46º ENCONTRO NACIONAL DE ECONOMIA

11 a 14/12/2018 – Rio de Janeiro

Área: Economia Industrial e da Tecnologia

Locational choice of R&D activities abroad. The U.S. corporates' R&D captive offshoring in developing countries.

Tulio Chiarini
National Institute of Technology (INT), Rio de Janeiro
tulio.chiarini@int.gov.br

Thiago Caliari
Aeronautics Institute of Technology (ITA), São José dos Campos
caliari@ita.br

Pablo Felipe Bittencourt
Federal University of Santa Catarina (UFSC), Florianópolis
pablofelipe.bittencourt@gmail.com

Marcia Siqueira Rapini
Federal University of Minas Gerais (UFMG), Belo Horizonte
msrapini@cedeplar.ufmg.br

Acknowledgements:
The opinions expressed herein are those of the authors alone. They do not necessarily reflect the views of, or involve any responsibility on the part of, the institutions to which the authors are affiliated. Any errors remain the fault of the authors.

Funding:
This work was supported by the Commission on Qualification of Graduated Human Resources (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*, CAPES) from the Brazilian Ministry of Education [BEX 5796/15-6].

Abstract

In the last decades, we witness an increase of the R&D performed abroad by multinational companies. These companies have progressively adopted an internationally integrated approach to their inventive activities. This paper contributes to the literature on R&D internationalization by analyzing locational factors, which drive multinational companies to use captive offshoring to fund their R&D activities in developing countries. The paper considers the R&D investment performed by the majority-owned foreign affiliates of U.S. parent companies abroad. We construct a temporal database panel containing 75 countries and apply a random-effect Tobit model. The results highlight some important determinants to explain U.S. R&D captive offshoring in a developing country: (1) R&D investment cumulativeness; (2) National Innovation Systems maturity; and (3) Market size. This implies that attracting knowledge and innovative activities from abroad depends on policies designed mainly to enhance some elements of National Innovation Systems.

Key words: Innovation, R&D internationalization, R&D captive offshoring, MNC.

JEL Classification: O32; O39; F63.

1 Introduction: setting the scene and research questions

In the last decades we testimony a fast and increase growth of R&D performed abroad by multinational companies (MNCs, henceforth) (UNCTAD, 2005a, 2005b; OECD, 2008) which has become recognized by many scholars who got interested in the strong trend towards its internationalization[1]. Notwithstanding that, international allocation of research activities is not recent (Lall, 1979; Cantwell, 1995).

The expansionary trend of private U.S. R&D performed abroad through foreign affiliates – the so-called R&D captive offshoring – provides a sound example of private R&D internationalization. Indeed, there are recent studies that demonstrate there is a continuing increase of U.S. private R&D abroad (Laurens *et al.*, 2015; NSB, 2016). Figures from 1997 illustrate that U.S. R&D captive offshoring was USD 18,935 million and it reached USD 39,470 million in 2010[2]. In relative terms, it represented 9.4% of overall R&D developed at home in 1997 and 14.1% in 2010.

Both economic and business literature has paid ample attention to the locational factors that affect U.S. R&D internationalization. There are numerous empirical studies carried out in the last decades which revel that R&D intensity of U.S. affiliates is determined mainly by domestic market size, overall R&D capability and cost of hiring R&D personnel (Kumar, 1996, 2001; Doh *et al.*, 2005; Thursby & Thursby, 2006; Flores & Aguilera, 2007; Hegde & Hicks, 2008; Athukorala & Kohpaiboon, 2010). Moreover, there are other relevant factors such as domestic business environment aspects – availability of technical personnel, nature of property right legislation, tax concessions, political stability, foreign trade regime (Athukorala & Kohpaiboon, 2010) – and also institutional and cultural aspects – political and legal systems, cultural similarities and levels of trust (Flores & Aguilera, 2007).

That being said, most U.S. R&D captive offshoring is performed in Europe, Canada and Japan – Triad countries (Chesnais, 1994). In fact, 'Triad' receives 73.6% of total U.S. R&D captive offshoring in 2010 and if we consider in this group other high-income countries such as Australia, New Zealand and the Asian Dragons (Hong Kong, Singapore, Taiwan and South Korea), the concentration increases to 88.5%. The other 11.5% goes to the 'Rest'of which Brazil, China and India concentrate 77.1%. Looking at a long-term perspective, Brazil, China and India seem to be more and more attractive players in global R&D while other middle and low-income countries are still not part of the game.

If that holds true, why do some developing countries such as Brazil, China and India concentrate more U.S. R&D investment? This question straightly leads to the following one: What are the local features that make some developing countries more 'inviting' for U.S. R&D captive offshoring?

Therefore, the aim of this study is to examine the locational factors that are more (or less) relevant in a developing country[3] to attract R&D investment from MNCs headquartered in the U.S.. Once we identify those factors, we can provide insights to answer the previous questions. Although there is an academic literature that examines empirically the factors that drive the location choice of R&D activity abroad (Demirbag & Glaister, 2010; Siedschlag *et al.*, 2013), there is a limited number of studies that present a specific analysis regarding developing countries' specificities focusing in emerging markets such as Brazil, China and India, taking into account the U.S. R&D

[1] See: Pearce and Singh (1992), Chesnais (1994), Dunning (1994), Patel (1995), Kumar (1996), Archibugi and Michie (1997), Cantwell and Santangelo (1999); Cantwell and Janne (2000), Cantwell and Santangelo (1999), Patel and Vega (1999), Patel and Pavitt (2000), Archibugi and Iammarino (2002), García-Vega and Huergo (2011), Iammarino and McCann (2013), D'Agostino (2015), Ietto-Gillies (2015), Laurens *et al.* (2015), Jabbour and Zuniga (2016), Athreye and Cantwell (2016), Danguy (2017), Filippetti *et al.* (2017), Tabrizy (2017) and Zacharewicz *et al.* (2017).

[2] Bureau of Economic Analysis. Current USD deflated by GDP deflator (year-base 2010) available at the World Bank.

[3] By developing country, we mean the low and middle income-country classification by the World Bank. We are aware of the limitations of this concept.

captive offshore. In short, this paper fills this gap, throwing some light on the locational features of Brazil, China and India that make them more attractive than other developing countries for U.S. companies' R&D investments. It also complements the work done by Chiarini (2017), who makes an exploratory analysis of the recent U.S. inward R&D-related FDI in Brazil, China and India. This is where the originality of this study lies and where it intends to make its contributions.

The reminder of the paper is organized as follows. On section 2, we make an appreciative theorizing, showing that R&D is a key activity and it is performed at home (onshore) and abroad (offshore). It is important to mention that by no means this section covers all the literature available on corporate R&D efforts and its internationalization as it goes beyond the scope of this paper and once it is possible to find it elsewhere[4]. Against this background, on section 3, we present the empirical methodology (data, some descriptive analysis of the database and the modelling). On section 4, we present the econometric results. On section 5, we introduce an exploratory discussion on what regards Brazil, China and India as the main developing countries receivers of U.S. R&D investment. Finally, in the last section, we address the main conclusions.

