Governance Matter Indicators, the control of corruption indicator measures the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Countries are scored according to their rank percentile position and higher values of this indicator reveal lower levels of corruption.

performance of the NSI can be conditioned by the productive structure, the trade sophistication and the national position in the global value chain. For this reason, the exports of high-tech manufacturing have been taken as an indicator of economic specialisation. Some recent works highlight that the more export-oriented a host country is, the greater the R&D intensity of foreign subsidiaries will be (Athukorala and Kohpaiboon, 2010). In line with this argument, it could be thought that the technological sophistication of exports reflects the capabilities and activities developed by foreign subsidiaries, which reinforces the idea that R&D is becoming a truly worldwide activity and support the argument of the role played by foreign networks in the decision of R&D internationalisation. Finally, the stock of inward FDI is included, which represents the competitive pressures which MNE are facing abroad with regard to their competitors' movements as well as their past experience in host countries (Álvarez and Marin, 2010; Barkema and Vermeulen, 1998; Mudambi, 1995). As it has been argued in the theoretical model developed in previous section, the stock of existing FDI in the host country may also affect the national technological capabilities and mitigate the effect of institutional quality on R&D internationalisation decision.

The NSI approach also claims the importance of other variables related to the socio-economic context such as labour market and fiscal system. These aspects are also partially coincident with the FDI models predictions such as the establishment costs in host economies -taxes- and the potential necessity of qualified workforce for developing sophisticated activities such as technology related ones –proxied by wages levels- (Markusen, 2002; Javorcick and Wei, 2009). These variables are included in the block of other factors (O) since they also may condition the internationalisation of R&D activities (Hall, 2011). Moreover, control variables are included in the analysis: The first one is the market size of host countries (measured by GDP) and the main reason for its inclusion is the possibility to control by the type of R&D developed by foreign subsidiaries in host locations. As known, a great amount of FDI is carried out in order to exploit the main competencies developed by MNE in their home countries through subsidiaries where R&D would be mainly oriented to the adaptation of products to domestic tastes (Dalton and Serapio, 1999).

The econometric model to be estimated is thus defined as follows:

$$\begin{aligned} \text{IRD} = & \beta_0 + \beta_1 \text{CC}_{it} + \beta_2 \text{XHT}_{it} + \beta_3 \text{PAT}_{it} + \beta_4 \text{FDIstock}_{it} + \beta_5 \text{GDP}_{it} + \beta_6 \text{W}_{it} \\ & + \beta_7 \text{TAX}_{it} + \eta_i + U_{it} \end{aligned} \quad (13)$$

where η_i represents the individual effects and U_{it} an error term. *CC* represents control of corruption, *XHT* denotes exports of high-tech, *PAT* refers to patents granted, *FDIstock* is the stock of inward FDI, *GDP* denotes Gross Domestic Product and *W* and *TAX* represent wages and tax pressures in host economies, respectively. The definition of these variables can be found in the Appendix.

In addition, considering our argument defending the importance that different levels of internationalisation may have for NSI as well as for the attraction of MNE, two more control variables have been included in the estimation of the model: First, the fact that patents can be assigned to domestic or foreign firms and second, whether these patents have been the result of collaboration with other agents from abroad. The stock of inward FDI comes to represent the competitive pressures which MNE are facing abroad with regard to their competitors' movements as well as their past experience in host countries (Álvarez and Marin, 2010; Barkema and Vermeulen, 1998; Mudambi, 1995). A related argument is related to the existence of subsidiaries with differentiated competences makes more likely that those more creative show a more dynamic technological performance and also broader links in international networks (Álvarez and Cantwell, 2011). The presence of these kinds of subsidiaries in host countries could favour the location of new knowledge intensive activities and, in consequence, the internationalisation of R&D being more likely. For this reason, other two specifications of the econometric model are defined as follows and estimated accordingly:

$$\begin{aligned} \text{IRD} = & \beta_0 + \beta_1 \text{CC}_{it} + \beta_2 \text{XHT}_{it} + \beta_3 \text{FOR_PAT}_{it} + \beta_4 \text{DOM_PAT}_{it} + \\ & \beta_5 \text{FDIstock}_{it} + \beta_6 \text{GDP}_{it} + \beta_7 \text{W}_{it} + \beta_8 \text{TAX}_{it} + \eta_i + U_{it} \end{aligned} \quad (14)$$

