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FDI ATTRACTION AND INNOVATION POLICY: AN ABSORPTIVE CAPACITY APPROACH

LA ATRACCIÓN DE LA IDE Y LAS POLÍTICAS DE INNOVACIÓN: UN ABORDAJE DE LAS CAPACIDADES DE ABSORCIÓN

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ABSTRACT

Foreign Direct Investment represents a strategic issue within countries' industrial policies, provided there is a widespread expectation this particular kind of investment can cause positive shocks on host markets' overall capabilities. Our argument, in consonance with dedicated literature, is that these contributions do not take place without "frictions", and that there is a significant complementarity between FDI's effects and the innovation policy framework (particularly those initiatives that influence the existent level of systemic absorptive capacities). Using panel datasets for developing and developed countries we estimate production functions taking labor productivity, industrial value added, and high-tech exports as output indicators of National Innovation Systems. Through the application of interaction terms we find that levels of absorptive capacity measured by aggregate R&D expenditures determine the effective generation of benefits arising from multinational firms, while human capital conditions seem to play a marginal mediating role in this process.

Key words: Foreign Direct Investment, National Innovation Systems, Innovation Policy. **JEL:** F23, O25, O38.

RESUMEN

La inversión directa extranjera representa una cuestión estratégica dentro de las políticas industriales, lo que se justifica por la expectativa generalizada respecto a los shocks positivos en las capacidades generales de los mercados anfitriones de este tipo particular de inversión. Nuestro argumento, en consonancia con la literatura especializada, es que estas contribuciones no tienen lugar sin "fricciones", y que hay una complementariedad significativa entre los efectos de la IDE y el marco de políticas de innovación (en particular las iniciativas que influyen en el nivel existente de las capacidades sistémicas de absorción). A partir de un conjunto de datos de panel para países desarrollados y en desarrollo, se estiman funciones de producción que tienen la productividad del trabajo, el valor añadido industrial y las exportaciones de alta tecnología como indicadores representativos de los Sistemas Nacionales de Innovación. A través de la aplicación de los términos de interacción, encontramos que los niveles de capacidad de absorción medido por el gasto agregado en I+D determinan la generación de efectivo de los beneficios derivados de empresas multinacionales, mientras que las condiciones de capital humano parecen jugar un papel mediador marginal en este proceso.

Palabras claves: Inversión directa extranjera, sistemas nacionales de innovación, política de innovación. **JEL:** F23, O25, O38.

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1. INTRODUCCIÓN

Attraction of Foreign Direct Investment in the form of multinational corporations (MNCs) has been a strategic part of the policymaking agenda in developed and developing countries for some time now (Guimón, 2009; Warwick, 2013). The rationale behind such behavior goes well beyond contributions to domestic stocks of capital. In this particular case, neoclassical economics is of little use, since projections of diminishing returns to scale would not warrant FDI flows into high income nations. The motivation, instead, is fundamentally supported by endogenous growth models, where knowledge and technology flows are expected to cause positive externalities in host markets (Carkovic; Levine, 2002), thus benefitting recipient locations with overall social gains (besides private returns that are internalized by MNCs). Consequently, impacts of FDI are likely to alter the dynamic efficiency of host economies, amplifying their aggregate innovative capacity (Balasubramanyam *et al*., 1999).

Nonetheless, there is a lack of agreement on the impacts of FDI flows in host markets in empirical literature (*Carkovic*; Levine, 2002), leading to a debate on whether public expenses on FDI tax incentives and subsidies are justifiable, since *ex ante* estimations of spillovers are highly imperfect (Warwick, 2013). In this scenario, further approaches on the effective interactions between FDI and recipient economies become extremely relevant for industrial policy frameworks. Aiming at contributing to this context, the focus of this research lies on the concepts of National Innovation Systems (NIS), directing analytical efforts towards MNCs' relationships with host markets' innovative dynamics.

We investigate the mediating role played by innovation policy in these processes. As previous assessments have demonstrated (e.g. Mody, 2004; Perez, 1997; Girma, 2005), the construction of an adequate economic environment in terms of absorptive capacities within innovation systems is a necessary condition for spillovers' appropriation by local agents. Hence, the empirical structure of our approach considers features related to initiatives that affect the aggregate levels of absorptive capacity in host economies, and how they relate to the effective contributions arising from the presence of MNCs. Our goal is to shed light on the expected complementarity between "absorptive capacity-enhancing" policies (within the realm of the broader concept of innovation policy frameworks) and FDI attraction incentives, thus proposing effective insights concerning the need for a closer coordination among these two analytical dimensions.

The methodological structure relies on panel data estimations via fixed-effects models for 35 high income countries (representing developed nations) and 31 upper-middle income countries (developing nations) over the period 1993-2008. Robustness tests for our models are provided through the use of instrumental variables that control for potential reverse causation concerning FDI and the dependent variables. We have addressed 3 different indicators of output, namely: labor productivity, industrial value added, and high-tech exports. We derive the models from the usual production function, though searching for more direct contributions of FDI to host innovation systems.

After these introductory aspects, the article is structured as follows: section 2 addresses issues related to impacts of FDI upon host markets. Section 3 reviews the literature regarding the conditionality of FDI's externalities upon institutional settings and policy frameworks that influence aggregate levels of absorptive capacity. The methodological rationale, characteristics of the sample and the construction of empirical models are presented in section

4. Results are discussed in section 5, and section 6 concludes with theoretical and practical implications for the analysis and promotion of FDI from a NIS perspective.