2 Framing corporate investment in R&D: why to invest abroad

Companies' competitive advantages come from their accumulated capabilities to create, transfer, combine, assemble, integrate and exploit knowledge assets. Knowledge assets help building the company's capabilities which in turn underpin the company's products and services offering to the markets (Teece, 2004). Consequently, performing R&D is a relevant activity, once not only does it generate new knowledge, but also enhances the company's ability to assimilate and exploit existing ones from the environment – what it is called a firms' 'absorptive' capacity (Cohen & Levinthal, 1989, 1990).

It is part of a company's strategy to decide to perform R&D in the home country (onshore) and/or in a foreign country (offshore). In order to take advantage of foreign technological capacities, companies locate their research labs and production facilities in many locations via networks of internal units (set of subsidiaries and headquarters) and via external networks. This way it is possible to access the tacit part of technology that is specific to the context in which new technologies are created. To access the complementary assets to innovation, MNCs have local presence through the combination of research (for learning) and skills related routines in the production.

We can say that the innovative efforts are a principal source of a company's ownership advantages. In this way, the ownership advantages are dynamic: they seek to improve and to search news advantages. The learning process that leads to innovation is also an ownership advantages, and subsidiaries can enlarge their knowledge base from the global, local or internal knowledge network, which are contingent on the strategic choice made by the headquarters (Athreye *et al.*, 2016). Therefore, MNCs that are able to organize a network – subsidiaries and parent companies – to knowledge creation and exploitation taking advantage of local specificities, act in different National Systems of Innovation.

Before the 1980s, innovative activities were mainly centralized and performed in-house in the home country (Kurokawa *et al.*, 2007) especially because of supply-side reasons such as scale economies (Vernon, 1966) and because of higher appropriability of R&D efforts (Granstrand *et al.*, 1993). Notwithstanding that, it was also possible to see a growing R&D outsourced to providers in the home country, especially to universities and research institutes (Nelson, 1990).

A strong trend towards the internationalization of R&D begins in the 1980s (Archibugi & Michie, 1997; Archibugi & Iammarino, 2002; UNCTAD, 2005a) both captive offshoring and offshore outsourcing, nevertheless empirical studies show that the former is still preferred to the latter (Albertoni & Elia, 2014). The increasing offshoring trend is driven in large measure by technology factors (Florida, 1997). Thus, companies perform R&D abroad to secure access to

[4] See Dachs (2014).

scientific and technical human capital (Florida, 1997) – even if they risk to have their R&D leaked to foreign competitors (Athukorala & Kohpaiboon, 2010) – in order to improve existing assets and to tap into knowledge around the globe (Dunning & Narula, 1995). Accordingly, this trend reflects the global character of knowledge assets creation and exploitation (Teece, 2004). In fact, a recent econometric study suggests that MNCs that offshore their innovative activities are more productive that those that offshore their non-innovative tasks (Tabrizy, 2017).

Innovation studies literature indicate that there are two centrifugal ‘forces’ capable of explaining the dispersion of R&D activities abroad. Firstly, because of the need to adapt production processes and products to suit to local conditions and regulations, i.e., asset/competence exploiting or home-base-exploiting R&D (Dunning & Narula, 1995; Kuemmerle, 1999; Cantwell & Mudambi, 2005). In fact, a large share of R&D investments from MNCs has been focused on the adaptation/standardization to local demand conditions, especially in developing countries.

Secondly, in order to benefit from localized technology spillovers in these locations, that is, companies locate R&D facilities abroad, especially in prominent centers of excellence in specific technologies, in order to enable themselves to enrich their own R&D (Athukorala & Kohpaiboon, 2010), i.e., asset/competence augmenting or home-base-augmenting R&D (Kuemmerle, 1999; Dunning, 2009). This is the case to overcome lock-in traps, i.e., MNCs perform research abroad to have access to external knowledge available (Levinthal & March, 1993), to benefit from potential knowledge spillover opportunities (Feinberg & Gupta, 2004) and to take advantage of qualified personnel (Lewin *et al.*, 2009).

Many developing countries try to attract high-value added activities (R&D, engineering and product design) from abroad, however, attracting foreign investment in R&D and trying to host innovative activities may require the participation of the most productive MNCs that are likely to be larger in size (Tabrizy, 2017). This may have negative effects for emerging countries.

For example, if MNCs acquire indigenous firms’ research facilities, the host country loses the control towards the technology previously locally produced and may also reduce the levels of research done locally. As part of rationalization strategies, mergers and acquisitions may lead to a reduction of R&D activities and the remaining R&D becomes narrower in scope (or more focused) and its time horizon becomes shorter (UNCTAD, 2005b). There are empirical evidences that show that less developed countries are chosen for low-value R&D (or adaptive R&D), that is, product and processes adaptation to local conditions and activities not related to knowledge creation. Therefore, MNCs may impose a new type of international division of labor in which advanced countries carry high-value R&D activities while less developed countries carry low-value R&D. The former adding more value in the global chains and the latter adding relatively much less value, blocking the national system of innovation access to the global knowledge network (Marin & Arza, 2009).

The arguments developed in this section point to the many locational factors that affect the decision of a company to offshore R&D. For example, different levels of territorial and social embeddedness may or may not motivate overseas R&D and its location (Cantwell & Piscitello, 2002). Therefore, the motivations and determinants to establish R&D labs in different developing economies may diverge and only a small number of them are able to attract foreign R&D investment. In the next section, we propose different econometric models that help us understand why only a few of them can take part of this very fierce game.

3 Empirical methodology

3.1 Data and some descriptive analysis

Our analysis is focused in a national-level panel data, with information about host countries. We compiled the dataset based on information available at the World Bank (WB), at the U.S. Bureau of Economic Analysis (BEA) and at the United States Patent and Trademark Office (USPTO). Table 1 presents the considered variables for the econometric model. Data regarding U.S.

R&D captive offshoring and regarding innovation system require a more detailed presentation. Therefore, in sections 3.1.1 and 3.1.2 we make an effort to present them.

Table 1 – Variables investigated

Variables	Units	Source
a. Dependent variable		
U.S. R&D captive offshoring	USD*	BEA
b. Independent variables		
Lagged value of U.S. R&D captive offshoring	USD*	BEA
GDP per capita	USD*	WB
Population	Number of inhabitants	WB
Open Trade[1]	% of GDP	WB
Innovation system		
1. R&D expenditure	% of GDP	WB
2. USPTO patents per capita	Per million inhabitants	USPTO
3. High-technology exports	% of manufactured exports	WB
4. Economic Complexity Index (ECI)	-	Hausmann *et al.* (2013)
5. Scientific/technical journal articles per capita	Per million inhabitants	WB
c. Control variables		
Dummy for geographical distance	Km	https://www.distancefromto.net/
Dummy for economic cycles[2]	-	Authors' own

Source: Authors' own. Note: ([1]) Sum of exports of goods and services plus imports of goods and services as a proportion of GDP; ([2]) Economic cycles identified in 2000-2001 and 2009. (*) Current U.S. dollars was deflated by GDP deflator (year-base 2010) available at the WB database.

3.1.1 Dependent variable: U.S. R&D captive offshoring data

The departure point of the database is the dependent variable U.S. corporates' R&D captive offshoring. The U.S. Bureau of Economic Analysis (BEA) provides historical series for outward direct investment including R&D figures in millions of current U.S. dollars for many countries worldwide. However, for many others BEA presents an aggregate value for a group of them according to their geographical region, this is so to avoid disclosure of confidential information or because the value invested was relatively insignificant.

