FDI productivity spillovers and absorptive capacity in Brazilian firms: A threshold regression analysis

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ABSTRACT: Existing literature points that foreign direct investment (FDI) brings firm-level productivity spillovers. However, few studies have been conducted in Latin-American economies. By using a unique Brazilian county-level FDI database, this paper explores whether the effect of the amount of FDI at the county level on firms' productivity growth depends on certain minimum levels of local companies' absorptive capacity. To do it, we use a threshold regression model, a formulation that appears to be robust to assess the specificities of developing economies. Results indicate that when FDI is set as the threshold and regime-dependent variable, Brazilian firms may suffer from negative productivity spillovers. However, local firms may collect positive spillovers if they are endowed with high absorptive capacity.

Key-Words: Foreign Direct Investment (FDI); Spillover; Threshold; Absorptive Capacity; Brazil.

JEL Classification: O33; C24; D2

1. INTRODUCTION

Foreign direct investment (FDI) in developing countries is widely accepted as a catalyst for productivity gains and efficiency of domestic firms through the generation of knowledge spillovers, inducing many governments to formulate policies aimed at attracting such investments through various incentives, and reinforcing internal factorial endowments such as infrastructures, legal systems, and governance (Groh & Wich, 2012; Kayalvizhi & Thenmozhi, 2018). These productivity spillovers occur because multinational companies tend to be technologically and managerially superior to firms in developing countries. Thereby, the presence of such organizations tends to be virtuous for domestic firms through technology and organizational spillovers, raising the productivity and efficiency of the receiving firms, as well as connecting national firms to international value chains (Kim, 2015; Y. Tang & Zhang, 2016).

Consequently, FDI can be considered a source of knowledge for the host economy, being an element capable of fostering the economic development of the recipient country, while it enables emerging market firms to diversify from home resource dependence which improves profitability (Cui & Xu, 2019).

However, such knowledge transfer requires absorptive capacity from the host country, so that companies close to the technological frontier have greater potential to absorb knowledge and enhance its productivity compared to technologically outdated organizations (Harris & Le, 2018; Huynh, Nguyen, Trieu, & Tran, 2019; Ubeda & Pérez-Hernández, 2017), especially when the receiving economy retains long-run FDI (Shi, 2019). Thus, organizations unable to absorb knowledge from multinational companies loose relative competitiveness with the increase of competition, causing negative productivity spillovers from FDI.

Nevertheless, absorptive capacity is not a binary concept. Pioneering studies such as Girma (2005) analyze whether the effect of FDI on firm-level productivity growth is dependent on its absorptive capacity, using Hansen (2000) threshold regressions. The author finds evidence of a non-linear threshold associated with a minimum level of absorptive capacity so that productivity spillovers from FDI can be negligible or even negative. Nonlinear moderation relationships regarding absorptive capacity levels are also found for innovation performance and sales growth (Kohtamäki, Heimonen, & Parida, 2019; Ubeda, Ortiz-de-Urbina-Criado, & Mora-Valentín, 2019).

Thus, negative spillovers may be caused by low absorptive capacity triggered by insufficient cognitive capital. All in all, in the context of developing economies, despite scarce, empirical evidence has shown that vertical positive spillovers are prevalent specifically in the presence of a minimum amount of absorptive capacity, while negative effects may appear in other situations (Behera, 2017; Djulius, 2017; Malik, 2015; Newman, Rand, Talbot, & Tarp, 2015; Thang, Pham, & Barnes, 2016). However, this evidence has been mostly evaluated on Asian economies, whereas Binyam A. Demena and van Bergeijk (2017) state that future research needs to cover more developing countries and investigate not only whether spillovers occur, but also to explore inside the black box of how spillovers actually emerge.

In light of the previous literature, the present study aims to identify the effects of productivity spillovers from FDI in Brazilian large companies, and whether these effects depend on a minimum level of national companies' absorptive capacity. It adds to the existing literature in three ways. First, it analyses an emerging economy not yet addressed, Brazil, in the context of Latin America, an under-investigated area. Indeed, the literature presents a wide range of studies on the effects of FDI in developing countries such as China (Anwar & Sun, 2014; Du, Lu, & Tao, 2008; Gunby, Jin, & Robert Reed, 2017; Huang, Liu, & Xu, 2012; Y. Wang, Ning, Li, & Prevezer, 2016; L. Zhang, 2017; M. Zhang, 2005). However, few studies have been conducted in other developing economies, especially Latin-American ones, so scientific evidence to date is not able to create a broad FDI scenario in such realities.

Although some studies in Latin America corroborate our results for Argentina and Chile in favor of positive spillover effects of regional FDI on firm-level productivity (Laborda Castillo, Sotelsek Salem, & Moreno, 2014; Marin & Bell, 2006), and Mexico (Armas & Rodríguez, 2017) when analyzing a Technology Capacity Index (which contains learning and investment, production, and linkage with other firms), generalization of the results found here should be done with caution, since Brazilian government (and other developing economies) does not have any official statistics on regional level FDI. Thereby, we propose an export-related FDI indicator by employing the whole municipality population of exporting companies, and by integrating our unique regional-level FDI database with Brazilian firms data, we try to contribute to the literature bringing some light to such dynamics in a Latin American important economy (one of the 10 largest economies in the world), evaluating whether local FDI has negative or positive spillover effects in Brazil.

Second, the present study goes beyond the existing literature in trying to calculate critical values (thresholds) of knowledge absorptive capacity so that Brazilian companies can benefit from productivity spillovers from multinational presence. This would allow for better FDI public policy attraction regarding local companies' absorptive capacity, in order to avoid negative FDI spillover effects.

Lastly, we rely on the assumption of previous studies that emphasize the importance of geographical proximity to the technology transfer that underlies the productivity spillover process from the presence of foreign firms (Hamida, 2013; Xu & Sheng, 2012). Indeed, despite the need of high levels of absorptive capacity, productivity spillovers tend to be more effective when the recipient is located near the source of knowledge, hence the significance and sign of spillover effects will depend on geographical proximity or vary with the level of foreign presence within a cluster (Binyam Afewerk Demena & Murshed, 2018; Girma, Gong, Görg, & Lancheros, 2015; Khachoo, Sharma, & Dhanora, 2018; Liang, 2017). Thus, we are implicitly evaluating the importance of proximity, since our database evaluates if local large enterprises in a regional environment intensive on foreign capital presence, are more likely to benefit from productivity spillovers.

The present paper is organized into five sections besides this introduction. Section 2 presents the literature review that seeks to identify the main recent evidence on FDI spillover effects on developing economies, and states the main objectives underlying this research. The third section contains the methods and the fourth section the results and discussion. Finally, the main considerations and limitations are found in the fifth section.

2. RELATED LITERATURE

2.1 FDI spillover effects: Previous theoretical and empirical evidence

Worldwide FDI flows began to expand in the late 1980s when governments of developing countries created a number of incentives to attract FDI in the expectation of receiving technological improvement. FDI was seen as an inexpensive and effective way of technology transfer, thus becoming a significant determinant of technological modernization and economic development in the host countries (Jude, 2016). In fact, the literature has provided robust evidence supporting the role of FDI in economic growth, most of these, productivity spillovers studies, finding evidence of the transmission process by which FDI stimulates productivity improvements in domestic firms (Gunby, et al., 2017).

While there is substantial evidence that foreign-owned firms are more efficient than domestic firms (Gorodnichenko, Svejnar, & Terrell, 2014), apart from foreign technologies and production processes, inward FDI also transfers organizational routines knowledge and practices to the host country firms (Ali, Cantner, & Roy, 2016). In addition, the acquisition of improved inputs will cause the recipient to appropriate some productivity spillover, in a process called rent-spillovers (Montoro-Sánchez, 2011; Verspagen, 1997).

The literature also points out that the effects of productivity spillovers tend to be more pronounced vertically (downstream links in the production chain) especially in the knowledge-intensive services since multinationals tend to transfer technology to their suppliers to be provided with more technologically advanced inputs, although foreign firms productivity spillovers were also found downstream in manufacturing sectors (Newman, et al., 2015; Orlic, Hashi, & Hisarciklilar, 2018). Harmfully, horizontal spillovers tend to be rarer, or even negative, given the competition and decrease in the market share of national companies, reducing their relative productivity (Aitken & Harrison, 1999; Kim, 2015), even though some positive evidence was found for European transition economies through worker mobility and increased competition (Orlic, et al., 2018).