2. FDI AND NATIONAL INNOVATION SYSTEMS

Foreign Direct Investments constitute a particular sort of international capital flows that is strictly related to productive activities usually impersonated by multinational corporations. There is a widespread perception that these investments play a central role within host markets' innovation systems (Guimón, 2009), integrating technological capabilities across countries and generating beneficial social returns (besides the internalization of private gains). The underlying rationale behind this proposition is straightforward: MNCs possess above average assets (tangible and intangible), constituting "hubs" of skills, technology and managerial expertise (Noorbakhsh and Paloni, 2001).

Nonetheless, these private advantages do not warrant the inclusion of FDI attraction in the economic policy framework in host countries. If overall capabilities could be perfectly internalized, MNCs would contribute to recipient economies only via the evolutionary process of resource reallocation through competitive pressure (Alfaro *et al.*, 2004; Kuemmerle, 1999; Kokko, 1994). Though aggregate productivity can be enhanced by this situation, negative shocks in groups of indigenous firms can offset the gains from a policymaking point of view. However, perfect internalization of assets is unlikely to exist, giving room to the incidence of positive externalities, also referred in this specific context as knowledge (or technological) spillovers. In this regard, benefits arising from multinationals are related to learning processes, generation of networks, and training of labor force (Alfaro *et al*., 2004; Kuemmerle, 1999), providing host markets with increasing returns and other beneficial shocks in productivity (De Mello, 1997; Warwick, 2013).

The externality-oriented approach is the most common theoretical framework for assessing the role of MNCs as agents of change throughout economic systems, considering that its expected effects surmount those coming from industrial reconfiguration. This can be especially relevant for the scrutiny of innovation systems and their respective policymaking processes, given the dynamics of knowledge generation and flows that are likely to be embedded in the context of FDI allocation across boundaries.

Under a neoclassical perspective, these productive investment inflows represent engines of economic convergence between nations as a function of diminishing marginal productivity of capital, i.e., having higher economic impacts in less developed and developing countries than in developed ones (De Mello, 1997). The usual argument is that countries that occupy positions of technological laggards depend on the diffusion of knowledge generated in more advanced locations in order to evolve economically in a typical catch-up process (Balasubramanyam *et al*., 1999). In this scenario, FDI provides these nations with the means to access state-of-the-art technologies, productive know-how and managerial practices (Borensztein *et al*., 1998; Balasubramanyam *et al*., 1996; De Mello, 1997). For example, a recent report from the World Bank regarding the economic structure of innovation systems in Latin America identifies that knowledge spillovers arising from the presence of multinational corporations are major ingredients for productivity gains in this subcontinent, given MNCs likelihood to pursue patents, establish innovation-driven networks, develop R&D investment structures and adopt foreign technologies (Lederman *et al*., 2014). While these analyses follow an attractive rationale, they have mostly failed to address the impacts of FDI in developing *and* developed nations, thus offering a fragmented empirical view of the phenomenon (Nair-Reichert and Weinhold, 2001).

As Blomstrom *et al*. (1996), and Xu (2000) have demonstrated, FDI's impacts actually seem to be stronger in more developed economies. These empirical findings are representations of endogenous growth approaches' validity concerning the role of FDI within innovative dynamics. Thus, the theoretical rationale that supports the perspective of systemic contributions of FDI regarding host economies (i.e. those that go beyond the idea of impacts upon the dynamics of investment stocks) is based on econometric models that take the generation of knowledge and technology as self-reinforcing features. These approaches allow foreign investments to continually exert influences on the technological environment by creating and diffusing innovations (Nair-Reichert; Weinhold, 2001), and, in its turn, this progress acts as a relevant driver of economic growth (Balasubramanyam *et al*., 1996). The main links that connect the activity of MNCs to this theoretical perspective are related to the generation of externalities, R&D investments and learning-by-doing processes (De Mello, 1997), i.e., systemic shocks that spread their influence across countries' economic structures.

Additionally, this issue also has impacts upon MNCs internationalization strategies. In this sense, multinationals in developed countries may contribute more in terms of externalities because of their higher propensity to develop innovative (R&D-intensive) activities, taking advantage of host markets' pool of capabilities through exploration strategies, while developing countries are usually addressed via asset exploitation approaches (Guimón, 2009).

Though in practical terms the inclusion of FDI in production functions seems like a subtle procedure, its theoretical implications are remarkable: the generation of economically valuable knowledge is no longer "manna from heaven", and policymaking becomes key in influencing the desirable state of things. Consequently, the expected beneficial impacts of inward FDI justify the inclusion of this item in the industrial policy agenda (Warwick, 2013). More emphasis on institutional settings is supplied by Nair-Reichert and Weinhold (2001): they found that positive contributions from FDI are conditional upon host markets' characteristics and their capacity of establishing effective connections with foreign subsidiaries. Therefore, the existence of "frictions" in the process of spillovers' generation brings forward a lack of agreement on whether social or private returns prevail in the dynamics of FDI (Balasubramanyam *et al*., 1999). The innovation system framework, designed and affected by dedicated policies, occupies the position of catalyst in this context, i.e., it drives the aggregate capability of nations to promote the desired flows of productive knowledge. This topic is further discussed in the next section.