We assumed null value for these grouped countries, since the sum by region was statistically irrelevant. For example, in 2000 'other European countries' accounted for about USD 9 million (only 0.05% of U.S. R&D captive offshoring in total Europe). In the same year, for instance, 'other South American countries' accounted for less than USD 500 thousand.

We also deflated the time series using the GDP deflator (year-base 2010) available at the WB database. Once the database regarding the U.S. corporates' R&D captive offshoring was done, the first things to note was its increase thorough time (Table 2) and its fluctuation together with economic cycles. From 1997 to 2000, the average growth rate was 10.50% per year, however, with the Dot.com bubble burst in late 1990s, U.S. corporate R&D investment abroad falls and the rate in 2001-04 reduces to 3.97% per year. In the following period (2005-08), investment starts to grow again, reaching 9.90% per year, when there is an economic recovery. However, with the 2008 financial crises, R&D investment abroad reduces drastically and there is a negative growth rate of 3.61% (in 2009-10). This suggests that R&D investment is pro-cyclical and it is sensitive to economic conditions (Archibugi & Michie, 1995). Therefore, we control the models with a dummy trying to capture the economic cycles.

Table 2 also permits us to verify right away that most of U.S. R&D captive offshoring is concentrated in developed countries and they concentrate as an average 91.09% of total U.S. R&D investment abroad (in 1997-2010).

Table 2 – R&D performed abroad by majority-owned foreign affiliates of U.S. parent companies (all industries), by region, Millions of constant U.S. dollars, 1997–2010

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EU	12,979	13,333	15,445	15,909	14,575	16,013	17,377	19,165	20,693	20,632	23,637	27,030	25,350	24,406
SA	679	702	463	414	348	463	432	460	498	679	807	995	1,158	1,571
CA[1]	180	259	311	404	331	470	0	365	0	0	0	491	326	379
AF	34	45	23	31	35	35	36	32	44	72	61	58	95	88
ME	270	181	492	779	877	876	802	994	847	897	1,068	2,033	1,879	1,965
AS & OC	2,425	2,058	4,078	4,865	5,069	4,506	4,740	5,234	5,242	6,260	7,019	8,663	7,922	8,313
Other EU	70	104	1	9	8	11	9	18	D	44	36	D	D	D
Other SA	1	3	*	*	2	1	1	1	1	0	D	D	3	4
Other CA	*	*	*	D	*	*	*	D	*	*	D	D	D	3
Other AF	3	4	1	*	1	D	4	2	4	7	5	6	5	6
Other ME	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Other AS & OC	1	1	*	*	*	1	*	*	*	1	3	4	2	2
Brazil	567	572	364	313	241	363	369	398	446	613	631	800	967	1,372
China	45	67	403	625	0	768	659	653	735	810	1,220	1,704	1,598	1,452
India	29	30	25	0	0	89	95	128	360	360	397	1,369	1,394	1,644
Developed	17,893	17,620	21,306	22,810	21,796	22,521	24,916	27,351	28,316	29,119	32,619	37,152	34,466	33,678
Developing	1,042	1,203	1,632	2,477	2,015	2,550	1,683	1,998	2,113	2,463	3,202	5,377	5,218	5,792
Total	18,935	18,822	22,938	25,287	23,811	25,071	26,600	29,349	30,429	31,582	35,821	42,529	39,684	39,470

Source: Authors' own. Data sourced from BEA, Survey of U.S. Direct Investment Abroad (annual series) and complied by Science and Engineering Indicators (2014). Note: Absolute value is in Millions of constant U.S. dollars. Current U.S. dollars was deflated by GDP deflator (year-base 2010) available at the WB. According to BEA, * = < $500,000; D = suppressed to avoid disclosure of confidential information. EU = Europe; SA = South America; CA = Central America; AF = Africa; ME = Middle East; AS = Asia; and OC = Oceania. ([1])Central America comprises also the Caribbean countries and Mexico.

3.1.2 Independent variable: Innovation system data

Another variable used in the model is what we called 'innovation system' and we defined it as the first factor obtained by the factor analysis technique for different variables. There many possible variables used in the literature to characterize an innovation system (IS) ranging from a narrow to broad definition of IS (Lundvall *et al.*, 2009). The previous focuses on effort-related and performance-related indicators. The main ones proposed are R&D expenditure, S&T expenditure, human resources allocation in R&D, patent applications, scientific publications, etc. (Lundvall *et al.*, 2009). However, some IS elements and relationships that directly affect the national learning capacity are both informal and difficult to measure. For this reason, in a broad perspective, other indicators that analyze social institutions, communication and education infrastructure, the type of relationship between actors, etc., should be considered (Lundvall *et al.*, 2009).

Unfortunately, due to the lack of comparable data in historical perspective for many countries, we opt to focus only on indicators from a narrow definition of IS. The ones selected are:

a. R&D investment;
b. Patents deposited at USPTO per capita;
c. High-technology exports;
d. Economic complexity index (ECI);
e. Scientific/technical journal articles per capita.

'R&D investment' is the current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge. R&D covers basic research, applied research, and experimental development. 'USPTO patents per capita', on its turn, refers to the number of patent applications filed in the United States Patent Office by country of origin – based on the residence of the first-named inventor – per million inhabitants.

The factor 'High-technology exports' represents products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. And the factor ECI, according to Hausmann et al. (2013), is a scale that uses the theory of and calculations for economic complexity to rank countries according to their level of complexity. It ranks how diversified and complex a country's export basket is[5].

Finally, the factor 'Scientific and technical journal articles per capita' refers to the number of scientific and engineering (physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences) articles published per million inhabitants.

The first factor is able to explain 99.75% of total variance. Besides, each variable has the following correlation with first factor: 'R&D expenditure': 0.9646; 'USPTO patents per capita': 0.8848; 'High-technology exports': 0.3671; ECI: 0.7497; 'Scientific/technical journal articles per capita': 0.8162.

3.1.3 List of countries

Getting a temporal database for a large number of countries is not an easy task. There is non-negligible lack of information for many of them, which makes quite hard to form a balanced panel data. We made an exhaustive work to make databases compatible in order to include the largest number of countries as possible. We got in total 75 countries (dispersed all over the world) that appears at least one year at the sample (Table 3). Unfortunately, we were not able to consider more countries since information were not available and among the considered 75 ones, there is still a lot of missing data, which means that we were obligated to deal with an unbalanced panel data[6]. These are probably unneglectable limitations of the database and consequently of the model.

With the list presented in Table 3, we could separate them into developed *versus* developing countries. It is worth to emphasize that the group of developing countries is not stable throughout our period of analyzes (1997–2010) once we used the level of income as a proxy for economic development. Therefore, some countries historically changed their income level status, according to the World Bank methodology. For example, Croatia is considered a high-income country only after 2008, so from 1997 to 2007 it is grouped as a developing economy (middle and low-income country). Other countries considered high income countries are: South Korea (from 2001), Saudi Arabia (from 2004), Trinidad and Tobago (from 2006), Barbados (from 2006), Czech Republic (from 2006), Estonia (from 2006), Slovakia (from 2007), Hungary (from 2007), Latvia (from 2009) and Poland (from 2009). Consequently, the groups of developing countries vary yearly.