A meta-analysis conducted by Binyam A. Demena and van Bergeijk (2017) investigates whether FDI actually generates productivity spillovers in the context of developing countries, being the empirical evidence inconclusive and contradictory. Their findings demonstrate that spillovers and their sign largely depend on specification characteristics, and suggest that future research needs to carefully consider the selection of explanatory variables in order to avoid specification bias.

Lin and Kwan (2016) argument that relatively little attention has been paid to the issue of potential negative spillovers, which can be substantial in the Chinese case, possibly due to market stealing or congestion pricing. Likewise, labor turnover could also generate negative spillovers to domestic firms when foreign firms poach local talents from their domestic counterparts. Gerschewski (2013) review of spillover effects in developing countries suggests the tendency to observe negative intra-industry productivity spillover effects while positive inter-industry spillovers.

Evidence on the spillover effects of FDI on developing Asian economies (especially China) tends to be more frequent than in other geographical areas. For instance, with Turkish and Indonesian firm-level data, respectively from Fatima (2016) and Suyanto and Salim (2013), it is found that horizontal linkages decrease the productivity of firms, while vertical bonds exert a positive impact onto the local productivity, implying that policymakers should reinforce supplier-buyer relationship in the FDI attraction strategy. Results for the Turkish economy are also given by Ebghaei and Akkoyunlu Wigley (2018), which evidence that horizontal productivity spillovers from FDI are more pronounced for export-oriented firms, a result also stated by Djulius (2017) for Indonesian firm-level data.

Evaluating the FDI spillovers in horizontal, upstream, and downstream industries on domestic manufacturing firms in Thailand, Wiboonchutikula, Phucharoen, and Pruektanakul (2016) indicate that upstream industries show negative spillover effects, while FDI in downstream industries reveals positive spillover effects.

Malik (2015) and Behera (2017) suggest that high-technology industries benefit more from FDI. Behera (2017) states that local Indian firms benefit from horizontal and vertical FDI productivity spillovers, the latter being stronger, and with the absorptive capacity of domestic firms being highly relevant. This result is also found by Salim, Razavi, and Afshari-Mofrad (2017), which verified that technological capabilities of Iranian subsidiary units are a mediating player that influences demonstration and training spillover channels. Finally, firm-level data from Cambodia reveals that domestic firms significantly benefit from productivity spillovers when their technological level is moderately below compared to foreign competitors (Cheng (2012).

A specificity of the relationship between FDI and productivity spillovers is evidenced by Anwar and Sun (2014), who presents that productivity spillovers arising from FDI from Hong Kong, Macau and Taiwan exhibit not only heterogeneity but also non-linearity, differently from other literature evidence which present heterogeneous but not curvilinear effects. The size of the estimated spillovers depends on firm age, capital intensity, and ownership structure. All in all, as agreed in Wooster and Diebel (2010), FDI spillovers are likely to be significant and positive for Asian countries. However, the evidence on Latin-American countries is still scarce.

2.2. Evidence for Latin American countries

Using firm-level panel data, Laborda Castillo, et al. (2014) test whether spillovers from FDI make a contribution to productivity growth in Chilean manufacturing firms, employing a generalized Malmquist output-oriented index. They find positive productivity spillovers from FDI (especially high in a competitive environment), as firms with high R&D effort tend to obtain higher spillovers, a result that reinforces the importance of firms' absorptive capacity in such Latin-American economies.

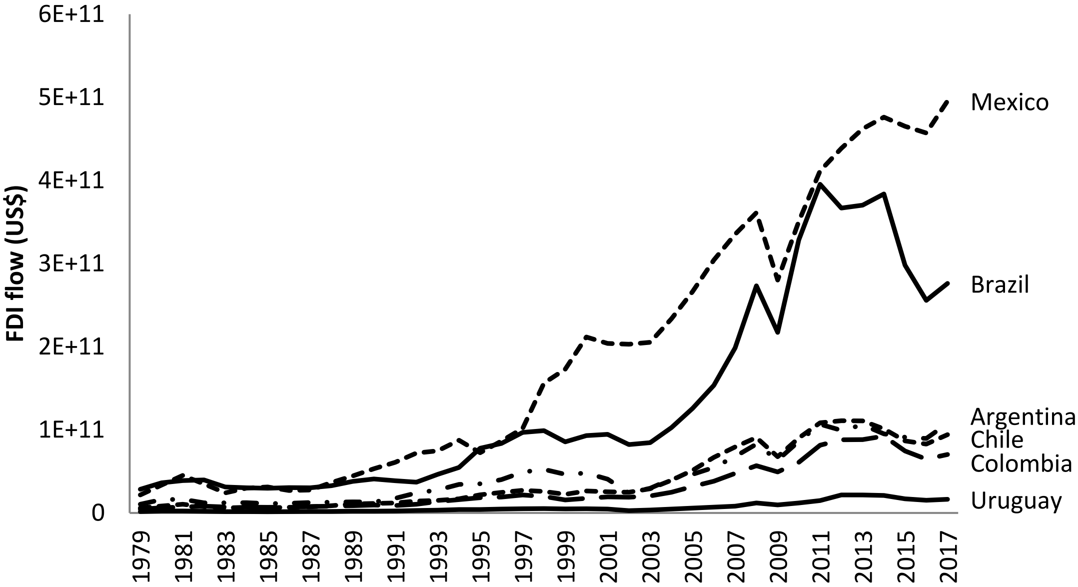
Using data from industrial firms ranging from 1992 to 1996, results for Argentina also suggest that absorptive capabilities were an important influence on the extent of FDI spillovers. In a similar way, Armas and Rodríguez (2017) show that after twenty years of NAFTA, many indigenous firms in Mexico must develop absorptive capacity to benefit from FDI.

Brazil, as one of the 10 largest economies in the world (considering nominal GDP), has historically relied on the import substitution strategy for diversification and generation of economic growth. However, such a state-oriented strategy, despite relative success in creating key infrastructure and activities, has resulted in a series of severe macroeconomic imbalances since the early 1980s. On the contrary, although with a similar per capita GDP at the beginning of the 1960s, South Korea achieved faster growth compared to Brazil by specializing in high sophistication and technological intensive goods, been the proactive policy of encouraging FDI partially responsible for it.

According to the Brazilian Central Bank, when choosing Brazil as an investment destination, foreign companies face several advantages such as extensive natural resources, a large middle-class and domestic market, and a depreciated real exchange rate. However, Brazil possesses weaknesses such as onerous labor laws, heavy taxation, high production costs, and fragile infrastructure. Indeed, the inherent characteristics of the Brazilian economy have changed the profile of foreign investments in Brazil from a proportion in 2010 of 45% for services, 39% in industry, and 16% in agriculture and livestock and mining to 55%, 37%, 8% respectively during 2016 (Bacen, 2018).

Even though Brazil is the largest economy in Latin America (in GDP absolute terms), and a major recipient of FDI in the last decades (see Figure 1), knowledge about its effects on local business productivity is still unknown, especially due to the absence of data. This precludes any study to relate the presence of foreign companies and productivity within Brazil and several developing economies.

Figure 1 – Inward FDI flow.



Source: World Bank database (2018)

Some initiatives such as Costa and de Queiroz (2002) pursued to investigate the implications of the growing presence of foreign affiliates for deepening technological capabilities in Brazilian industry, finding that foreign affiliates score higher than their local counterparts in more complex capabilities, confirming their centrality in the Brazilian learning system. Another interesting effort from Marin and Costa (2009) explored FDI spillovers in Brazil. However, their study suffers from some methodological shortcomings, since it employed pooled data of enterprises from a database composed only by innovative companies (Pintec – the Brazilian Innovation Survey), therefore postulating a priori, that "spillovers arise only in the more 'advanced' or 'technologically intensive' industries", and spillovers are "captured only by domestic firms with high-absorptive capabilities". This demonstrates that the absence of data presents itself an important limitation to the knowledge of such dynamics. Using our unique regional-level FDI database, we try to contribute to the literature bringing some light to such dynamics in a Latin American important economy, evaluating whether FDI has negative or positive spillover effects in Brazil.