3. INNOVATION POLICY, ABSORPTIVE CAPACITY AND THE CONDITIONALITY OF FDI SPILLOVERS

As outlined in the previous section, inward FDI has the capacity of exerting positive influences in host countries' economic environments. This situation, however, does not take place without "frictions" that hinder the perfect mobility of firms' intangible assets. Literature has suggested FDI's beneficial impacts are conditional upon institutional settings of the host market (Carkovic; Levine, 2002; Balasubramanyam *et al*., 1999; De Mello, 1997; Fransman, 1995; Kokko, 1994; Crespo; Fontoura, 2007). On the other hand, though FDI attraction policies have become a policy trend, initiatives often fail to address issues that are related to the nature of benefits arising from the presence of MNCs (Narula and Dunning, 2010).

This lack of coordination between specific and systemic policies may yield undesirable outcomes. In the absence of fundamental conditions, foreign direct investments can actually be counterproductive for the economic context, not only diluting the possibility of increased social returns in the host market (Balasubramanyam *et al*., 1996; De Mello, 1997), but also having perverse impacts on recipient economies (Mayer-Foulkes; Nunnenkamp, 2009;

Dunning, 1994). To mediate this situation, attention must be given to systemic absorptive capacities (Girma, 2005; Crespo; Fontoura, 2007).

According to the seminal foundations of the absorptive capacity concept, technological learning and diffusion require the existence of prior related knowledge (Cohen; Levinthal, 1990). Though originally oriented towards the microeconomic environment, this rationale has been widely used in aggregate terms concerning innovation systems (e.g. Lall, 1992; Katz; Kosacoff, 1998; Katz, 2001). In the context of our research, the principle is rather simple: MNCs' intangible assets spill over firms' boundaries (as externalities, they ought to be outside the control of agents), but their effective contribution to innovation systems will be largely contingent upon existing learning abilities of indigenous players. This proposition is consistent with empirical findings that support higher levels of benefits in developed nations than in developing ones (see section 2 above), as there is an inherent endogeneity between the quality of innovation systems and their absorptive capabilities.

Nonetheless, the analytical dimensions which represent the idea of absorptive capacity (particularly when the scope is macro-oriented) are vast. In this regard, we have narrowed down the proxies to two relevant aspects, namely:

a) Human capital: one fundamental feature of the knowledge stock in firms, regions or countries is related to individuals' aggregate intellectual capabilities. It is hard to imagine that MNCs' spillovers can be of use within National Innovation Systems that lack human resources with sufficient levels of education;

b) Technological position and innovative efforts: the technological position of a given NIS largely defines the level of accumulated (economically valuable) knowledge that is locally available. Countries that lag behind in innovation input and output indicators demonstrate weaker capabilities in this regard in comparison to advanced nations.

Following these propositions, literature has addressed both dimensions depicted above, though human capital has been assessed more deeply. This latter aspect is understood as a fundamental determinant of countries evolution throughout their respectives development paths (Noorbakhsh and Paloni, 2001). Moreover, the construction of a high-quality human capital stock is fundamental not only in the process of exploiting the potential benefits that can arise from MNCs presence in host economies, but also in determining the dynamics of FDI attraction (Guimón, 2009).

The use of econometric models that include interactive terms between FDI and human capital (usually addressed by mean years of schooling) to assess impacts of foreign investment upon GDP growth has been the subject of a number of studies (see Nair-Reichert and Weinhold, 2001; Borensztein *et al*., 1995; Balasubramanyam *et al*., 1996; De Mello, 1997). Borensztein *et al*. (1995) have found that when schooling levels are extremely low, FDI has negative effects on economic systems, providing confirmatory evidence for the possibility of MNCs perverse effects in laggard NISs. In contrast, Carkovic and Levine (2002) find the stock of human capital does not exert any positive influences on the effects of FDI on economic growth, though their results also largely refute the possibility of systemic contributions arising from foreign productive investments in general.

In its turn, empirical findings concerning the technological position perspective suggest the existence of a large technological gap between MNCs and agents in host markets can be detrimental to the effective generation of absorbable spillovers (Kokko, 1994). However, this phenomenon is not of a linear nature, since FDI spillovers tend to be maximized when technology gaps between MNCs and local firms are moderate (Girma, 2005). The explanation lies in the fact that large gaps suggest the lack of absorptive capacity in local agents, while

small gaps denote equivalence of knowledge stocks between indigenous and foreign-owned firms. These results strongly point towards theoretical flaws in exogenous growth models, rejecting the possibility of diminishing returns. In sum, the "natural" behavior of markets faces severe constraints regarding the role of FDI as an agent of knowledge diffusion across innovation systems, suggesting that policy settings matter. In the next section we describe the methodological structure of our empirical assessment, aimed at further investigating the relationship between innovation policy and inward FDI.

4. METHODOLOGICAL STRUCTURE

Our empirical approach comprehends data for 31 developing and 35 developed countries (see Appendix I for the list of countries). This classification follows that of the World Bank where developed countries are those nations with high levels of income ("high-income countries" or HICs), while developing countries (or DCs) represent the group of nations classified as "upper-middle income". These countries were observed throughout the period 1993-2008. This particular timeframe allows satisfactory conditions in terms of missing data, and it also avoids undesirable fluctuations derived from the 2008 financial crisis. This latter item is extremely relevant for our research interests, since global financial markets' shocks can distort the prevalence of fundamental forces of economic activity and the natural behavior of agents, thus hindering the appropriation of theoretical and policy-related implications of our analytical exercise.