Table 3 – List of the 75 countries used in the econometric models

Argentina	Cuba	Israel	Norway	South Africa
Australia	Czech Republic	Italy	Pakistan	South Korea
Austria	Denmark	Japan	Panama	Spain
Azerbaijan	Ecuador	Kazakhstan	Paraguay	Sri Lanka
Belarus	Egypt	Kuwait	Peru	Sweden
Belgium	Estonia	Latvia	Philippines	Switzerland
Bolivia	Finland	Lithuania	Poland	Thailand
Brazil	France	Macedonia	Portugal	Trinidad and Tobago
Bulgaria	Georgia	Malaysia	Romania	Tunisia
Canada	Germany	Mauritius	Russian	Turkey
Chile	Greece	Mexico	Saudi Arabia	Ukraine
China	Hungary	Moldova	Serbia	United Kingdom
Colombia	India	Morocco	Singapore	Uruguay
Costa Rica	Iran	Netherlands	Slovak Republic	Venezuela
Croatia	Ireland	New Zealand	Slovenia	Zambia

Source: Authors' own.

3.2 Modelling

[5] For a methodological presentation of ECI, check Hausmann et al. (2013).

[6] According to Wooldridge (2008) this should not be considered a crucial problem, since the reason for the lack of data of some observation *i* is not correlated with the idiosyncratic errors.

With the data available, we opt to use a panel data econometric method for censored outcomes through random-effect Tobit model[7]. The panel data is important considering the time interval (1997-2010) and it combined with a Tobit model since a large number of countries has null values for U.S. R&D captive offshoring during the period (so, a left-censored dependent variable in zero).

The random-effects Tobit model is calculated using quadrature, which is an approximation whose accuracy depends partially on the number of integration points used. Then, we establish a procedure to check the quadrature approximation, verifying whether the changes in the number of integration points affect the outcomes[8]. We define three distinct models:

a. a complete model with all the 75 countries in data base;
b. a model with only developed countries (high-income countries); and
c. a model with only developing countries (low and middle-income countries).

To test the robustness of each model we tried two different specifications:

a. GDP per capita and population presented in logarithm values;
b. GDP per capita and population presented in natural value.

Therefore, we have six different models. Finally, we performed different tests to find the best quadrature for all six models. As a rule of thumb, if the coefficients do not change by more than a relative difference of 10^{-4} (0.01%), the choice of quadrature points does not significantly affect the outcome, and we can confidently interpret the results. We reach confidence when considering a maximum of 195 integration points (the upper limit of integration points) since the model with developed countries subsample specified by GDP per capita presented in log values (called *Model 2*) demands that. *Model 1* (full sample specified by GDP per capita presented in log values) reached consistent results with at least 120 integration points. We present the models in the next section.

4 Econometric results and discussions

As presented in section 3.2 before, we had two different specifications of our models. We use GDP per capita and population data in both logarithm values and in natural values. The two specifications seem to be robust, that is, GDP per capita and population in both logarithm and natural values do not change drastically the estimation results. In Table 4, we present the parameter estimates and results for all the models, and then, in the next subsections, we propose some possible interpretations.

[7] There is no way to proceed with a parametric conditional fixed-effects model, as it does not exist a sufficient statistic allowing the fixed effects to be conditioned out of the likelihood. Unconditional fixed-effects Tobit models would be fit with the Tobit command, but the estimators would be biased. The software used is STATA 13.

[8] We use the quadrature check command in Stata (quadchk) to verify coefficient results' consistency.

Table 4 – Parameter estimates and results

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
	Full sample	Developed countries subsample	Developing countries subsample	Full sample	Developed countries subsample	Developing countries subsample
U.S. R&D captive offshoring (t-1)	0.880***	0.940***	0.959***	0.885***	0.955***	0.967***
	(31.43)	*(25.96)*	*(21.92)*	*(28.47)*	*(22.55)*	*(20.86)*
Ln GDP per capita	217.5***	54.05	104.9**	-	-	-
	(4.07)	*(0.52)*	*(2.62)*	-	-	-
Ln Population	176.1***	124.9**	107.6***	-	-	-
	(6.33)	*(2.95)*	*(5.03)*	-	-	-
GDP per capita	-	-	-	0.00625*	-0.000384	0.00730*
	-	-	-	*(2.32)*	*(-0.15)*	*(2.00)*
Population	-	-	-	0.000000591**	0.0000029	0.000000405**
	-	-	-	*(3.17)*	*(1.68)*	*(3.19)*
International openness	0.617	0.751	0.778	-0.605	0.466	-0.124
	(1.2)	*(1.58)*	*(1.52)*	*(-0.98)*	*(0.93)*	*(-0.22)*
Innovation System	88.88**	80.15**	17.69***	129.1**	84.68*	14.61*
	(2.78)	*(2.63)*	*(2.63)*	*(3.27)*	*(2.49)*	*(2.24)*
Distance	-0.016	-0.0165	-0.00902	-0.0108	-0.0156	-0.00156
	(-1.68)	*(-1.4)*	*(-1.44)*	*(-0.87)*	*(-1.19)*	*(-0.2)*
Dummy 2000/2001	-34.36	-70	1.743	-44.29	-73.23	-0.709
	(-1.14)	*(-1.39)*	*(-0.09)*	*(-1.47)*	*(-1.45)*	*(-0.03)*
Dummy 2009	-121.2**	-177.5**	-41.97	-121.4**	-184.3**	-42.7
	(-3.21)	*(-3.06)*	*(-1.47)*	*(-3.16)*	*(-3.17)*	*(-1.47)*
Constant	-5087.6***	-2546.5	-2907.2***	-168.1	7.938	-235.9*
	(-5.9)	*(-1.8)*	*(-4.34)*	*(-1.32)*	*(-0.06)*	*(-2.01)*
sigma_u						
_cons	182.1***	111.0**	88.78***	268.4***	124.1*	139.4***
	(-5.9)	*(-2.58)*	*(-4.31)*	*(-6.11)*	*(-2.36)*	*(-4.16)*
sigma_e						
_cons	216.7***	271.2***	94.88***	217.0***	271.9***	94.95***
	(-29)	*(-22.16)*	*(-18.28)*	*(-28.86)*	*(-21.91)*	*(-18.15)*
N	746	312	434	746	312	434
Zero Value	317	49	268	317	49	268
% zero value	42.5%	15.7%	61.8%	42.5%	15.7%	61.8%
Wald chi2(22)	2,918.76	3,559.7	974.34	1,579.24	2,726.46	829.62
Prob > chi2	0.00	0.00	0.00	0.00	0.00	0.00
Log likelihood	-2,987.78	-1,870.06	-1,028.42	-3,011.58	-1,875.69	-1,042.64

Source: Authors' own. Note: (*) p<0.1, (**) p<0.05, (***) p<0.01.

4.1 Previous R&D investments

We find there is a positive relation of current R&D expenditure with previous year's R&D expenses for all the models presented in Table 4. This positive relation may be derived from the rigidity of investment in innovative activities, since previous R&D investments define a sort of sunk cost whose maintenance of investment becomes necessary for the maintenance of already established R&D activities. In other words, technological knowledge generation may be characterized by elements of a path-dependent persistence (Narula, 2002; Antonelli & Colombelli, 2013).