2.3. The role of absorptive capacity on FDI-related productivity spillovers

The direction and intensity of both vertical and horizontal spillovers surveyed above, depend on the absorptive capacity of domestic firms (Orlic, et al., 2018), a concept that, although widely accepted in the literature, still lacks clarity. Indeed, being currently considered one of the most important characteristics when studying the impact of the innovative effort, absorptive capacity can be defined as the ability to identify, assimilate, and commercially apply knowledge created abroad (Cohen & Levinthal, 1990; Nieto & Quevedo, 2005; Veugelers, 1997). Still, the absorptive capacity requires more than exposure or familiarity, being in fact a function of pre-existing knowledge abundance. Thus, learning has better performance when the learning object is related to what is already known, since absorptive capacity reflects multidimensional interaction of many factors, mainly including the country's FDI policy, human capital, research and development (R&D), and infrastructure quality (Caragliu & Nijkamp, 2012; Y. Tang & Zhang, 2016).

Studies have shown that national innovation systems should be reconsidered and designed in such a way as to be able to improve the absorptive capacity, since in addition to the internal innovation system, the FDI-related strategy seems to have a positive influence on catching-up processes, especially in the Chinese case (M. Tang & Hussler, 2011). Generally, FDI has been beneficial for the Chinese economy because its industries with high absorptive capacity were prepared to take advantage of spillovers from foreign-owned firms (Chen, Kokko, & Tingvall, 2011).

Thereby, companies endowed with cognitive capacities that allow the internalization of knowledge brought by multinational organizations tend to increase productivity when exposed to new techniques, procedures, and technologies. In fact, absorptive capacity would explain the negative FDI-related productivity spillovers in African countries and the positive ones in Asia and Europe (Njikam & Leudjou, 2019; Ubeda & Pérez-Hernández, 2017). Several studies have stressed the role of absorptive capacity for productivity gains through knowledge exploitation (Jacobs, Zámborský, & Sbai, 2017; Laborda Castillo, et al., 2014; Liang, 2017; Liao, Liu, & Wang, 2012; Marcin, 2008; Y. Tang & Zhang, 2016), while others claim that at least absorptive capacity has the ability to mitigate possible negative FDI spillovers (Kim, 2015).

Correspondingly, despite the relative consensus on the role of absorptive capacity for the appropriation of external knowledge, few studies consider the heterogeneity of the spillover effect given its dependence on the absorption capacity, determined by its own R&D, export performance, and output level (Kim, 2015). Among others, it is possible to highlight Girma (2005) and Girma & Görg (2007), who show that the relationship between absorptive capacity and extra-regional spillovers of FDIs has a non-linear relationship, i.e. inverted U-shape. These papers measure absorptive capacity as the ratio between the TFP and the maximum TFP and uses the threshold regression technique given by Hansen (2000). This evidence displays a nonlinear threshold so that the benefit of FDI productivity grows to a threshold level, from which it makes the effect less pronounced, that is, growing at decreasing rates. Girma (2005) also finds a minimum level of absorptive capacity so that the receiving companies are able to appropriate positive spillovers. Recent similar results using threshold regression models may also be found in Huang, et al. (2012) and Ubeda and Pérez-Hernández (2017).

Thus, policies aiming to attract FDI without enough attention to absorptive capacity may experience negative spillovers resulting from the loss of relative productivity. Or at least, it may induce becoming host for cheap-labor seeking, resulting in FDI having a transient increase in productivity performance, but ending up linked into global value chains as suppliers of labor-intensive products and components only, without enhancing their technological standards and productivity (Aitken & Harrison, 1999; Lin & Kwan, 2016; Y. Tang & Zhang, 2016).

Following this evidence, we plan to study whether there is a threshold of absorptive capacity for FDI productivity spillovers to become positive in a foreign capital intensive area, such as Brazil.

3. METHODS

3.1. Data Sources and Variables

We collect information from the consolidated financial statements of 194 Brazilian companies included in the Economática database for the period from 2010 to 2014. The sample is composed of large-sized companies from manufacturing and services sectors listed on the B3 (Brazilian Stock Exchange - formerly BM&FBOVESPA), which were categorized according to the NACE classification of industries and services. Companies that left the B3 Stock Exchange during the period, and some inconsistent information about labor expenses and revenues in some firms forced us to exclude certain companies in order to achieve greater reliability. Also, the threshold model requires the panel to be balanced, so we selected the range that maximized the sample size while keeping a balanced panel. The sectoral distribution of such companies is presented in Table 1.

Table 1 - Sectorial distribution

Sector	Share	Sector	Share

Activities auxiliary to road transport	11.3%	Hardware industry	0.5%
Activities auxiliary to transport	1.0%	Health & Personal Care Store	0.5%
Administrative, scientific and technical consultancy	1.0%	Hotel and other types of accommodation	0.5%
Agricultural machinery, construction and mining	0.5%	Industrial Machinery	0.5%
Agriculture	0.5%	Insurance Company	0.5%
amusement park	0.5%	Knitwear industry	0.5%
Assorted Goods Store	0.5%	Manufacture of ceramic and refractory products	0.5%
Auto parts industry	3.1%	Medical equipment and supplies industry	1.0%
Basic chemical industry	1.0%	Medical Examination Laboratory	0.5%
Bolts, washers, nuts and turned products	0.5%	Mining Equipment & Supplies	0.5%
Business Administration and Entrepreneurship	3.6%	Odontological office	0.5%
Business support services	0.5%	Other activities auxiliary to transport	0.5%
Canned fruit and vegetable industry and special foods	0.5%	Other activities related to financial investments	0.5%
Car body and trailer industry	1.5%	Other food industries	0.5%
Car Rental	0.5%	Other heavy and civil engineering constructions	1.0%
Chemical industry	1.0%	Other industries	0.5%
Cleaning industry	0.5%	Other metal products industries	2.1%
Clothing store	1.5%	Other Other Industries	0.5%
Computer and electronics industry	0.5%	Other Recreation Industries	0.5%
Computer and peripheral industry	0.5%	Other support services	0.5%
Construction Materials	2.6%	Other transport equipment	0.5%
Construction of roads, streets, bridges and tunnels	0.5%	Other types of schools	0.5%
Dealerships of other motor vehicles	1.5%	Paper, pulp and paper industry	1.5%
Department store	1.5%	Plastic products industry	1.0%
Education	1.0%	Printing and auxiliary activities	0.5%
Electricity, gas and water company	1.0%	Railway Equipment Industry	0.5%
Engineering and architecture services	0.5%	Railway transport	2.6%
Engines, turbines and power transmitters	0.5%	Real Estate	1.0%
Extraction of non-metallic minerals	0.5%	Road transport	0.5%
Extraction of oil and gas	2.1%	Sales by mail or electronic means	0.5%
Fabric garment industry	4.1%	School of higher education	0.5%
Fertilizers and pesticides	1.0%	Shipyards	1.0%
Financial and insurance services	0.5%	Slaughterhouses	1.5%
Food industry	0.5%	Smoke industry	0.5%
Footwear industry	1.5%	Steel transformation in steel products	2.1%
Forging and stamping	1.0%	Storage service	0.5%
Foundry	0.5%	Telecommunications	2.1%
Fruit and nut cultivation	0.5%	Water, sewage and other systems	4.1%
Generation, transmission and distribution of electricity	9.8%	Weaving	2.1%
Grain mil	0.5%	Wholesale	0.5%

As a residual of a production function (also known as Solow's residual), Total Factor Productivity (TFP) contains everything that is not measured by physical factors. Its difference in time will compute changes in non-technical efficiency, such as creativity, managerial aptitude, and all knowledge that comes from global improvements over time and regional knowledge. Thus, this residual can be interpreted as the rate of product growth above the rate of capital growth, or growth not explained by production factors, reflecting the variation in the technological efficiency with which these factors are employed (LeSage, 2009).