4.1 Empirical Rationale

The fundamental augmented production function that is applied in empirical approaches dedicated to address economic growth impacts of FDI upon host economies takes the following structure (De Mello, 1997)[1]:

$$Y = A\,(K, L, F, \Omega)$$

Equation 1

Where Y denotes economic output, A stands for Total Factor Productivity (TFP), K is capital, L is labor, F represents inward FDI, and Ω comprehends a set of ancillary variables. In this regard, the statistical structure of our empirical models is based upon these guidelines and it follows the econometric propositions of Nair-Reichert and Weinhold (2001) and Borenzstein *et al*. (1995). Nonetheless, our models aim at adapting these regressions to a broader view of the absorptive capacity dimension (which is usually restricted to human capital). In this respect, besides approaching human capital as a conditional factor for FDI knowledge spillovers to take place, we added R&D efforts as a mediating vector of this phenomenon.

[1] It is important to notice that we take the traditional (neoclassical) structure of production functions as an approximation of the economic dynamics concerning the determination of output. We are aware of the limitations that this instrument may cause when aggregating heterogeneous units of capital and labor (the Cambridge Controversy), particularly in an analysis that includes variations over time. This is also true for the estimation of constant factor proportions across different sectors of the economy. Nonetheless, the methodological validity of this procedure justifies its application in this research (for a thorough evaluation of this discussion refer to Stiglitz, 1974 and Harcourt, 1969).

The rationale behind this strategy is provided by Cohen and Levinthal (1990) who identified R&D investments at the firm level as a source not only of innovation *per se*, but also of increased absorptive capabilities. Our appropriation of this concept extends its functionality to the level of National Innovation Systems. Under a similar perspective, Castellacci and Natera (2013) have found aggregate R&D expenditures positively influence the conditions of absorptive capacity of macroeconomic systems (their results are also consistent with the human capital conditions), thus offering support for our empirical construction.

In order to evaluate the expected intermediary role played by both sources of absorptive capacities used in our analysis (R&D and human capital), we have created two interaction terms (FDI*GERD and FDI*HK, see equation 2 for the econometric structure of our approach and table 1 for the definition of analytical variables) that allow the verification of the association between "pure" (FDI alone) and "conditional" (interaction terms) impacts of FDI within the host economic system. As the simultaneous inclusion of interactive terms and both of its components is likely to generate statistical instability in estimations due to collinearity issues (Carkovic and Levine, 2002), R&D expenditures and human capital (approximated by mean years of schooling) do not appear in empirical models as separate variables.

Another derivation we have made regarding Equation 1 concerns the dependent element of regressions. Whereas usual estimations take economic output (Y) as an element of aggregate production (GDP or GDP per capita, and their dynamics of growth), we aim at assessing more specific indicators of innovative capacity within National Innovation Systems. We opt for this procedure so an evaluation of direct potential impacts of FDI's spillovers can be undertaken. Furthermore, it should be noted that multinational companies' contributions are highly marginal to the overall picture of productive structures (De Mello, 1997; Van Pottelsberghe; Lichtenberg, 2001). Even through the use of ancillary controls in estimations, the relationship between economic spillovers and overall output only happens via shocks in mediating activities, which suggests traditional estimations found in literature may contain a significant amount of noise in statistical relationships.

A last aspect that should be highlighted in this conceptualization of our methodological approach concerns the risk of "reverse causation" among the core variables in our analysis, i.e., output variables from National Innovation Systems (productivity, value added in industrial activities, and high-tech exports) and FDI. Borensztein *et al*. (1998), Balasubramanyam *et al*. (1999), de Mello (1997), and Carkovic and Levine (2002) are among the authors who recognize this issue, suggesting a self-reinforcing dynamic between technical evolution and the attraction of multinational companies. In this case, estimations that introduce instrumental variables can be helpful, as there is a theoretical risk of inefficiency regarding direct methods of statistical estimation.

Nonetheless, there is no agreement on which instruments can better solve this puzzle. Our approach takes as instruments a group of variables (see section 4.2 for operational details) that represent markets' attractiveness for foreign direct investment. We have also assessed the possibility of reverse causation on interaction terms, as they are significantly related to FDI itself. Since instruments are rarely perfectly adequate for their theoretical and empirical purposes, models have also been estimated without corrections for potential reverse causation biases, and we take both estimation methods as complementary sources of empirical information.

Analytical variables that have been used in our estimations and mentioned so far in the formulation of empirical models are described in table 1 according to their function in statistical regressions. There are three dependent variables that represent our indicators of

National Innovation Systems' output (PROD, VALADD and HITECHX). While we recognize that these items do not respond for the complex and extensive dynamics of NISs, they are able to offer a diversified and relevant picture of the phenomena under scrutiny in this article. We have taken data for FDI stocks instead of the more usual approach of FDI flows. Though information for flows can be more convenient in terms of availability, it is hardly more efficient in the evaluation of spillovers (Van Pottelsberghe and Lichtenberg, 2001). There is not an optimal form of establishing the timing of externalities, i.e., how long do they take to occur (assuming they occur at all) and when these impacts can be translated into aggregate gains for the economic system as a whole. These problems are inherently addressed by the use of FDI stocks, since they are less volatile and represent the current reserves of MNCs assets in a given country in a specific period[2].

Furthermore, besides FDI, GERD and HK, which represent the core features of our research, a set of ancillary variables is proposed for a thorough examination of spillovers arising from MNCs activities. INV offers a control for the situation of overall domestic investment, a potential source of gains in the three dependent dimensions that are addressed in our study. The use of GDPPC functions as a control for the level of income of countries included in the sample. GDP per capita also controls for the purchasing power of the domestic market, a factor that is likely to drive output growth both quantitatively and qualitatively (Balasubramanyam *et al*., 1999).