That being said, one can propose that R&D is cumulative and complementary, that is, inventive activities are conditioned on knowledge levels already achieved by the companies. Therefore, the generation of new knowledge is built upon current and past knowledge (Nelson & Winter, 1985; Malerba & Orsenigo, 1993) and innovative success yields profits that can be invested again in R&D (Nelson & Winter, 1985), encouraging more R&D and innovation. According to Antonelli and Colombelli (2013), the "generation of new knowledge at time *t* is possible only standing upon the shoulders of the technological knowledge that has been generated until that time" (p. 31). Therefore, R&D cumulativeness and complementarity may create a group of developing host countries where U.S. companies keep investing in R&D, promoting a sort of R&D centralization.

The previous finding corroborates other empirical studies presented in the literature. For example, Demirbag and Glaister (2010) show that MNCs' prior R&D activities in a specific country increases the likelihood of that country being selected by the MNCs for offshoring R&D projects.

Indeed that is exactly what data presented in Table 2 shows: most U.S. R&D captive offshoring throughout the years is still confined to Triad countries even though it seems to be evolving into a 'new geography' (Bruche, 2009), increasingly extending its investment to some developing countries. In this regards, Table 2 shows that, in 1990s the target of U.S. corporate R&D in developing economies was focused in Latin American countries (huge investments in Brazil). However, in the 2000s there is a turn towards South Asian countries. China and India enter the global R&D scene (Bruche, 2009).

4.2 Market size

The market size is measured by two aspects: population size and income (whose proxy is GDP per capita). While population size presents statistical significance for all the models (except for *Model 5*), GDP per capita presents statistical significance for *Model 1* and *Model 4* (which consider all 75 countries) and for *Model 3* and *Model 6* (which consider only developing countries through the years). *Model 2* and *Model 5* (which consider only developed countries) do not have GDP per capita statistically significant. That said, we can suggest that U.S. corporate' captive offshoring may be affected by host countries' population and GDP per capita – market size proxies. This confirms the importance of demand as presented in some empirical studies (Cantwell & Janne, 2000). This is an expected result, as local demands generate product adaptation needs. In this sense, cultural preferences, local infrastructure features or even climatic conditions – i.e., particularities of markets – are taken into consideration.

For example, in Brazil it is well known that automotive industry performs what it is called 'tropicalization'(Costa, 2005; Consoni & Quadros, 2006) – adaptation of products to local conditions. One example of this is that carmakers subsidiaries in the country need to equip cars with specially developed damping systems due to road conditions.

4.3 International openness

In all models presented in Table 4, the sum of exports of goods and services plus imports of goods and services as a percentage of GDP – proxies for the country's international openness – was not statistically significant. Therefore, data tell us that characteristics of international openness are not relevant for U.S. corporate R&D captive offshoring.

This finding corroborates the empirical analysis proposed by Kumar (2001) that says that economic openness is not statistically significant for attracting U.S. R&D expenditure to developing countries. His openness variable is different than the one proposed here. He tries to capture the relative policy openness of a country's trade regime and his variable was estimated by adjusting the trade intensity (total merchandise trade as a percentage of GNP) for structural factors. According to him "more restrictive trade regimes may attract more R&D investments than more open ones keeping other things same, especially in developing countries. A possible explanation for this outcome is that import barriers encourage MNE affiliates to undertake indigenization and hence product and process adaptations locally by making imported alternatives more expensive." (p. 169).

This is a significant result once it goes against the expectation that productive integration would be an inductor of the technological upgrade. This refers to other inductive factors, and immediately to the role of the State capable of inducing such investments.

4.4 *Innovation system*

The factor representing the National Innovation Systems – R&D expenditure, USPTO patent application per capita, high-technology exports, economic complexity index, and scientific and technical articles per capita – is relevant for U.S. corporate R&D captive offshoring.

Although the National Systems of Innovation are statistically significant in all models, there are considerable differences in coefficient magnitudes. Considering only developed countries (*Model 2* and *Model 5*) one can conclude that their Innovation Systems seem to be relatively more relevant to U.S. companies in their decision in R&D captive offshoring than developing countries (*Model* 3 and *Model 6*), which could confirm the knowledge augmenting type hypothesis of R&D abroad in developed countries (Kuemmerle, 1999; Dunning, 2009).

The influence of the National Innovation System of a host country on the location decision of MNCs' R&D activities was also empirically presented by Demirbag and Glaister (2010). They show that the more developed the knowledge infrastructure and the larger the pool of experts for R&D projects of a country, the greater the likelihood of that country being selected by a MNC for offshore R&D projects.

For the developing countries, it seems that U.S. companies are interested in their level of income, indicated by their GDP per capita. It does not mean, however, that developing countries' Innovation Systems are not important – since the coefficient of this variable is significant – however less important that developed countries' innovation systems. This could corroborate the thesis of knowledge exploiting or home-base-exploiting R&D in developing countries (Dunning & Narula, 1995; Kuemmerle, 1999).

In this regard, the average value for 'Innovation System' variable in developing countries with positive values for U.S. R&D captive offshoring is -0.46, and -0.66 for countries with null values. In developed countries these values are, respectively, 1.04 and -0.36. Furthermore, comparing trajectories of countries that have reached a high-income country status (proxy for development) during the period gives interesting insights. Countries with null values for U.S. R&D captive offshoring – Croatia, Estonia, Latvia, Saudi Arabia, Slovak and Trinidad and Tobago – have medium values of Innovation Systems equal to -0.56 in 1997 and -0.30 in 2010 (only Estonia presents significance improvement on results, from -0.48 to 0.46). The other countries – Czech Republic, Hungary, Korea Republic and Poland – obtained an average growth for U.S. R&D investments of 14.9% per year in the face of an average increase in the Innovation System's value of 0.03 to 0.72.

4.5 *Controlling variables*

For all the models presented, we use a group of controlling variables (distance and dummy for economic cycles). Geographical distance is not significant in any model, that is, U.S. companies do not consider the distance of the country where they are going to invest in R&D. This is so once those 'transactional benefits of spatial proximity' are much less important today than they were before (Dunning, 2009). Therefore, the decision to invest in R&D either in Brazil or in Mexico is not affected by the proximity to the U.S. This is congruent with other empirical studies that show that geographic distance has a relatively low impact on R&D investment (Castellani *et al.*, 2013).

The other controlling variable used is the dummy for economic cycles. This is done once there are fluctuations of R&D investment during the period of analysis. From Table 2, we can noticed that U.S. R&D captive offshoring declined during economic crisis (2000-01 and 2009) mainly because of the investment reduction in developed countries, as those countries were the epicenter of the crisis (Lane, 2012). Therefore, we can expect that R&D expenditures are sensitive to economic cycles, as presented in the literature (Archibugi & Michie, 1995; Guellec & Ioannidis, 1997; François & Lloyd-Ellis, 2009).