In order to perform the calculation of the TFP, which is the result of the estimate of a Cobb-Douglas production function, we used the following proxies: gross sales revenue as product, total fixed assets as capital, and legal labor obligations as a proxy for labor, since this variable represents a fixed percentage of paid wages. All data were deflated by Brazil's general price index (IGP-DI) to deal with inflationary effects. See Table 2 for a definition of the variables.

Usually, starting from a Cobb-Douglas framework (Behera, 2017; Moralles & do Nascimento Rebelatto, 2016), the TFP estimation is performed using the semi-parametric procedure of Levinsohn and Petrin (2003) (LP), since the problem of the simultaneity associated to the choice of inputs makes parameters estimation by ordinary least squares (OLS) inconsistent. This procedure solves the problem of endogeneity by using an intermediate input demand function. Nevertheless, recent literature shows that the consolidated methods of Olley and Pakes (1996) (OP) and Levinsohn and Petrin (2003) (LP) while addressing the correlation between input levels and productivity shocks for the TFP computation, may yield estimates that suffer from functional dependence problems. Accordingly, Ackerberg, Kevin, and Garth (2015) (ACF) propose an estimator that inverts input demand functions that are conditional on the choice of the labor input, being more general than the technique proposed by Wooldridge (2009).

We choose the ACF correction in the OP method, given data availability. Specifically, financial statements in Brazil do not have a specific account that identifies materials as an intermediate input for the LP method, making it difficult and unreliable to identify such information. Yet, investment data is clear and trustworthy.

Regarding the regional FDI measure (a municipality-level variable), it is necessary to emphasize that there are no governmental statistics on the intensity of FDI at state and city levels. This fact virtually explains the nearly total absence of studies on the effects of FDI spillovers in Brazil, and perhaps in other developing economies. In fact, China has 51 studies related to the keywords "*FDI*", "*Spillovers*", and

"*China*" in the Scopus database, given that it has aggregate and disaggregate public FDI statistics. For Brazil, a similar search returns only one article, which does not employ regional FDI data. Thus, following the aforementioned literature, we construct a proxy for regional FDI presence based on export data from the Brazilian Integrated Foreign Trade System (SISCOMEX).

Based on the assumption that small enterprises are not able to induce significant spillovers of knowledge and productivity, the regional FDI measure is constructed adjusting the FDI regional share logic used in Ferragina and Mazzotta (2014), and Lin and Kwan (2016) that calculates the share of labor-related FDI in a region relative to total employment in that region. Similarly, the FDI variable was constructed by means of a relative measure of the FDI presence (number of exporting multinational companies) related to the total number of exporting companies in a region "*j*".

However, despite assessing the presence of multinational companies, this simple measure is not able to capture the impact of FDI in a region, since it does not capture the extent or the complexity of the activity performed by foreign companies. A proportionately small presence can generate a large added value, and consequently, induce transient spillovers through workers (positive knowledge spillovers from labor market turnovers and imitation or negative spillovers like multinationals thieving local talents) and market-related spillovers, such as market stealing, competition, and crowd-out effect (Lin & Kwan, 2016; Wu, Yuan, Wang, Cao, & Zhou, 2019). Accordingly, the developed FDI indicator was settled in order to consider the multinational company presence ratio weighted by their exported value range in that region. Therefore, we created six strata of weights for the exported values (in US dollars): up to 1 million; between 1 and 5 million; between 5 and 10 million; between 10 and 50 million; between 50 and 100 million; and over 100 million.

As a consequence, each company had as its weight the upper band value of the presented strata. However, since the last band (over 100 million) would be compromised, an exponential OLS functional approximation was applied to calculate the relative weight to the companies of the superior band. Each exporting company received one of the six specific weights (upper band export value), which were summed over *i* to result in the variable "*W*" on equation (1) which reflects the presence of FDI adjusted for the exports value of foreign companies in relation to the total exports of each region *j* and time *t*:

$$FDI_{jt} = \sum_{i=1}^{k} W_{ijt} \left(\frac{MNC_{jt}}{T_{jt}} \right) \quad \text{, for each region } j. \qquad (1)$$

where,

MNC is the number of exporting multinational companies in the region "*j"*;

T is the total number of exporting companies (domestic and foreign) in the region *j*;

W is the adjustment weight for each company *i*, and *k* is the total number of companies in each region.

Instead of simply summing the exported value of each company in a specific municipality and year to obtain a FDI measure, this specific weight (W_{ijt}) was necessary because the Brazilian government does not provide the exact values exported by the companies. However, it should be noted that we are not dealing with just a sample, but the information on exporting companies refers to the entire population of exporting companies in a specific region. Accordingly, the proposed export-related regional FDI indicator presented in equation (1) accounts both for the variety of foreign capital in a given municipality (i.e. the proportion of foreign companies in relation to the total amount), which may reflect the variety of techniques, procedures, and knowledge brought by multinational companies into an specific region, and the economic relevance of the foreign capital.

Finally, it is noteworthy that the exporter's database of the SISCOMEX system does not identify whether the origin of the company is national or international. Also, the Economática database does not specify the municipality in which the Brazilian company is located. This led to an extensive manual check of almost 60000 registers on the exporters' database for regional FDI calculation and the Brazilian companies database (for the calculation of the TFP) since the whole population of exporting companies of each one of the 101 municipalities had their origin (national or international) verified. This makes the database built for this investigation unique since it's the first initiative to calculate FDI at the municipal level in Brazil which resulted in a balanced panel with 970 observations, 194 companies for 5 years in 101 Brazilian municipalities.

As it will be presented later, the proposed FDI measure generated results consistent with the literature, indicating that the constructed proxy is capable of reflecting the intensity of regional FDI, and can be employed in other countries where there are no official FDI statistics.

In order to measure the firms' level absorptive capacity (*ABC*), we follow the widely employed form used by studies like Girma (2005), Ubeda and Pérez-Hernández (2017), Y. Zhang, Li, Li, and Zhou (2010), Ali, et al. (2016), and Jude (2016), which use the technological frontier distance (technology gap) as a proxy, as shown in equation (2), in order to relate the TFP of a company *i* to the Maximum TFP, as follows:

$$ABC_{it} = \frac{TFP_{it}}{\max(TFP)_{it}} \quad (2)$$

where TFP is the measurement of total factor productivity for each company *i* in the time period *t*, and max(TFP) is its maximum value.[1]

We also consider a set of controls, since firm characteristics may moderate FDI spillover effects. First, since we are dealing with service and manufacturing sectors, the study employs the Eurostat aggregation of the manufacturing industry according to their technological intensity based on NACE Rev. 2 at 3-digit level for compiling aggregates on manufacturing and services. For manufacturing, four control dummies were applied: High technology (HT), medium high-technology (MHT), medium low-technology (MLT), and low-technology (LT). However, since many of the companies listed in the sample belong to the service sector (57%), and given its large range of economic activities, we apply a stratification greater than the usually employed of just Knowledge-intensive services (KIS) and Less knowledge-intensive services (LKIS). Specifically, for Knowledge-intensive services (KIS) four control dummies were built: Knowledge-intensive market services, excluding high-tech and financial services (KIMS), High-tech knowledge-intensive services (HTKIS), Knowledge-intensive financial services (KIFS), Other knowledge-intensive services (OKIS). Lastly, for the Less knowledge-intensive services (LKIS), two control dummies were assembled: Less knowledge-intensive market services (LKIMS) and Other less knowledge-intensive services (OLKIS).