$$\begin{aligned} \text{IRD} = & \beta_0 + \beta_1 \text{CC}_{it} + \beta_2 \text{XHT}_{it} + \beta_3 \text{FOR_PAT_COL}_{it} + \\ & \beta_4 \text{DOM_PAT_COL}_{it} + \beta_5 \text{FDIstock}_{it} + \beta_6 \text{GDP}_{it} + \beta_7 \text{W}_{it} + \beta_8 \text{TAX}_{it} + \eta_i + \\ & U_{it} \end{aligned} \quad (15)$$

where η_i represents the individual effect and U_{it} is the error term; FOR_PAT denotes those patents granted to foreign firms and DOM_PAT are the patents granted to domestic firms; FOR_PAT_COL represents foreign patents granted with collaboration from abroad and DOM_PAT_COL are those domestic patents granted with collaboration from abroad. The definition of these variables can be found in the Appendix.

Regarding expected signs, it can be thought that institutional quality provides a favourable scenario for R&D internationalisation in such a way that the higher is the governance level in the host country, the higher the attraction for MNE investments will be, and especially for R&D activities. With regard to the indicators of national technological capabilities, the sign of the coefficient referred to patents can be defined according to the R&D strategies followed by subsidiaries abroad, i.e. knowledge creation versus knowledge exploitation. When the former strategy prevails, a positive sign would be expected because of the interest of MNE in tapping into the knowledge base of host location and complement their core competencies, while ensuring the property rights derived from the knowledge generated abroad. On the other hand, R&D internationalisation would be positively related to more sophisticated productive structures and those with a more active role in the global value chain; therefore, a positive sign for the variable corresponding to the relative importance of high-tech exports is expected. Regarding inward FDI stock, a positive sign is expected given the fact that previous experience of foreign subsidiaries in host countries could contribute to reduce the risk of performing R&D activities abroad and it would reflect the so called “moving behind”.

Likewise, the location of R&D activities abroad is positively related to those NSI with higher levels of labour qualification. In this sense, it can be assumed that innovative subsidiaries require from local labour markets more qualified workers that would also receive higher compensations. Then, the expectation is a positive sign in wages instead of the traditional negative relationship between FDI and salaries that economics models predict. Regarding fiscal pressure, this is understood as part of the establishment costs that MNE face when they take the decision of locating abroad. However, we cannot anticipate the sign of this relationship when the internationalisation of R&D is in focus

because the internationalisation decision can be also related to other activities of subsidiaries, such as production, distribution and marketing.

Finally, the sign of the host market size is not clear because it would be a proxy of the relative importance of the subsidiaries' strategies evolution from market seeking to knowledge seeking: while a positive sign would reflect the prevalence of competence exploiting activities in host countries, a lack of significance would reflect the subsidiary evolution to more technology seeking activities. Expected signs are summed up in Table 1.

Table 1. Expected signs

Dependent variable	Predictors						
	CC	XHT	PAT	FDIstock	W	TAX	GDP
IRD	+	+	+	+	+	?	?

According to the specifications (14) and (15) of the econometric model, expected signs for the variables that remain in the model prevail. By contrast, those signs related to foreign and domestic patents are hard to be anticipated because they will reveal the dynamics of the technological performance of host NSI in connection with the relative importance that global networks have for both domestic and foreign firms in the internationalisation of R&D activities, an important element of our explanatory framework.

The empirical analysis is carried out using data for a sample of 21 countries over a time span of thirteen years (1996-2008). The availability of panel data allows us to apply either fixed effects or random effects regression models. It seems more suitable to estimate through the latter method in order to account for unobserved heterogeneity across countries. However, this estimation procedure relies on the absence of correlation between the unobserved individual effects and the explanatory variables to ensure the efficiency and consistency of the estimators (Wooldridge, 2002). In order to choose the appropriate estimation procedure -fixed vs. random effects-, the Hausman test was conducted. Failing to reject the null hypothesis means that the random effects regression model is valid. Results from this test allow us to focus on random effects estimators throughout the remaining of the paper.