Still on the same argument, looking at Table 4, we can see that the Dotcom Crisis (2000-01) was not statically significant for any model. However, the Financial Crisis (2009) was for *Model 1* and *Model 4* (which consider the 75 countries) and *Model 2* and *Model 5* (which consider only developed countries), affecting negatively U.S. R&D captive offshoring. In other words, in those years, U.S. corporate R&D captive offshoring in developed countries was negatively affect by economic cycles. This is expected, once returns to R&D investment are subject to uncertainty and during national income drastic reductions companies do not expect to invest in risky and long-term activities.

In what regards *Model 3* and *Model 6*, crisis were not statistically significant to explain U.S. corporate R&D captive offshoring in developing countries. The previous finding may suggest that U.S. R&D captive offshoring in those countries is more resilient to the financial crisis than developed countries. This may be so once R&D performed in developing countries are home-base-exploiting type. Therefore those countries, which did not suffer immediately the negative impacts of the crisis, continued to receive R&D investment from the U.S. (especially Brazil, China, India and Indonesia) in order to get adapted production processes and products to suit local conditions and to take advantage of their market size.

We could also suggest that the strategy of U.S. companies in what regards their inventive activities is to reduce monetary inversions in countries where there is a higher stock of investments (developed countries), preserving the values in countries with lower R&D structure (developing countries). The U.S. R&D captive offshoring average in developed and developing countries were, respectively, USD 959.9 million and USD 56.4 million during all period of analysis[9]. During the economic downturns, the R&D investment decline in relation to the previous year was 7.3% for developed countries and 5.1% for developing ones in the first cycle (2000–01) and 12.5% for the former and 2.0% for the latter in the second cycle (2009).

5 Brief analysis of the most attractive developing countries to U.S. R&D investment

Brazil and China are emblematic cases to understand the evolution of U.S. R&D captive offshoring in developing countries and their ability in attracting it. During the period 199 –2010, the increase in GDP per capita was of 27.4% and 215.9% in Brazil and China, respectively.

The increase of U.S. R&D captive offshoring experienced by China – and presented in Table 2 – must have happened for the most part because of Chinese Innovation System. Brazil has its value for ‘Innovation System variable’ varying between -0.10 and -0.24 in the period, without a clear improvement trend. China, on the other hand, has seen its ‘Innovation System variable’ value jump from -0.49 in 1997 to 0.43 in 2010, in a constant upward trend.

Therefore, considering the models’ findings presented in Table 4, the national innovation capacity improvement is important to ensure China has a better long-term position to maintain and increase its attractiveness in R&D investments from U.S. companies. Therefore, if Brazil continues ‘to skid’ on innovative results, its trend should be less satisfactory than the Chinese ones. Consequently, upgrading S&T infrastructures and institutions must be a continuous policy in developing countries. In fact, recent empirical studies demonstrate that those countries that join the league of receivers of knowledge and innovation from FDI invest in elements of absorptive capacity (Filippetti *et al.*, 2017). For that reason, investments in human resources, physical infrastructure and R&D are the basic policies a developing country should focus on.

Back to the question proposed in the Introduction of this paper: why do some developing countries such as Brazil, China and India concentrate more U.S. R&D investment? According to our models, the answer lies on the fact that those three countries have already accumulated great amounts of U.S. R&D investment, the size of their markets and because of their relatively better Innovation System *vis-à-vis* other developing countries.

Despite the increasing of U.S. R&D in Brazil, China and India, some recent empirical studies demonstrate that favorable conditions of host countries may not lead to the enhancement of subsidiaries’ R&D functions (Achcaoucaou *et al.*, 2017). Therefore, knowledge integrations

[9] Data sourced from the BEA.

between parent companies and their subsidiaries are not simple and do not happen automatically (Singh, 2008).

In fact, in what regards the case of Brazil, China and India, Chiarini (2017) show elements present in the literature that demonstrate that most R&D undertaken in the three previous countries is directed to local adaptations and not directed to new product development. In other words, R&D captive offshore in Brazil, China and India is focused mainly in activities devoted merely to adapting products to local reality, that is, 'adaptive R&D'.

6 Final considerations

With significant changes in international economic scenario, companies have changed their strategies taking into consideration the governance (outsourcing versus internal development) and geographical location (offshoring versus domestic) of their innovative efforts (Mudambi, 2008; Martinez-Noya *et al.*, 2012). Indeed, large MNCs have progressively adopted an internationally integrated approach to their inventive activities.

In this paper, we provided a statistical investigation aimed at gaining further understanding of corporates' R&D internationalization, which has been increasing in the last decades towards developing countries. From stylized facts of U.S. R&D performed by business enterprises abroad in their majority-owned foreign affiliates, we presented our research question: what are the local features that make some developing countries – like Brazil, China and India – more 'inviting' for U.S. R&D captive offshoring?

To present quantitative elements to answer the previous question, we proposed different models. Our models' results were pretty much in line with those already identified in the literature on MNCs' location choice decision; however, they extended it presenting additional considerations and identifications of relevant differences of R&D captive offshoring determinants for developing countries.

Our study found that R&D investment cumulativeness, National Innovation Systems' features and market size are important determinants to explain U.S. R&D captive offshoring in a developing country. Notwithstanding that, our study revealed that international openness have no statistical relevance for the same group of countries.

It is necessary to say that each country may benefit differently depending of the type of R&D undertaken and to the particularities of their National Innovation Systems. Therefore, even with the increase of U.S. R&D captive offshore in Brazil, China and India, only a considerably small number of affiliates seem to be performing relevant R&D that goes further beyond adaptive R&D and only a few of these centers are integrated into the overall innovative strategy of the multinational company. Still, even if R&D is integrated into global value chains, the benefits to local society may not be reached if domestic absorptive capacity is low and if there are mechanisms that do not permit the flows of tacit knowledge from those subsidiaries to indigenous companies, affecting the national overall learning process.

In order to contribute to domestic companies in host countries, subsidiaries should have specific types of knowledge creation associated with investments in disembodied knowledge and human capital (Marin *et al.*, 2007). MNCs could have and exacerbated used of local incentives provided by local government, generating loss of revenue, slacken of intellectual property laws and employment policies socially burdensome (UNCTAD, 2005b).

Finally, it is important to mention that attracting those investments is not *per se* going to solve developing countries' challenges to overcome underdevelopment. It may be important for technological catch-up, once positive effect are likely to occur, however it does not mean national companies will automatically benefit from MNCs' R&D activities performed in their territories. Domestic companies must enhance their absorptive capacity to benefit from external knowledge from MNCs and governments can make efforts to improve their industrial and innovation policies in a way to incentivize the dissemination of MNCs expertise locally (Archibugi & Pietrobelli, 2003; Filippetti *et al.*, 2017).

References

Achcaoucaou, Fariza, Miravitlles, Paloma, & León-Darder, Fidel. (2017). Do we really know the predictors of competence-creating R&D subsidiaries? Uncovering the mediation of dual network embeddedness. *Technological Forecasting & Social Change, 116*, 181-195.

Albertoni, Filippo, & Elia, Stefano. (2014). Focus on the internationalization of firms: The global sourcing of business services: evidence from the offshoring research network survey. *Economia e Politica Industriale, 41*(2), 131-144.

Antonelli, Cristiano, & Colombelli, Alessandra. (2013). *Knowledge cumulability and complementarity in the knowledge generation function*. GREDEG Working Paper Series (2013-08). Nice (France): Groupe de Recherche en Droit, Economie, Gestion (GREDEG), Université Nice Sophia Antipolis.