It is also interesting to establish some kind of control regarding the environment of market concentration in which a particular company is exposed. However, such information is not accounted for by the public Brazilian statistics agencies or trade associations, so that a proxy variable was constructed. Thus, based on a general database containing all the companies that were part of the B3 stock exchange, a market share indicator was constructed considering the net patrimony of a company "*i*" in relation to the sum of the patrimony of all the companies in a given sector. Obviously, this indicator does not accurately capture the market share of sectors, given that many companies outside are outside B3 database, especially sectors that have some large leading companies with the rest of the market pulverized in small competitors. However, most of the sample collected is composed of highly concentrated sectors or public concessions that generate regional monopolies such as road and rail transportation, water and sewage, electricity

[1] Indeed, the domestic enterprise ability to exploit knowledge will be higher if the technological gap with the foreign firms is small. This is true despite the growth theory states that facing a high technological gap implies a higher speed of convergence than for the technologically proximate ones.

generation and transmission, telecommunications; or other sectors whose economies of scale are relevant such as steel transformation and auto parts. As a consequence, even with the aforementioned limitation, the proxy is able to reasonably capture the market share of a given company, and was applied to construct a modified version of the Herfindahl-Hirschman index presented in (3), where S_i is the market share, and N is the number of companies operating in a specific sector:

$$HHI = \sum_{i=1}^{N} (S_i)^2 \tag{3}$$

Given that in some cases a company may have negative net patrimony (when the value of the obligations to third parties is higher than the value of the assets), this situation may lead to a distortion in the index, particularly when an entire sector has negative net patrimony. In order to accommodate this situation, these sectors were adjusted to the minimum HHI of the sample, since those sectors experiencing crises would be less able to establish entry barriers, and therefore, would be more susceptible to deconcentration or external competition. In any case, only 3.2% of the sample required such a procedure.

Firm age and intangible assets were also applied as firm-level controls, the latter being inserted in order to capture any productivity variation from investments in information technology, employee training, trademarks, and patents, or acquired copyrights. Finally, GDP per capita was employed as a regional control. Table 2 presents variable definitions and descriptive statistics.

Table 2 – Variable definition and descriptive statistics.

Variable	Definition	Source	mean	min	max	Sd
Gross Revenue (x1000 BRL)	Consolidated income	Economática Database	5.48E+06	7.09E+01	4.05E+08	2.75E+07
Capital (x1000 BRL)	Consolidated fixed assets property stock (plant and equipment)	Economática Database	4.68E+06	1.20E+00	6.99E+08	4.20E+07
Labor (x1000 BRL)	Consolidated spenditures on labor and other social securities	Economática Database	9.01E+04	2.73E+00	6.60E+06	4.11E+05
Intangible (x1000 BRL)	Consolidated spenditures on intangible asstes	Economática Database	1.60E+06	1.00E-05	1.27E+08	7.31E+06
Patrimony (x1000 BRL)	Consolidated net worth	Economática Database	4.42E+06	-6.92E+06	4.73E+08	3.21E+07
Investment (x1000 BRL)	Consolidated investment spenditures	Economática Database	3.55E+05	1.00E-05	2.21E+07	2.00E+06

Age	Company age	B3 website	5.59E+01	4.00E+00	1.52E+02	3.32E+01
HHI	Herfindahl-Hirschman index	B3 website	4.08E+03	7.17E+02	1.00E+04	3.21E+03
GDP pc (x1000 BRL)	Per capita gross domestic product	Brazilian Institute for Geography and Statistics	4.25E+01	9.79E+00	1.85E+02	2.89E+01
FDI	FDI constructed proxy following equation (1)	SISCOMEX Database	3.97E+02	1.00E-05	1.46E+03	4.66E+02

Note: All monetary variables are adjusted for inflation in thousands of Brazilian Reals.

3.2. Econometric Model and Estimation Strategy

In order to proxy for the productivity of the national industry, we employ the aforementioned concept of Total Factor Productivity (TFP). By means of first differences, we employ the TFP rate of growth. Accordingly, for the purpose of testing the presented hypotheses, we express the relationship between changes in TFP, FDI, and absorptive capacity in two equations, which were inspired and later adapted from the studies developed by Girma (2005), Huang, et al. (2012), and Ubeda and Pérez-Hernández (2017), as follows:

$$\begin{aligned} \Delta TFP_{it} &= \beta_0 + \beta_1' X_{it-1} + \beta_2' d_i Z_{it} + \beta_3' M_{jt} + \\ &\alpha_1' FDI_{ijt-1} I(FDI_{ijt} \geq \gamma_1) + \alpha_2' FDI_{ijt-1} I(FDI_{ijt} < \gamma_1) + a_i + \varepsilon_{it} \end{aligned} \tag{4}$$

$$\begin{aligned} \Delta TFP_{it} &= \beta_0 + \beta_1' X_{it-1} + \beta_2' d_i Z_{it} + \beta_3' M_{jt} + \\ &\alpha_1' FDI_{ijt-1} I(ABC_{it} \geq \gamma_2) + \alpha_2' FDI_{ijt-1} I(ABC_{it} < \gamma_2) + a_i + \varepsilon_{it} \end{aligned} \tag{5}$$

where

X: Firm-level controls (Intangible, Age, HHI);

Z: Firm-level controls (Company market share);

d: Firm-level controls (Matrix of dummy variables that control for the sector of *i*, with two digits NACE classification);

M: Regional level control (Municipality GDP per capita);

FDI: Foreign direct investment;

ABC: Absorptive capacity;

I(.): Indicator function;

a: Firm Time-Invariant Characteristics (Fixed Effects);

γ_i : Thresholds to be estimated;

ε *:* Stochastic disturbance;

Thus, for equation (4), FDI represents both the threshold and the regime-dependent variables. As for equation (5), the threshold variable is the FDI, while the ABC is the regime-dependent variable. Regarding the control variables, we also employed the weighting interaction of market-share of each individual company with the sectorial control dummies (according to the aforementioned NACE classification), in order to avoid size bias within the sectoral classification, as well as to avoid time-invariant controls. Therefore, the parameters γ_1 and γ_2 will allow concluding whether Brazilian firms present a threshold of FDI and absorptive capacity so that FDI productivity spillovers become positive.

We estimate a fixed-effect panel threshold model based on the method proposed by Hansen (2000), by fitting the fixed-effect panel threshold model given the threshold estimator, which requires balanced panel data (Q. Wang, 2015). In addition, the computations use robust estimates to heteroscedasticity and serial correlation.

As for the threshold estimation, which must be performed in combination with the slope parameters, $S_n[\beta(\alpha), \gamma(\alpha)]$ represents the sum of the squares of residuals (SSR) of equation (6), and such function can be minimized by ordinary least squares (OLS) with all possible values of α , in order to choose the one with the lowest SSR, as presented in (6).

$$\hat{\alpha} = \arg_{\alpha} \min S(\alpha) \qquad (6)$$

Therefore, Girma (2005) proposes the use of quantiles of the threshold variable to calculate the threshold values, as $\{1\%;\ 1,25\%;\ 1,50\%;\ \cdots\ ;98,75\%;99\%\}$, resulting in 393 quantiles. After computing the parameter, it is necessary to test the threshold effect, that is, if there are actually two regimes for the regime-dependent variable according to the threshold variable. This is done by testing the null hypothesis ($H_0 : \alpha_1 = \alpha_2$) using likelihood ratio test statistics and their bootstrapped *p*-values on 150 replications for each estimation.

4. RESULTS

Before estimating the threshold model specified in equations (4) and (5), it is necessary to test the robustness and validity of the control variables. For this, we developed three alternative specifications of a non-linear panel model, estimated by Feasible Generalized Least squares (FGLS) considering the first-order autocorrelation process of each specific company. The estimation results are presented in Table 3. A reasonable number of controls were statistically significant, and the global F-statistic strongly rejects the null hypothesis. Nonetheless, there was still a concern with the validity of the sectoral control variables (NACE classification) iterated with market share. Thus, a specific F-test was conducted with such variables, whose p <0.000, validating the subset of controls.