OPEN is a proxy for trade policy regimes, which affect the competitive environment in a given country, also influencing the efficiency of FDI as a generator of social returns (Balasubramanyam *et al*., 1999; De Mello, 1997) and the dynamic quality of institutions by creating a more sophisticated and demanding environment (Alonso; Garcimartín, 2011). Additionally, trade flows and openness to trade have demonstrated a potential to increase innovative capabilities through knowledge spillovers (Coe; Helpman, 1995; Van Pottelsberghe; Lichtenberg, 2001). Using R and INF also allows controlling for the aggregate economic stability of nations, a potential source of shocks (positive or negative) upon output indicators.

As per instrumental variables, GINI functions as proxy for institutional quality (as suggested by Alonso and Garcimartín, 2011), whereas higher rates of inequality are related to weaker and worse sets of regulating institutions. In this case, this variable affects the attractiveness of FDI by defining the stability (or lack thereof) of host markets. GDPGRT, POP and GDP are measures of market attractiveness for MNCs, particularly those that are oriented towards asset-exploiting strategies (expected to be more relevant for inward FDI into developing countries). POWCONS serves the purpose of offering a proxy for the conditions of infrastructure in host countries.

TABLE 1: ANALYTICAL VARIABLES

Function	Code	Definition	Source

[2] MNCs tend to follow an evolutionary process in terms of knowledge creation in host markets (Guimón, 2009). This poses serious constraints on the use of FDI flows (instead of stocks) concerning FDI's impacts on recipient innovation systems, as *greenfield* initiatives are less prone to engage in innovative activities. Also, from the policymaking perspective, it suggests that attracting more FDI may not be as efficient in terms of social returns as providing support for MNCs that are already established in a given host market ("aftercare").

Dependent Variables	PROD	Labor productivity per person employed in 2013 US$ (converted to 2013 price level with updated 2005 EKS PPPs).	Conference Board
	VALADD	Value added in industry (ISIC divisions 10-45).. Data are in current U.S. dollars.	World Bank
	HITECHX	High-technology exports. It representsexports of products with high R&D intensity. Data are in current U.S. dollars.	World Bank
Independent Variables	FDI	Inward Foreign Direct Investment Stocks. Data are in current millions of U.S. dollars.	UNCTAD
	INV	Total investment as represented by gross fixed capital formation. Data are in current U.S. dollars.	World Bank
	GDPPC	GDP per capita. Data are in current U.S. dollars.	World Bank
	OPEN	Openness to trade measured as the sum of exports and imports as a percentage of GDP.	World Bank
	R	Real interest rate (%).	World Bank
	INF	Inflation as measured by the consumer price index (%).	World Bank
	GERD	Gross expenditures in R&D as a percentage of GDP.	CANA Dataset
	HK	Mean years of schooling in population over the age of 14.	CANA Dataset
Instruments	GINI	Gini index.	CANA Dataset
	GDPGRT	Annual percentage growth rate of GDP at market.	World Bank
	POWCONS	Electric Power Consumption (kWh per capita).	World Bank
	POP	Total population.	World Bank
	GDP	Gross Domestic Product. Data are in current U.S. dollars.	World Bank

4.2 Econometric Models and Procedures

After the methodological discussions presented above, we turn to the presentation of the empirical models of this investigation. First of all, it should be noticed that variables (except those that are expressed in percentages) are assessed via their natural logs. Equation 2 describes the general analytical model:

$$LnY_{it} = \alpha + \beta_1 LnFDI_{it} + \beta_2 LnINV_{it} + \beta_3 LnGDPPC_{it} + \beta_4 OPEN_{it} + \beta_5 R_{it} + \beta_6 INF_{it} + \beta_7 LnFDI*AC_{it} + \alpha_i + \varepsilon_{it}$$

Equation 2

Where:

α: constant of the model;

β_k: k^{th} coefficient of independent variables;

i: identifier of each cross-section unit;

t: identifier of each time-period;

α_i: time-invariant error term;

ε_{it}: observation-specific error term.

AC: represents the dimensions of Absorptive Capacity. It takes the functional form of [$LnFDI*GERD_{it}$] in models 1.1, 1.2, and 1.3, concerning the R&D dimension of AC. In its

turn, it takes the functional form [LnFDI*HK_{it}] in models 2.1, 2.2, and 2.3, regarding the Schooling/Human Capital dimension of AC.

There are six empirical models in total that are derived from equation 2. They are divided into two groups, the first one (models 1.1, 1.2, and 1.3) is dedicated to evaluating the "pure" and "*conditional upon gross expenditure in R&D*" impacts of FDI. The second group (2.1, 2.2, and 2.3) aims at assessing the conditionality of FDI impacts considering its interaction with host markets' human capital stock. The estimation method for equation 2 in models 1.1 through 2.3 is that of fixed-effects for panel data. The use of this particular strategy represents a fundamental tool in the verification of FDI effects upon economic systems' dynamics, since this technique allows controlling for time invariant characteristics of different national settings while taking into account their evolution over different periods (Nair-Reichert; Weinhold, 2001).

In a first moment the estimations do not include any instrumental variables (IVs). However in a second stage of statistical approaches, the possibility of reverse causation between "FDI", "FDI*AC" and the dependent constructs (the respective instruments are outlined in table 1 above).We remind that results from IV fixed-effects estimations should be addressed carefully, as accurate instruments are often extremely difficult to be found from a statistical point of view (though they may be theoretically robust).