Archibugi, Daniele, & Iammarino, Simona. (2002). The globalization of technological innovation: definition and evidence. *Review of International Political Economy, 9*(1).

Archibugi, Daniele, & Michie, Jonathan. (1995). The globalisation of technology: a new taxonomy. *Cambridge Journal of Economics, 19*.

Archibugi, Daniele, & Michie, Jonathan. (1997). Technological globalisation or national systems of innovation? *Futures, 29*(2), 121-137.

Archibugi, Daniele, & Pietrobelli, Carlo. (2003). The globalisation of technology and its implications for developing countries Windows of opportunity or further burden? *Technological Forecasting & Social Change, 70*.

Athreye, Suma, Batsakis, Georgios, & Singh, Satwinder. (2016). Local, global, and internal knowledge sourcing: The trilemma of foreign-based R&D subsidiaries. *Journal of Business Research, 69*(12), 5694-5702.

Athreye, Suma, & Cantwell, John. (2016). A Bigger Bang for the Buck: Trends, Causes, and Implications of the Globalization of Science and Technology. In S. Dutta, B. Lanvin & S. Wunsch-Vincent (Eds.), *The Global Innovation Index 2016. Winning with Global Innovation* (pp. 75-80). Geneva (Switzerland): Cornell University and the World Intellectual Property Organization (WIPO).

Athukorala, Prema-chandra, & Kohpaiboon, Archanun. (2010). Globalization of R&D by US-based multinational enterprises. *Research Policy, 39*, 1335-1347.

Bruche, Gert. (2009). The emergence of China and India as new competitors in MNCs' Innovation networks. *Competition & Change, 13*(3), 267-288.

Cantwell, John. (1995). The globalisation of technology: what remains of the product cycle model? . *Cambridge Journal of Economics, 19*(1), 155-174.

Cantwell, John, & Janne, Odile. (2000). The Role of Multinational Corporations and National States in the Globalization of Innovatory Capacity: The European Perspective. *Technology Analysis & Strategic Management, 12*(2), 243-262.

Cantwell, John, & Mudambi, Ram. (2005). MNE competence-creating subsidiary mandates. *Strategic Management Journal, 26*, 1109-1128.

Cantwell, John, & Piscitello, Lucia. (2002). The Recent Location of Foreign R&D Activities by Large MNCs in the European Regions. The Role of Different Sources of Spillovers. *Journal of International Management, 8*(1), 69-96.

Cantwell, John, & Santangelo, Grazia D. (1999). The frontier of international technology networks: sourcing abroad the most highly tacit capabilities. *Information Economics and Policy, 11*, 101-123.

Castellani, Davide, Jimenez, Alfredo, & Zanfei, Antonello. (2013). How remote are R&D labs? Distance factors and international innovative activities. *Journal of International Business Studies, 44*, 649-675.

Chesnais, François. (1994). *La mondialisation du capital*. Paris: Syros.

Chiarini, Tulio. (2017). *U.S. R&D captive offshoring in Brazil, China and India, 1997-2014*. Working Paper Series, (103). Rome: Istituto di Ricerche sulla Popolazione e le Politiche Sociali (IRPPS), Consiglio Nazionale delle Ricerche (CNR).

Cohen, Wesley M., & Levinthal, Daniel A. (1989). Innovation and Learning: The Two Faces of R&D. *The Economic Journal, 99*(397), 569-596.

Cohen, Wesley M., & Levinthal, Daniel A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Consoni, Flávia, & Quadros, Ruy. (2006). From adaptation to complete vehicle design: a case study of product development capabilities in a carmaker in Brazil. *International Journal of Technology Management, 36*(1/2/3), 91-107.

Costa, Ionara. (2005). *Technological learning, R&D and foreign affiliates in Brazil*. Paper presented at the Globalization of R&D and Developing Countries: Expert Meeting, Geneva.

D'Agostino, Lorena M. (2015). The neglected effects of R&D captive offshoring in emerging countries on the creation of knowledge at home. *Economia e Politica Industriale, 42*, 61-91.

Dachs, Bernhard. (2014). Internationalisation of R&D: a brief survey of the literature. In B. Dachs, R. Stehrer & G. Zahradnik (Eds.), *The Internationalisation of Business R&D* (pp. 5-26). Cheltenham (UK): Edward Elgar Publishing Limited.

Danguy, Jérôme. (2017). Globalization of innovation production: a patent-based industry analysis. *Science & Public Policy, 44*(1), 75-94.

Demirbag, Mehmet, & Glaister, Keith W. (2010). Factors Determining Offshore Location Choice for R&D Projects: A Comparative Study of Developed and Emerging Regions. *Journal of Management Studies, 47*(8), 1534-1560.

Doh, Jonathan P., Jones, Gary K., Mudambi, Ram, & Teegen, Hildy. (2005). Foreign Research and Development and Host Country Environment: An Empirical Examination of U.S. International R&D. *Management International Review, 45*(2), 121-154.

Dunning, John H. (1994). Multinational Enterprises and the Globalisation of Innovatory Capacity. *Research Policy, 23*, 67-88.

Dunning, John H. (2009). Location and the Multinational Enterprise: a neglected factor? *Journal of International Business Studies, 40*(1), 5-19.

Dunning, John H., & Narula, Rajneesh. (1995). The R&D Activities of Foreign Firms in the United States. *International Studies of Management & Organization, 25*(1), 39-74.

Feinberg, Susan E., & Gupta, Anil K. (2004). Knowledge spillovers and the assignment of R&D responsibilities to foreign subsidiaries. *Strategic Management Journal, 25*, 823-845.

Filippetti, Andrea, Frenz, Marion, & Ietto-Gillies, Grazia. (2017). The impact of internationalization on innovation at countries' level: the role of absorptive capacity. *Cambridge Journal of Economics, 41*(2), 413-439.

Flores, Ricardo G., & Aguilera, Ruth V. (2007). Globalization and location choice: an analysis of US multinational firms in 1980 and 2000. *Journal of International Business Studies, 38*, 1187-1210.

Florida, Richard. (1997). The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the USA. *Research Policy, 26*(1), 85-103.

François, Patrick, & Lloyd-Ellis, Huw. (2009). Schumpeterian cycles with pro-cyclical R&D. *Review of Economic Dynamics, 12*, 567-591.

García-Vega, María, & Huergo, Elena. (2011). Determinants of International R&D Outsourcing: The Role of Trade. *Review of Development Economics, 15*(1), 93-107.

Granstrand, Ove, Håkanson, Lars, & Sjölander, Sören. (1993). Internationalization of R&D: a survey of some recent research. *Research Policy, 22*(5-6), 413-430.

Guellec, Dominique, & Ioannidis, Evangelos. (1997). Causes of fluctuations in R&D expenditures: a quantitative analysis. *OECD Journal: Economic Studies, 29*, 123-138.

Hausmann, Ricardo, Hidalgo, Cesar A., Bustos, Sebastián, Coscia, Michele, Chung, Sarah, Jimenez, Juan, . . . Yildirim, Muhammed A. (2013). *The Atlas of Economic Complexitu.*

Mapping paths to prosperity. Cambridge (MA): Massachusetts Institute of Technology and Center for International Development, Harvard University.