Table 3 – Non-threshold results for control validity

VARIABLES	(1)	(2)	(3)
Intangible$_{it-1}$	0.00530***	0.00487***	0.00581***
	(0.00116)	(0.00117)	(0.000990)
Age	-0.0534***	-0.0513***	-0.0537***
	(0.00989)	(0.0109)	(0.0109)
HHI	0.00386	-0.000373	-0.00303
	(0.00726)	(0.00743)	(0.00765)
HT*mktshare	-0.200***	-0.193***	-0.233***
	(0.0517)	(0.0523)	(0.0674)
MHT*mktshare	0.161***	0.157***	0.182***
	(0.0275)	(0.0270)	(0.0238)
MLT*mktshare	-0.00256	-0.00244	-0.00404
	(0.0143)	(0.0142)	(0.0139)
LT*mktshare	0.0462**	0.0512	0.0364*
	(0.0231)	(0.0317)	(0.0219)
KIMS*mktshare	0.394**	0.413**	0.465***
	(0.179)	(0.183)	(0.179)
HTKIS*mktshare	-0.808	-0.762	-0.799
	(0.757)	(0.757)	(0.802)
KIFS*mktshare	-0.0965	-0.0811	-0.141
	(0.180)	(0.176)	(0.235)
OKIS*mktshare	-0.200***	-0.198**	-0.244***
	(0.0742)	(0.0809)	(0.0609)
GDP per capita	0.0365***	0.0449***	0.0526***
	(0.0113)	(0.0136)	(0.0116)
FDI$_{it-1}$	-0.000920	-0.00137	0.000597
	(0.00137)	(0.00202)	(0.00129)
FDI squared $_{it-1}$		-3.26e-05	
		(0.000251)	
ABC $_{it-1}$	-0.826***	-0.811***	-0.994***
	(0.0525)	(0.0549)	(0.0497)
ABC squared $_{it-1}$			-0.291***
			(0.104)
Global F statistic	0.000	0.000	0.000
Observations	776	776	776
Number of companies	194	194	194

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Also, Table 3 draws attention to the negative value of the "Age” control variable. However, such a result is expected, since the Brazilian market has a considerable number of large companies that have shown rapid growth, especially in Business to Consumer (B2C) commerce, highway concessions, and electricity generation or distribution, the latter due to liberalization of such markets in the 1990s. Whereas some older more consolidated sectors have faced serious difficulties for various reasons.

Firms’ productivity may also be influenced positively by intangible assets, as found by Orlic, et al. (2018) on transition European economies. We find evidence that it may hold for Brazil since Table 3 presents highly significant and positive lagged intangible assets expenditures.

In fact, the results in Table 3 contrast to the outcomes in threshold models of equations (4) and (5) in terms of the statistical significance of controls. This may occur because the threshold model splits the sample in order to calculate the threshold parameter, which leads to some subsets low variability and consequent insignificance, especially for small samples, thus justifying the validation of controls through a non-threshold model. Additionally, the statistically insignificant values for the FDI parameters on Table 3 may be deceiving, despite the significance of the absorptive capacity variable, since this study postulates the existence of two different regimes that may differ in terms of parameter signal and significance, according to the regime variable in the presence of nonlinearity. Thus, the threshold model estimated results are presented in Table 4.

Table 4 presents four alternative specifications for the threshold model. Column (3) employs the one-year lagged FDI as the regime-dependent variable, as proposed by equation (4), in order to verify the effect on productivity variation for high and low FDI lagged values. Following equation (5), column (4) introduces ABC as the regime-dependent variable for the FDI, in order to verify the effect of lagged FDI on productivity variation for high and low ABC values. The specifications of columns (1) and (2) follow the logic of equations (4) and (5), although employing the non-lagged FDI.

Table 4 – FDI threshold model estimates

VARIABLES	(1) FDI regime-dependent	(2) ABC regime-dependent	(3) FDI regime-dependent	(4) ABC regime-dependent
Intangible $_{it-1}$	-0.00499	0.00838	-0.00502	0.00787
	(0.0198)	(0.0164)	(0.0195)	(0.0166)
Age	-0.707	-0.422	-0.716	-0.363
	(0.844)	(1.018)	(0.848)	(1.032)
HHI	-0.0266	-0.0794	-0.0239	-0.0776
	(0.119)	(0.0699)	(0.121)	(0.0700)
HT*mktshare	0.542**	0.201	0.543**	0.248
	(0.271)	(0.400)	(0.274)	(0.417)
MHT*mktshare	0.217	0.688***	0.214	0.690***
	(0.259)	(0.208)	(0.269)	(0.209)
MLT*mktshare	-0.0169*	-0.00538	-0.0100	-0.00683
	(0.00883)	(0.00981)	(0.00943)	(0.0102)
LT*mktshare	-0.423	-0.423	-0.345	-0.494
	(0.431)	(0.439)	(0.403)	(0.444)
KIMS*mktshare	-2.234***	0.604	-2.206**	0.631
	(0.845)	(0.530)	(0.848)	(0.534)
HTKIS*mktshare	8.138***	8.409**	8.166***	7.920**
	(2.778)	(3.796)	(2.764)	(3.771)
KIFS*mktshare	1.217**	-0.0310	1.133**	0.0673
	(0.468)	(0.493)	(0.461)	(0.499)
OKIS*mktshare	-0.466***	-0.703**	-0.439***	-0.660**
	(0.168)	(0.278)	(0.166)	(0.291)
ABC	4.088***		4.059***	
	(0.458)		(0.458)	
GDP PC	0.296	0.344	0.263	0.337
	(0.239)	(0.236)	(0.233)	(0.235)
$FDI_{ijt} < \gamma_1$ / $FDI_{ijt-1} < \gamma_1$	0.0332*		0.0274	
	(0.0185)		(0.0176)	
$FDI_{ijt} \geq \gamma_1$ / $FDI_{ijt-1} \geq \gamma_1$	-0.205*		-0.160**	
	(0.108)		(0.0687)	
$ABC_{ijt} < \gamma_2$		-0.0202		0.00126
		(0.0194)		(0.0395)
$ABC_{ijt} \geq \gamma_2$		0.0924***		0.110**
		(0.0246)		(0.0452)
Constant	2.914	0.832	2.822	0.553
	(3.099)	(3.560)	(3.121)	(3.607)
Observations	776	776	776	776
R-squared	0.441	0.109	0.439	0.101
Number of companies	194	194	194	194
Threshold Value	2.330	0.080	2.251	0.080
Threshold Test p-value	0.067	0.000	0.167	0.000

*** p<0.01, ** p<0.05, * p<0.1 ; Robust standard errors in parentheses

Regarding column (3) of Table 4, the model indicates that for regional FDI values below the estimated threshold, the indigenous companies do not have their productivity affected. Though, for FDI values above the threshold, local firms face negative spillovers.

Attention is drawn to the estimated threshold value of 2.251 for (3) and 2.330 for (1), the models with FDI as both threshold and regime-dependent variable of Table 4, which is relatively low. The number of observations above the threshold is respectively 840 and 836 in a sample of 970, implying that almost 86% of the companies in the sample would suffer from negative spillovers. Thus, we observe that the threshold of regional FDI yields negative productivity spillovers for native companies.

Here, we notice the p-value of 0.167 for the threshold test in order to verify the existence of two distinct regimes (below panel of Table 4), which is not able to reject the null hypothesis at 10% significance. This fact is probably due to the small sample size employed in the study since in the column (1) of Table 4 (model with non-lagged values of FDI) the test is able to reject the null hypothesis. Despite this, we notice that the results of the lagged FDI model (3) and the contemporaneous model (1) are similar, except for the positive parameter and statistically significant values below the threshold in the model (1).

As stated by Lin and Kwan (2016) on the Chinese case, negative FDI spillovers can arise along the spatial dimension, possibly due to market stealing or labor turnover. However, our results agree with Kim (2015) who arguments that the firms' absorptive capacity has the ability to mitigate the negative effects of FDI.

Thus, column (4) of Table 4 stresses the role of ABC, considering that when the model is estimated with the threshold variable being the FDI and ABC as the regime-dependent variable, it is verified that for ABC values below the threshold, native companies do not have their productivity affected; however, national companies with ABC above the threshold are able to acquire positive productivity spillovers stemming from the presence of foreign companies in their region.

The results confirm the findings of other studies in Latin American developing economies such as Mexico, Chile, and Argentina (Armas & Rodríguez, 2017; Laborda Castillo, et al., 2014; Marin & Bell, 2006), especially when foreign-owned and domestic firms location are geographically concentrated (Jordaan, 2005), which demonstrate that absorptive capacity is the major moderator for capturing productive positive spillovers from FDI. Adversely, the foreign firms established after 1973 had no impact on Uruguayan firms productivity, although they may pick up some export-related knowledge from outward-oriented foreign MNCs (Kokko, Zejan, & Tansini, 2001).