5. RESULTS

Results from estimations are presented in tables 2 (fixed-effects) and 3 (fixed-effects with instrumental variables). Results from fixed-effects panel estimations (without IVs) highlight the fundamental role played by GERD as a conditional factor for the appropriation of FDI's spillovers. Also, it can be gathered from table 2 that these effects are stronger for HICs than for DCs, which is contrary to expectations that FDI can act as an agent of economic convergence; once the conditionality of FDI's spillovers is unraveled, countries with stronger innovation systems have a better grasp on the social returns from MNCs' activities.

This finding supports both FDI as a source of valuable knowledge transmission regarding systemic contributions to the innovative environment, and the relevant role of aggregate absorptive capacity as a catalyst in the learning process. Particularly, MNCs seem to exert positive influences on the high-tech export behavior of countries. On this regard, FDI, given the proper conditions, is likely to drive DCs' propensity to escape middle-income traps (though the marginality of impacts suggests this trend could only take place in the long run).

Under the same operational approach, outcomes for the Schooling Dimension of absorptive capacity are not so straightforward. The conditionality of FDI's contributions upon human capital is significant only for HICs in the case of productivity gains, and for DCs concerning added value in industrial activities (though it should be noticed that whenever these effects are statistically valid, they are somewhat strong). It must be recognized, however, that "mean years of schooling" offers only a very limited view of human capital quality.

For example, educational quality (which is not captured by our human capital proxy) is an extremely relevant issue, particularly in the case of DCs (as it can be concluded from overall results from the Programme for International Student Assessment - PISA[3]). The evaluation of the time spent in school among labor forces does not consider these "softer"

[3] Available at http://www.oecd.org/pisa/

aspects, and it also fails in developing a clearer picture of populations' characteristics in terms of knowledge-oriented activities (formal training in STEM, R&D personnel or general quality of upper-tail human capital[4]). Unfortunately, these statistics are not consistently available for a large group of countries throughout long periods of time, hindering its use in panel data assessments.

Furthermore, it is noteworthy that in none of the models FDI alone shows a positive contribution in terms of productivity, value added, and high-tech exports. That result is valid for both DCs and HICs. Whenever this variable is statistically significant, its impacts are fundamentally negative, offering support to the hypothesis that in the absence of sufficient levels of absorptive capacity, MNCs activities can have perverse effects in host economies. Additionally, as expected, estimations highlight this feature is particularly sensitive in developing nations. In this sense, we find no evidence that FDI's spillovers take place "naturally". They seem to be dependent on the economic conditions provided by institutional settings of the host nations, at least in the cases of constructs that address the development of NISs.

As per the control variables of our analysis, results come without relevant surprises. LnINV does not perform a statistically significant role as it would be expected, and its sign is negative in models 1.1, 1.3, 2.1 and 2.3 for the case of DCs. This, however, does not indicate that fixed capital investments are actually bad for innovation systems, but rather that there is an inconsistency of domestic productive investments in developing nations, which can be considered as evidence of the lack of maturity of these economic environments (an aspect that hinders their evolution towards developed conditions). LnGDPPC is a relevant indicator in our approach, having a positive and statistically significant sign in most models (whenever the value of this particular coefficient is negative, it is not significant). This finding is contrary to the expectation of economic convergence (according to the set of dependent variables) in our models. OPEN, for logical reasons, is mainly related to models 1.3 and 2.3, i.e., those related to exports. The rate of interest (R) and the rate of inflation (INF) have mixed signals, making it difficult to perceive their overall impacts upon our indicators of innovation systems' performance. Since an in-depth evaluation of monetary policies is not within the scope of this paper we do not proceed to further discussions on these aspects.

Turning to IV fixed-effects models, impacts of conditional FDI become scanter. This correction for the risk of reverse causation between FDI-related variables and dependent constructs helps analyzing the possibility of reverse causality occurring in the relationship embedded in the analysis of i) MNCs as a source of spillovers; or ii) NISs' strengths as sources of asset-seeking motives for this group of firms. According to these evaluations, FDI's contributions are rather marginal, though they emphasize the importance of absorptive capacity conditions in DCs, more than in HICs.

[4] This particular issue has been recently addressed by Squicciarini and Voigtländer (2014). They found "scientific elites" have a broad effect on aggregate economic growth.