Hegde, Deepak, & Hicks, Diana. (2008). The maturation of global corporate R&D: Evidence from the activity of U.S. foreign subsidiaries. *Research Policy, 37*(3), 390-406.

Iammarino, Simona, & McCann, Philip. (2013). *Multinationals and economic geography. Location, technology and innovation*. Cheltenham: Edward Elgar.

Ietto-Gillies, Grazia. (2015). Innovation, internationalization, and the transnational corporation. In D. Archibugi & A. Filippetti (Eds.), *The Handbook of Global Science, Technology, and Innovation* (pp. 127-143). West Sussex: John Wiley & Sons.

Jabbour, Liza, & Zuniga, Pluvia. (2016). The Outsourcing of Research and Development in Global Markets: Evidence from France. *The World Economy, 39*(3), 339-368.

Kuemmerle, Walter. (1999). The drivers of foreign direct investment into research and development: An empirical investigation. *Journal of International Business Studies, 30*(1), 1-24.

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

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

Kurokawa, Sam, Iwata, Satoshi, & Roberts, Edward B. (2007). Global R&D activities of Japanese MNCs in the US: A triangulation approach. *Research Policy, 36*(1), 3-36.

Lall, Sanjaya. (1979). The international allocation of research activity by U.S. multinationals. *Oxford Bulletin of Economics and Statistics, 41*(4), 313-331.

Lane, Philip R. (2012). The European Sovereign Debt Crisis. *The Journal of Economic Perspectives, 26*(3), 49-67.

Laurens, Patricia, Bas, Christian Le, Schoen, Antoine, Villard, Lionel, & Larédo, Philippe. (2015). The rate and motives of the internationalisation of large firm R&D(1994–2005): Towards a turning point? *Research Policy, 44*(3), 765-776.

Levinthal, Daniel A., & March, James G. (1993). The myopia of learning. *Strategic Management Journal, 14*, 95-112.

Lewin, Arie Y, Massini, Silvia, & Peeters, Carine. (2009). Why are companies offshoring innovation? The emerging global race for talent. *Journal of International Business Studies, 40*, 901-925.

Lundvall, Bengt-Åke, Joseph, K. J., Vang, Jan, & Chaminade, Cristina. (2009). Innovation system research and developing countries. In B.-A. Lundvall, K. J. Joseph, C. Chaminade & J. Vang (Eds.), *Handbook of innovation systems and developing countries: building domestic capabilities in a global setting* (pp. 1-32). Northampton (USA): Edward Elgar.

Malerba, Franco, & Orsenigo, Luigi. (1993). Technological Regimes and Firm Behavior. *Industrial and Corporate Change, 2*(1), 45-71.

Marin, Anabel, & Arza, Valeria. (2009). The Role of Multinational Corporations in National Innovation Systems in Developing Countries: From Technology Diffusion to International Involvement. In B.-Å. Lundvall, K. J. Joseph, C. Chaminade & J. Vang (Eds.), *Handbook of Innovation Systems and Developing Countries. Building Domestic Capabilities in a Global Setting* (pp. 280-310). Cheltenham: Edward Elgar Publishing Limited.

Marin, Anabel, Sasidharan, Subash, & Costa, Ionara. (2007). *Active MNC subsidiaries and technology spillovers in late industrialising countries: the case of Argentina and India*. Paper presented at the 5th Globelics International Conference. Regional and national innovation systems for development, competitiveness and welfare: the government-academia-industry partnership (theory, problems, practice and prospects), Saratov (Russia).

Martinez-Noya, Andrea, Garcia-Canal, Esteban, & Guillen, Mauro F. (2012). International R&D service outsourcing by technology-intensive firms: Whether and where? *Journal of International Management, 18*, 18-37.

Mudambi, Ram. (2008). Location, control and innovation in knowledgeintensive industries. *Journal of Economic Geography, 8*, 699-725.

Narula, Rajneesh. (2002). Innovation systems and 'inertia' in R&D location: Norwegian firms and the role of systemic lock-in. *Research Policy, 31*(5), 795-817.

Nelson, Richard R. (1990). Capitalism as an Engine of Progress. *Research Policy, 19*(3), 193-214.

Nelson, Richard R., & Winter, Sidney G. (1985). *An Evolutionary Theory of Economic Change*. Cambridge (Massachusetts): Harvard University Press.

NSB. (2016). *Science & Engineering Indicators 2016*. Arlington: National Science Board (NSB), National Science Foundation (NSF).

OECD. (2008). *The internationalisation of Business R&D. Evidence, impacts and implications*. Paris: The Organisation for Economic Co-operation and Development (OECD).

Patel, Pari. (1995). Localised production of technology for global markets. *Cambridge Journal of Economics, 19*(1), 141-153.

Patel, Pari, & Pavitt, Keith. (2000). National systems of innovation under strain: the internationalisation of corporate R&D. In R. BARRELL, G. MASON & M. O'MAHONY (Eds.), *Productivity, innovation, and economic performance* (pp. 217-235). New York: Cambridge University Press.

Patel, Pari, & Vega, Modesto. (1999). Patterns of internationalisation of corporate technology: location vs. home country advantages. *Research Policy, 28*(2-3), 145-155.

Pearce, Robert D., & Singh, Satwinder. (1992). *Globalizing research and development*. London: MacMillan Press.

Siedschlag, Iulia, Smith, Donal, Turcu, Camelia, & Zhang, Xiaoheng. (2013). What determines the location choice of R&D activities by multinational firms? *Research Policy, 42*, 1420-1430.

Singh, Jasjit. (2008). Distributed R&D, cross-regional knowledge integration and quality of innovative output. *Research Policy, 37*, 77-96.

Tabrizy, Saleh S. (2017). Productivity and offshoring innovative activities. *Economics of Innovation and New Technology, 26*(6), 501-515.

Teece, David. (2004). Knowledge and competence as strategic assets. In C. W. Holsapple (Ed.), *The Hanbook on Knowledge Management: Knowledge Matters* (pp. 129-152). Heidelberg: Springer.

Thursby, Jerry, & Thursby, Marie. (2006). *Here or There? A survey of factores in multinational R&D location*. Report to the Government-University-Industry research roundtable. Washington: The National Academies Press.

UNCTAD. (2005a). *The impact of FDI on development: globalization of R&D by transational corporations and implications for developing countries*. (TD/B/COM.2/EM.16/2). Geneva: United Nations Conference on Trade and Development (UNCTAD/UN).

UNCTAD. (2005b). *Transnational Corporations and the Internationalization of R&D*. World Investment Report. Geneva: United Nations Conferece on Trade and Development (UNCTAD/UN).

Vernon, Raymond. (1966). International investment and international trade in the product cycle. *Quarterly Journal of Economics, 80*(2), 190-207.

Wooldridge, Jeffrey. (2008). *Introductory Econometrics: A Modern Approach*. Mason (USA): South-western Cengage Learning.

Zacharewicz, T., Sanz Menendez, L., & Jonkers, K. . (2017). *The Internationalisation of Research and Technology Organisations*. Joint Research Centre Science for Policy Report - EUR 28442. Luxembourg: Publications Office of the European Union.