In fact, when searching for literature on productivity spillovers associated with the presence of FDI in Latin American economies, few studies were found, probably due to the lack of data. Thus, of the few studies listed in the paragraph above, most employed outdated data from the 1990s or early 2000s, and some of them address productivity-related topics such as export intensity and structural change in Latin American economies (Duran & Ryan, 2014; Mühlen & Escobar, 2019).

However, it is still necessary to evaluate the magnitude of the absorptive capacity estimated threshold value in the dataset of Brazilian companies, and thereafter, the sectoral proportion capable of obtaining positive spillovers, i.e., firm-level absorptive capacity above the threshold. Such an analysis is presented in Table 5.

Table 5 - Number of companies above the ABC threshold by NACE classification.

NACE	Total number of observations	Observations with ABC > Threshold	Relative sectoral share	Absolute total share
HT	10	4	40%	1%
MHT	130	28	22%	9%
MLT	90	28	31%	9%
LT	180	40	22%	13%
KIMS	165	60	36%	19%
HTKIS	20	10	50%	3%
KIFS	15	6	40%	2%
OKIS	70	17	24%	6%
LKIMS	290	116	40%	38%
Total	**970**	**309**	**-**	**100%**

Table 5 shows that the Brazilian sectors with the highest proportion of companies able to capture positive productivity spillovers (ABC> $\gamma 2$) from the regional FDI were High technology (HT), High-tech knowledge-intensive services (HTKIS), Knowledge-intensive financial services (KIFS) and Less knowledge-intensive market services (LKIMS). Deepening the sectorial disaggregation, Brazilian businesses that would possibly be successful on harvest positive spillovers were “Auxiliary road transport activities”, “Generation, transmission and distribution of electricity”, sectors that were gradually privatized in the mid-1990s. Accordingly, we can state that in the Brazilian case there are some specific segments which are more able to capture such effects.

4.1 Robustness analysis

A key concern that may arise is that the FDI variable may be endogenous, although the adoption of one-year lag structure for the FDI should lessen the issue. Thus, in order to verify the statistical consistency of the results, a fixed effects LIML (Limited Information Maximum Likelihood) instrumental variables model was estimated (Mark, 2005). We postulate that FDI is by itself an element that favors the diversification of economic activities, as well as the presence of foreign companies induces the national companies of the region to supply them, with more complex products, as verified by Javorcik, Lo Turco, and Maggioni (2018) in a Turkish framework. Thus, in order to select the instruments to be used, a pair-wise correlation matrix of all the explanatory variables as well as the potential instruments (Table 6) served as the basis for the selection of FDI instruments. Specifically, seven variables were proposed to appear as FDI instruments: “Total employment”, “Number of companies”, “Number of exporting companies”, “Ocupation diversity”, “Effective occupation diversity”, “Activity diversity”, and “Effective activity diversity”. Here, the variables that contain the term "effective" are built as the antilog of Shannon's entropy available on DataViva[2] in order to adjust the absolute variable by the share that each unit represents.

The raw variable "Activity diversity" (diversity of economic activities) and one year lagged value of FDI variable were selected as instruments since the first one is highly correlated with FDI (0.6759*), but uncorrelated with the dependent variable (0.0211). Furthermore, the other proposed instruments were dropped since all of them were also strongly correlated with "Activity diversity". Thus, for the FDI fixed effects instrumental variables model, Hansen J statistic for over-identification test of all instruments p-value was 0.560, indicating that instruments may be valid. Also, the C-statistic (inference of two Sargan-Hansen statistics) points out that FDI is indeed exogenous with a p-value of 0.443.

[2] DataViva website was developed by the State government of Minas Gerais (Brazil), in partnership with researchers from the MIT Media Lab, integrating a large set of databases through Big Data technology.

Table 6 - Pair-wise Correlation Matrix for instruments selection

	Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1)	dTFP	1																					
(2)	Intangible	-0.0001	1																				
(3)	Age	-0.0416	-0.1446*	1																			
(4)	HHI	-0.0192	-0.2073*	0.2693*	1																		
(5)	HT*mktshare	-0.01	0.0431	-0.0488	0.1161*	1																	
(6)	MHT*mktshare	0.0691	-0.0968*	0.0575	0.1128*	-0.0258	1																
(7)	MLT*mktshare	-0.0052	-0.0224	0.0389	-0.0029	-0.0104	-0.0271	1															
(8)	LT*mktshare	-0.0043	0.008	0.2084*	0.2420*	-0.0289	-0.0757*	-0.0305	1														
(9)	KIMS*mktshare	0.0541	0.0389	0.0163	0.1471*	-0.0128	-0.0336	-0.0135	-0.0377	1													
(10)	HTKIS*mktshare	-0.0152	0.0890*	-0.0929*	-0.0116	-0.0102	-0.0268	-0.0108	-0.03	-0.0133	1												
(11)	KIFS*mktshare	0.0097	0.0638	0.0073	0.1003*	-0.0088	-0.0232	-0.0093	-0.026	-0.0115	-0.0092	1											
(12)	OKIS*mktshare	-0.01	0.0644 *	-0.0662*	0.0932*	-0.0158	-0.0415	-0.0167	-0.0465	-0.0206	-0.0164	-0.0142	1										
(13)	ABC	0.2553	0.2607*	-0.0676*	-0.0464	-0.0073	-0.1100*	0.0091	0.0316	0.0136	0.0323	-0.0098	-0.0371	1									
(14)	GDP PC	-0.005	0.1137*	-0.1650*	0.0353	0.0983	* 0.0477	-0.0414	-0.0764*	0.1595*	0.0184	0.0113	0.1448*	0.0273	1								
(15)	FDI	0.0081	0.0169	0.0832*	0.1118*	0.0514	0.051	-0.1186*	0.0147	0.0841*	0.0696*	0.0608	0.0539	-0.002	0.3675*	1							
(16)	Total employment	0.0518	0.0213	-0.0002	0.0573	-0.0067	-0.0747*	-0.0341	0.0072	0.1082*	0.1334*	0.1185*	0.0287	-0.0185	0.1465*	0.5457*	1						
(17)	Number of firms	0.0542	-0.0017	0.0413	0.0427	-0.0069	-0.0803*	-0.0296	0.0043	0.0823*	0.1338*	0.1185*	0.0089	-0.0339	0.0669*	0.5203*	0.9865*	1					
(18)	Number of exporting firms	0.037	0.0132	0.0077	0.0861*	0.0438	0.0107	-0.0326	-0.0176	0.1453*	0.1224*	0.1111*	0.0681*	-0.0184	0.4135*	0.6906*	0.8728*	0.8542*	1				
(19)	Ocupation diversity	0.0211	-0.0207	0.0498	0.0161	0.0348	0.0234	-0.0935*	-0.0207	0.0823*	0.0745*	0.0634*	0.003	-0.0005	0.3830*	0.6759*	0.5925*	0.6164*	0.7628*	1			
(20)	Effective ocupation diversity	0.0368	-0.0205	0.0875*	0.0553	0.0289	-0.0554	-0.0528	-0.0063	0.0772*	0.0963*	0.0851*	0.0219	-0.0331	0.1961*	0.6145*	0.9335*	0.9407*	0.8827*	0.7654*	1		
(21)	Activity diversity	0.0211	-0.0207	0.0498	0.0161	0.0348	0.0234	-0.0935*	-0.0207	0.0823*	0.0745*	0.0634*	0.003	-0.0005	0.3830*	0.6759*	0.5925*	0.6164*	0.7628*	1.0000*	0.7654*	1	
(22)	Effective activity diversity	0.0364	0.0018	0.0516	0.0254	0.0105	-0.0555	-0.0528	-0.0132	0.0753*	0.0887*	0.0777*	0.0298	-0.0206	0.2235*	0.6289*	0.9297*	0.9220*	0.8625*	0.7412*	0.9811*	0.7412*	1

* p<0.05

Previously, the descriptive statistics in Table 2 reveals the presence of extreme values in firm-level variables. Thus, in order to verify whether outlier firms or periods in time are influencing the results, a new estimation of the model was conducted without the 5% upper and 5% lower values for each firm-level variable.