TABLE 2: ESTIMATIONS FOR PANEL DATA FIXED-EFFECTS MODELS

Absorptive Capacity Dimension

	R&D						**Schooling**					
	Model 1.1		**Model 1.2**		**Model 1.3**		**Model 2.1**		**Model 2.2**		**Model 2.3**	
	LnPROD		**LnVALADD**		**LnHITECHX**		**LnPROD**		**LnVALADD**		**LnHITECHX**	
	DCs	HICs	DCs	HICs	DCs	HICs	DCs	HICs	DCs	HICs	DCs	HICs
const.	9.030*** [.580]	12.368*** [2.327]	15.426*** [.718]	13.062*** [.480]	16.699*** [3.067]	12.368*** [2.327]	8.694*** [.624]	8.577*** [.347]	13.947*** [.716]	13.035*** [.492]	15.017*** [3.401]	9.159*** [2.538]
LnFDI	-.077*** [.022]	-.014 [.158]	-.071** [.029]	-.104*** [.031]	.102 [.127]	-.014 [.158]	.048 [.118]	-.183** [.081]	-.699*** [.134]	.078 [.104]	-.523 [.664]	-.223 [.600]
LnINV	-.082* [.042]	.235 [.167]	.009 [.053]	.122*** [.032]	-.468** [.225]	.235 [.167]	-.107** [.042]	.002 [.022]	.025 [.050]	.121*** [.030]	-.552** [.231]	.289* [.161]
LnGDPPC	.395*** [.056]	.151 [.214]	1.001*** [.072]	.953*** [.039]	1.312*** [.303]	.151 [.214]	.451*** [.056]	.141*** [.029]	.933*** [.068]	.953*** [.038]	1.412*** [.313]	.062 [.212]
OPEN	.044 [.056]	1.227*** [.155]	.266*** [.063]	.049* [.028]	1.576*** [.316]	1.227*** [.155]	.158*** [.054]	.089*** [.022]	.245*** [.057]	.070** [.028]	1.547*** [.308]	1.240*** [.165]
R	.146*** [.049]	.224 [.549]	-.155** [.065]	-.325*** [.104]	.135 [.274]	.224 [.549]	.147*** [.048]	-.090 [.071]	-.204*** [.060]	-.257*** [.098]	.126 [.285]	1.065** [.533]
INF	-.002 [.009]	-2.837*** [.502]	.002 [.012]	.385*** [.094]	.043 [.054]	-2.837*** [.502]	-.005 [.009]	-.723*** [.062]	-.006 [.012]	.433*** [.089]	.033 [.057]	-2.547*** [.510
LnFDI*GERD	.091*** [.020]	.277** [.136]	.055** [.026]	.061** [.028]	.214* [.111]	.277** [.136]	-	-	-	-	-	-
LnFDI*HK	-	-	-	-	-	-	-.040 [.114]	.228*** [.079]	.666*** [.130]	-.113 [.102]	.813 [.642]	.515 [.585]
R^2	.957	.983	.995	.998	.978	.983	.955	.982	.996	.998	.976	.984
Valid N	276	412	308	388	291	412	290	442	328	404	308	433

Std. Errors in brackets

*sig. at 10%
**sig. at 5%
***sig. at 1%

TABLE 3: ESTIMATIONS FOR PANEL DATA FIXED-EFFECTS MODELS WITH INSTRUMENTAL VARIABLES

Absorptive Capacity Dimension

	R&D						**Schooling**					
	Model 1.1 LnPROD		**Model 1.2 LnVALADD**		**Model 1.3 LnHITECHX**		**Model 2.1 LnPROD**		**Model 2.2 LnVALADD**		**Model 2.3 LnHITECHX**	
	DCs	HICs	DCs	HICs	DCs	HICs	DCs	HICs	DCs	HICs	DCs	HICs
const.	8.993*** [.707]	9.888*** [.483]	19.469*** [1.999]	13.112*** [1.193]	19.316*** [3.041]	6.274* [3.393]	7.395*** [1.070]	22.667 [17.067]	12.536*** [1.609]	-15.618 [29.388]	15.644*** [3.858]	126.104 [155.691]
LnFDI	-.255*** [.050]	.105 [.162]	-.027 [.142]	-.861** [.464]	-.070 [.219]	.441 [1.300]	-.566* [.323]	3.905 [5.607]	-2.265*** [.486]	-9.248 [9.601]	-1.229 [1.196]	39.025 [50.997]
LnINV	-.063 [.052]	-.028 [.032]	.079 [.147]	.253*** [.083]	-.627*** [.212]	.525** [.210]	-.108* [.059]	-.367 [.402]	.030 [.088]	.821 [.728]	-.628*** [.214]	-2.289 [3.674]
LnGDPPC	.505*** [.101]	.083* [.043]	.191 [.285]	1.069*** [.094]	1.786*** [.398]	-.162 [.327]	.678*** [.096]	.096 [.107]	.552*** [.145]	.806*** [.255]	1.963*** [.332]	0.082 [.903]
OPEN	.053 [.113]	.026 [.037]	-.661** [.320]	.197*** [.079]	1.450** [.658]	1.307*** [.237]	.299*** [.092]	-.054 [.096]	-.203 [.139]	.059 [.187]	1.791*** [.403]	1.196 [.801]
R	.063 [.065]	-.143 [.145]	.149 [.185]	-.834* [.430]	.282 [.271]	.539 [.966]	.027 [.078]	-.122 [.331]	.040 [.117]	-.440 [.704]	.297 [.281]	.206 [2.690]
INF	-.021 [.014]	-.776*** [.111]	.112*** [.41]	-.240 [.414]	.031 [.052]	-2.878*** [1.031]	-.044*** [.016]	-.512 [.316]	.047* [.024]	.041 [.616]	.006 [.054]	-1.500 [2.711]
LnFDI*GERD	.188*** [.055]	-.008 [.123]	.451*** [.156]	.618* [.361]	.195 [.274]	-.148 [.991]	-	-	-	-	-	-
LnFDI*HK	-	-	-	-	-	-	.410 [.300]	-3.480 [5.199]	2.396*** [.452]	8.558 [8.935]	1.167 [1.116]	-35.896 [47.262]
R^2	.720	.860	.713	.915	.738	.789	.615	.406	.863	.561	.704	.218
Valid N	238	391	238	379	231	383	250	407	250	395	242	399
Substituted covariates: LnFDI; LnFDI*GERD							**Substituted covariates: LnFDI; LnFDI*HK**					
Instruments: GINI; GDPGRT; LnPOWCONS; POP; GDP							**Instruments: GINI; GDPGRT; LnPOWCONS; POP; GDP**					

Std. Errors in brackets

*sig. at 10%

**sig. at 5%

***sig. at 1%

This finding is consistent with the high level of institutional heterogeneity among developing nations, while the existence of more developed innovation systems represents the reality of HICs. Accordingly, it is much harder to differentiate cases amongst developed economies in terms of absorptive capacities. On the other hand, this is evidence that perhaps FDI can in fact operate some sort of economic convergence over the long run, where MNCs contributions to DCs' innovation systems can surmount those impacts of inward FDI in HICs.