5.2. Discussion of results

The estimation results for the general model (column 1 in Table 2) highlight the relevance of institutional quality in host location for the internationalisation of R&D. Contrary to our expectations, control of corruption exerts a negative effect on the relevance of foreign R&D in host countries and it remains in the other two estimations (columns 2 and 3 in Table 2). This result reveals that R&D activities performed by foreign subsidiaries are more significant in host NSI in which the perception of control of corruption is lower. The explanation for this negative sign seems to be related to the higher importance that the fear of knowledge leakage has for foreign subsidiaries performing R&D activities. In such a case, the likelihood of potential externalities and the lower perception of the power exerting intellectual property rights operate as an important restriction for the market option. The choice of subcontracting R&D activities with local firms will not be a preferable option when large corporations choose R&D internationalisation within their network of subsidiaries.

In relation to those variables directly associated to national capabilities, it is more likely that MNE perform higher levels of R&D in those economies with a higher presence of more technologically sophisticated activities, this reflected in the positive sign of the high-tech export coefficient in the three estimations (see Table 2). In such a case, NSI are more attractive for technological functions where there is a higher specialisation in more sophisticated industries, which reflects the relevance of the global value chain inside and outside the MNE. There is also a significant positive relationship between the R&D activities performed by foreign units and the patenting activity of host countries (column 1 in Table 2), a result that highlights the relevance of local technological capabilities as a mechanism for attracting global R&D investments. It is certain that the level of patents can be associated with a more stable intellectual property rights protection, an aspect that can favour the R&D investments of foreign subsidiaries. However, when the nationality of patents granted is considered (column 2 in Table 2), the presence of a negative and significant relationship with patents assigned to domestic companies arises. This negative relationship, although being indicative of a higher propensity of knowledge generation by domestic firms over foreigners, is mitigated by the fact that patents granted to foreign firms exert a greater positive effect for foreign R&D activities attractiveness to locations. This result underlines the prevalence of new

inventions carried out by foreign subsidiaries in local contexts revealing also the fact that foreign units accede preferentially to patents as a tool to preserve the intellectual property rights associated to the new knowledge generated by R&D in place. In such a case, it can be thought that technology-driven investments prevail over other strategies such as adaptation to national consumption.

Table 2. Estimations results

	(1)	(2)	(3)
CC	-0.2013 (0.0978)**	-0.1940 (0.0943)**	-0.1874 (0.0860)**
XHT	0.3806 (0.1303)***	0.3650 (0.1363)***	0.3486 (0.1095)***
PAT	0.1628 (0.0874)*		
FDISTOCK	0.1990 (0.0892)**	0.2954 (0.0752)***	0.2098 (0.0783)***
GDP	0.1104 (0.0928)	0.0812 (0.0792)	0.1362 (0.0871)
W	0.4581 (0.3210)	0.4163 (0.2821)	0.3335 (0.2504)
TAX	-0.2557 (0.2075)	-0.2523 (0.1902)	-0.3285 (0.1620)**
FOR_PAT		0.2418 (0.0706)***	
DOM_PAT		-0.1892 (0.0548)***	
FOR_PAT_COL			0.2693 (0.0702)***
DOM_PAT_COL			-0.1532 (0.0611)**
Constant	2.5227 (2.8664)	2.7628 (2.1193)	2.6082 (2.1939)
R ²	0.451	0.624	0.741
Wald χ^2	104.98***	114.04***	132.89***
Observations	123	123	123

* significant at 10% level; ** significant at 5% level; ***significant at 1% level

Robust standard errors in parentheses.

All variables are included in logarithms.

The previous argument is also supported by the results obtained for the GDP variable, which is not significant in any of the estimations (see Table 2). The lack of significance of market size in host countries would reveal that foreign R&D investments oriented to the development of new competencies inside the MNE prevails. On the other hand, the previous experience of MNE in host countries, as well as the competitive pressures that they have to face, are key determinants in the internationalisation of R&D, an aspect that is reflected in the positive and significant sign of the FDI variable (see Table 2). This result could reflect the ability of MNE to tap into local knowledge and their capability to benefit from the knowledge developed in geographically dispersed locations. Regarding the result for the labour variable, this is in line with previous evidence that highlight how the need of qualified workers is not a prerequisite for the internationalisation of R&D; the lack of significance confirms the predictions of FDI theoretical models in which higher value added activities such as R&D are not commonly differentiated.