Specifically, our dataset was sorted and all extreme values were withdrawn. Subsequently, the panel was reconfigured only with the companies that maintained the entire period from 2010 to 2014 in order to keep the balanced patter, resulting in a global sample size reduction from 970 to 650 observations. Table 7 reproduces the same estimations as in Table 4 with this new dataset.

Table 7 – Sample extreme-value sensitivity analysis

VARIABLES	(1) FDI regime-dependent	(2) ABC regime-dependent	(3) FDI regime-dependent	(4) ABC regime-dependent
Intangible$_{it-1}$	-0.00917	-0.0191	-0.00922	-0.0182
	(0.0168)	(0.0215)	(0.0159)	(0.0206)
Age	-0.357	-0.544	-0.307	-0.301
	(0.560)	(0.546)	(0.532)	(0.511)
HHI	-0.0952	-0.0568	-0.0722	-0.0567
	(0.0987)	(0.0721)	(0.0866)	(0.0672)
HT*mktshare	0.867***	1.472***	0.837***	1.447***
	(0.184)	(0.134)	(0.170)	(0.128)
MHT*mktshare	-1.330	-1.762	-1.190	-1.511
	(1.303)	(1.241)	(1.256)	(1.375)
MLT*mktshare	-0.0167***	-0.0270***	-0.0168***	-0.0275***
	(0.00464)	(0.00634)	(0.00466)	(0.00634)
LT*mktshare	0.00223	-0.513	0.0458	-0.475
	(0.253)	(0.390)	(0.264)	(0.379)
KIMS*mktshare	0.914	1.383**	0.859	1.461***
	(1.040)	(0.583)	(1.003)	(0.547)
HTKIS*mktshare	34.26***	18.59	29.35**	23.56**
	(12.54)	(12.04)	(11.84)	(11.80)
KIFS*mktshare	0.880**	-0.421	0.776*	-0.437
	(0.429)	(0.416)	(0.399)	(0.404)
OKIS*mktshare	-0.260**	0.168**	-0.234**	0.170**
	(0.108)	(0.0838)	(0.105)	(0.0837)
ABC	3.055***		3.054***	
	(0.319)		(0.318)	
GDP PC	0.0616	0.155	0.0365	0.110
	(0.154)	(0.146)	(0.159)	(0.138)
$FDI_{ijt} < \gamma_1$ / $FDI_{ijt-1} < \gamma_1$	0.0156		-0.000986	
	(0.0153)		(0.00889)	
$FDI_{ijt} \geq \gamma_1$ / $FDI_{ijt-1} \geq \gamma_1$	-0.0593		-0.0555**	
	(0.0420)		(0.0213)	
$ABC_{ijt} < \gamma_2$		-0.0587**		-0.0608**
		(0.0226)		(0.0256)
$ABC_{ijt} \geq \gamma_2$		0.0375**		0.0299**
		(0.0168)		(0.0151)
Constant	2.192	2.231	1.775	1.453
	(2.049)	(1.898)	(1.901)	(1.798)
Observations	520	520	520	520
R-squared	0.326	0.139	0.329	0.121
Number of companies	130	130	130	130
Threshold Value	3.2304	-0.0704	5.7395	-0.0698
Threshold Test p-value	0.4933	0.000	0.3467	0.000

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 estimations in columns (2) and (4), both with ABC as the statistically significant regime-dependent variable show that, for low values of ABC, FDI had a negative and significant impact, while for high ABC values, FDI yields positive and significant productivity spillovers. The only difference with respect to the estimations (2) and (4) from Table 4 is the significant low values regime for ABC, and the magnitude of the spillover estimated parameter for the high ABC regime, which was approximately one-third of the one obtained on the full sample results presented in Table 4. Apart from this, similar results are obtained, so that we can conclude that results are not affected by outliers.

As the first study for Brazil, our results are broader, comprehending also firms from different manufacturing sectors and services, while implicitly evaluating if local enterprises in a regional environment intensive on foreign capital presence are more likely to benefit from productivity spillovers. The obtained results corroborate the notion that domestic firms are indeed heterogeneous when accounting the collected benefits from FDI, though domestic firms with high absorptive capacity are more likely to benefit from FDI, while competition-related negative spillovers appear to be absorbed by local firms with high technological capacities (Hamida, 2013; Xu & Sheng, 2012).

5. CONCLUSIONS

This study adds to the existing literature by deepening the comprehension of FDI productivity spillover effects on developing economies (especially the under-studied region of Latin-American) and the thresholds of absorptive capacity in order to analyze to what extent and in which cases Brazilian companies benefit from productivity spillovers from multinational presence.

The absence of official regional FDI statistics makes the database built for this investigation unique since it is the first initiative to calculate FDI at the municipal level in Brazil. Thus, the proposed FDI measure based on exports database yields literature consistent results, indicating that the constructed proxy is capable of reflecting the intensity of regional FDI, and can be employed in other countries where there are no official FDI statistics.

The results showed that when FDI is set as the threshold and regime-dependent variable only, Brazilian firms may suffer from negative productivity spillovers. However, when evaluating FDI as the threshold variable but with the ABC as regime-dependent variable, local firms collect positive spillovers in the presence of a low technological gap. These results demonstrate that the nonlinearity of the process can lead to misleading results, reinforcing the findings of Demena and van Bergeijk (2017), who suggest that the model specification is extremely relevant for the signal and significance of the FDI impacts, and therefore for understanding the phenomena in developing economies.

Additionally, the threshold model appears to be robust to assess threshold effects in developing economies by capturing different regimes, something common in such realities, where advanced sectors inhabit together with relatively archaic activities, and there is a tendency of public intervention with the aim of creating market reserve for some sectors, generating distortions in the absorptive capacity of these in relation to their counterparts in developed economies.

In terms of policy implications, results suggest that FDI attraction policies should incentivize the establishment of FDI capital in high absorptive capacity enterprises, or at regional clusters that concentrate companies from High technology (HT), High-tech knowledge-intensive services (HTKIS), Knowledge-intensive financial services (KIFS) and Less knowledge-intensive market services (LKIMS), since a small technological gap fosters productivity spillovers. Thus, as stated by (Piperopoulos, Wu, & Wang, 2018) and other recent studies, the innovation-enhancing effect for local companies depends not entirely on FDI, but also on the geographic location choices, as FDI attraction seems to be an effective way to overcome underdeveloped home institutional environments.

In this context, with a trade agreement between Mercosur (Southern Common Market) and the European Union (EU) signed in June 2019, there is the expectation that European investors will have greater incentive to choose Brazil. In fact, predictions made by the Brazilian government indicate an investment increase of US$ 113 billion over 15 years, as the inward FDI between the EU and Mexico tripled one decade after signing a trade agreement (Rennan Setti, 2019). Thus, opening the Brazilian domestic market and creating a healthy institutional environment for FDI would facilitate technology improvement of domestic firms. At the same time, some general fiscal incentives (since Brazil has a complex taxation system) to foreign companies to stablish joint ventures with domestic firms may facilitate knowledge transfer and, accordingly with the results in this paper, subsequent productivity spillovers.

Despite our results are in agreement with previous literature, the study presents some limitations that are worth noting. First, the sample size is relatively small due to the difficulty of finding reliable information for Brazilian firms to allow a robust productivity computation. Despite it, we believe that the caution in its construction may yield robust results. This same difficulty caused the sample to contain only large companies (in any case, the net profit of the firms in the sample represented approximately 6% of the

Brazilian GDP in 2014). Consequently, we are cautious and stress that we cannot generalize the results obtained in the present study to the bulk of the Brazilian firms, and especially not in the case of small and medium-sized companies. As a pioneering work in the case of Brazil, the results would provide a first view of the effects of FDI in large firms. In the future, new analyses should be done with larger samples that also consider small and medium enterprises.

As one of the first evidence from Brazil (and one of the few in Latin America), much still needs to be done for future studies. Although reasonably studied in several countries, the main agenda for future studies in Brazil and other Latin American economies lies in the evaluation of horizontal and vertical FDI productivity spillovers, since empirical results indicate that horizontal linkages tend to decrease the productivity of local firms, although vertical linkages exert positive spillovers on indigenous firm's productivity. Such knowledge is of utmost importance for the planning of the FDI attraction in order to avoid negative spillovers.

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