In consonance with the models that do not include IVs, there are no signs of spillovers arising "automatically", i.e., FDI *per se* does not find support in our estimations as a vector of knowledge diffusion. This finding is robust across all of our assessments, representing an extremely relevant issue in favor of the argument that a closer coordination between FDI-attraction policies and more general innovation-related initiatives that promote the generation of stronger absorptive capacities is of fundamental importance if proper benefits should take place. This is primarily relevant for relatively laggard NISs, i.e., those of developing countries.

However, positive impacts of FDI identified in this article and in related literature should be analyzed carefully. Through the use of basic production functions it is hard to define if the role of R&D expenditures and human capital are good representations of agents' absorptive capacity or of agents' internal innovative capabilities. It is reasonable to hypothesize that the relevance of conditional dimensions can influence the competitiveness of domestic agents in face of the presence of MNCs, a situation that is not directly related to the ability of indigenous firms to absorb FDI externalities, but rather to their capability of properly addressing the dynamics of resource reallocation that occurs in the context of competitive pressure exerted by MNCs. The more likely rationale, however, is that there is a strong complementarity between favorable spillovers and the aggregate level of domestic firms' competitiveness (an argument that follows the two-sided benefits of knowledge-related investments, as outlined by Cohen and Levinthal, 1990).

Regarding control variables, comments follow a similar pattern to those outlined for estimations without IVs. INV seems to be weakly related to positive changes in innovation systems. This result could be interpreted as a sign of the importance of "soft" or "knowledge-related" assets for progress within this particular realm, as well as a latent situation of diminishing returns from physical capital. Nonetheless, if different macroeconomic variables were included as dependent dimensions, we believe that the behavior of INV would be somewhat distinct (as there is no reason to downgrade the economic benefits that arise from fixed capital investments). The other ancillary variables do not add much new information: OPEN remains as a significant explanatory factor mostly for high-tech exports' models (though it is surprisingly negative in model 1.2), while R and INF have a relatively unstable behavior.

6. CONCLUDING REMARKS AND INNOVATION POLICY IMPLICATION

This article addressed the issue of complementarity between innovation policies (in terms of aggregate absorptive capacities) and the role of FDI as a source of positive externalities upon National Innovation Systems. According to our estimates, FDI can become an important vector of NISs evolution through investments in R&D (primarily) and in human capital (secondarily). In this sense, benefits arising from the activity of MNCs call are conditional. The main implication of this finding is that FDI attraction *per se* is not necessarily a source of knowledge and technological spillovers expected by policymakers. Hence, the outcomes of this research suggest the need for a closer coordination among the innovation policy mix and FDI-attraction strategies with the aim of enhancing indigenous

agents' capabilities to absorb knowledge spillovers (similar conclusions can be found in Balasubramanyam *et al*., 1999; Guimón, 2009 and Warwick, 2013).

As a consequence of this conditionality of spillovers, the absence of synchronization between FDI attraction and indigenous absorptive capacities can cause FDI to have detrimental effects on the technological dynamics of domestic markets. This is particularly true for the case of developing countries, taking into account their average characteristic of technological laggards *vis-à-vis* developed nations. Our econometric exercise has highlighted the importance for developing economies to establish a sound environment in terms of R&D intensity and education of the labor force concerning their capacity to absorb externalities arising from the presence of MNCs.

Besides its direct implications, this assessment also highlights the need for further scrutiny concerning the mechanisms through which MNCs effectively contribute to host innovation systems. In this regard, one important avenue of future research is that of evaluation and screening of FDI projects. Investigations in this area may help establishing if FDI "selectivity" would be able to generate beneficial impacts of higher orders and help fostering a more rapid evolution of National Innovation Systems.

We recognize, however, that these suggestions should be considered cautiously, as these matters still deserve further empirical investigations. First of all, it must be noticed that the groups of countries used in the analysis (high-income countries and developing countries) have substantial levels of heterogeneity regarding their economic structures, an aspect that affects FDI attraction and the appropriation of its impacts. Therefore, the aggregation of these economies might entail a significant diversity within groups, an issue that can potentially affect overall results and model explanations. By the same token, aggregated data hinders the analysis of sectoral and regional idiosyncrasies within countries.

Furthermore, while, the methodological structure of our research has provided relevant information on the complementarity between innovation policy frameworks and the dynamics of FDI, the econometric models are of a limited reach in the complex context of NISs. Yet, there is little reason to believe that FDI *per se* performs the expected levels of knowledge diffusion. Its inclusion and interaction with broader concepts of innovation policy is essential.

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Appendix I. Countries included in the empirical approach

High-Income Countries (HICs)

Australia, Austria, Belgium, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, South Korea, Kuwait, Netherlands, New Zealand, Norway, Poland, Portugal, Qatar, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States.

Upper-Middle Income Countries (DCs)

Albania, Algeria, Argentina, Botswana, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Ecuador, Iran, Jamaica, Jordan, Kazakhstan, Latvia, Lebanon, Lithuania, Malaysia, Mexico, Namibia, Panama, Peru, Romania, Russia, South Africa, Thailand, Tunisia, Turkey, Uruguay, Venezuela.