The consideration of those patents granted to both domestic and foreign firms that correspond to inventions generated in collaboration with other agents from abroad enrich this analysis in which the fact that foreign subsidiaries belonging to global networks respond to a more realistic conception of large MNE to study R&D internationalisation (column 3 in Table 2); this variable exerts a positive effect that underlines the potential process of technology creation by more creative subsidiaries. On the contrary, the patenting activity of domestic firms with collaboration from abroad has a negative influence in the internationalisation of R&D. This shows that the technological competitive pressure exerted by the host environment functions as an entry barrier to foreign R&D activities, and the host country innovative networks deter the R&D investments by foreign subsidiaries. These findings reinforce the relevance of international networks and the globally dispersed technological activities in the worldwide value chain.

Finally, being aware of other factors that affect R&D internationalisation such as the establishment costs abroad –proxied by the tax variable–, there is initially a lack of significance while this variable becomes relevant only when controlling by the collaboration of domestic and foreign firms in patenting activity (column 3 in Table 2). In that case, the level of fiscal pressure has a negative influence. Therefore, the

strategies of R&D internationalisation respond to a pattern that is not necessarily coincident with the theoretically determinant factors of firms' internationalisation. The specificity of knowledge generation activities that are involved by definition in the R&D performed by foreign subsidiaries would explain that fiscal pressure is not a determinant factor for R&D investments with the exception of those subsidiaries with an active collaborative role in the generation of knowledge within international networks.

These findings provide new insights about foreign R&D location decisions, supporting the idea that institutional quality plays a crucial role in the internationalisation of R&D and claiming the relevance of the technological capabilities of host NSI as well as the international knowledge related activities. Regarding previous evidence, our results allow us to argue only partially that the control of corruption increases the attractiveness of countries in terms of foreign R&D activities (Doh et al., 2005). One interpretation for this type of result is that in those countries where there is a high level of corruption, foreign technologically sophisticated firms fear the potential technological leakage that can be derived from subcontracting innovative activities to local partners (Javorcik and Wei, 2009) and, consequently, prefer the establishment of R&D facilities in host locations. On the other hand, it has been argued that in locations where corruption is present but there is a high level of FDI stock, the choice of MNE for new investments is likely (Barassi and Zhou, 2012; Wei, 2000). This argument is in line with our results and offers a complementary interpretation since the previous and overall presence of MNE in foreign countries favours the location of R&D activities and seems to reduce the risk of performing innovative activities in more corrupt countries, the so called "agglomeration effect" or "moving behind" mitigating the impact of corruption on R&D internationalisation.

Our results also denote that R&D activities of foreign subsidiaries are more oriented to technology-seeking strategies than to market-seeking ones because the technological capabilities and economic specialisation of host countries are primary drivers of R&D location over the more traditional economic factors. This suggests that R&D internationalisation allows the MNE knowledge sourcing function in those local environments of high strategic value, taking advantage of the benefits derived from knowledge spillovers. Accordingly, the argument based on the dual embeddedness of

subsidiaries -i.e. linkages with internal and external actors to the MNE- in host countries for the creation of new technological capabilities and the possibilities to gain competence-creating mandates (Athreye et al., 2014) gains all the sense here. Similarly to this, our empirical findings confirm the relevance of the international networks of foreign subsidiaries for knowledge generation in local contexts, and especially when the collaboration links from abroad takes place, what favours R&D investments. On the contrary, technological competitive pressures and rivalry arising from domestic firms and their international networks discourage the R&D activities carried out by subsidiaries in foreign contexts. One possible interpretation is that foreign investments are more oriented to sustain those competencies developed by other MNE units (Andersson et al., 2014) when domestic innovative capabilities exceed the foreign ones. This situation could be more related to new and late entrants because they might find more difficult to establish connections with local actors as they are more adverse to institutional instability and perceive the risks of investments to outweigh the rewards (Steven and Dykes, 2013).

6. Concluding remarks

This contribution enhances our present understanding about the attractiveness of countries for foreign R&D activities recurring to arguments based on the institutional framework and the international generation of technology. The theoretical model and the empirical analysis presented here support the relevance of the characteristics of the national system of innovation in host countries for the analysis of R&D internationalisation since they mitigate, and even overcome, the effect of institutional quality on the foreign R&D location and investment decisions. The discussion of results point out the relevance of institutional quality in the internationalisation of R&D activities while the overall effect of the institutional set up is conditioned by the competitive pressures that MNE face in local contexts and the features of host NSI.

The implications from here are diverse despite the fact that the analysis has been carried out at the aggregated level. Accordingly, it is possible to affirm that the MNE decision to internationalise its R&D activities is highly conditioned by the presence of “good governance” in host economies but also by the potential integration of foreign subsidiaries in both local contexts and international networks for technology generation, a combination of aspects that may favour the evolution of foreign subsidiaries from

market-seeking to technology-seeking strategies in host countries. As a consequence, those initiatives of national governments oriented to attract foreign R&D investments can be mitigated by the importance of some elements regarding the development of the private sector and should be also directed to guarantee that these elements are present, or can be improved, in the national context. If these elements are not in place or the conditions are not supported to create them, a potential substitution effect of the R&D performed by foreign subsidiaries in those host contexts with lower levels of R&D efforts may exist (R&D crowding out effect). Moreover, the importance of this is due to the fact that a good level of absorptive capacities in host productive systems can provide more solid linkages for foreign subsidiaries to strength the possibilities of spillover effects and even the potential benefits from reverse knowledge flows.

R&D attractiveness policies defined and implemented by national governments have to be then aware about the fact that technological strategies followed by foreign subsidiaries can act as a reinforcement mechanism in the internationalisation of host NSI, and also promoting the technological upgrading of host countries and providing international links to knowledge networks. Particularly, the extension of these findings may encourage future research in this direction by the development of new explanations and evidence that differentiate by the diverse activities that subsidiaries carry out abroad and their subsequent impacts.

Finally, some limitations of this study are found in the short availability of aggregated data that would allow a better empirical test of the role of different MNE strategies in the internationalisation of R&D activities and their conditioning effect on the attractiveness of host locations in terms of institutional quality. Besides, due to the lack of information, it is not possible to identify the home country of the MNE, an aspect that could shed more light on R&D internationalisation and the potential reverse knowledge flows. These and other questions will lead further research. The previous analysis defines the core income versus costs setting and provides the basis to develop a dynamic version of the strategic environment faced by MNE. It is plausible to think on the fact that MNE with previous connections within the host country can modify the level of corruption faced by foreign subsidiaries and are able to exploit the technological capabilities of the host country to a greater extent. This is a strategic aspect that can be of considerable importance for MNE. At the same time, less corrupt

adverse subsidiaries manage to easily acquire knowledge spillovers following from any additional R&D being performed by the existing firms within the local market.

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Appendix

Table A1. Summary of Variables

Name	Description	Source
IRD	R&D expenditure of multinational enterprises as a percentage of total R&D business enterprise.	OECD Statistics on Measuring Globalisation database
CC	Control of corruption	Worldwide Governance Indicators, World Bank
FDIstock	Stock of inward foreign direct investment. Constant PPP \$US 2005	UNCTAD FDI database
GDP	Gross Domestic Product. Constant PPP \$US 2005	World Development Indicators, World Bank
PAT	Patents granted at the USPTO divided by midyear population (in thousands).	OCDE Science and Technology Statistics
XHT	High-technology exports as a percentage of total manufacturing exports.	World Development Indicators, World Bank
W	Total compensations of employees divided by total employees. Constant PPP \$US 2005	OCDE Labour Statistics
TAX	Tax revenue as percentage of the GDP	World Development Indicators, World Bank
FOR_PAT	Foreign ownership of domestic inventions granted at the USPTO divided by midyear population (in thousands).	OCDE Science and Technology Statistics
DOM_PAT	Domestic ownership of inventions granted at the USPTO divided by midyear population (in thousands).	OCDE Science and Technology Statistics
FOR_PAT_COL	Percentage of foreign ownership of domestic inventions granted at the USPTO with collaboration from abroad	OCDE Science and Technology Statistics
DOM_PAT_COL	Percentage of domestic ownership of inventions made abroad granted at the USPTO with collaboration from abroad.	OCDE Science and Technology Statistics