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The Environmental Cost of Attracting FDI: An Empirical Investigation in Brazil

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Abstract: Many emerging economies seek to increase their Foreign Direct Investment (FDI) inflows to achieve some promised benefits, such as economic growth and advanced technologies. Nevertheless, FDI does not represent a random investment decision, and international literature demonstrates that foreign investors are mostly interested in fast-growing regions. Therefore, this study uses traditional panel data econometrics coupled with Data Envelopment Analysis (DEA) to investigate the environmental impact in regions with great potential to attract foreign investments (e.g., more advanced regions with growing infrastructure), therefore analyzing the environmental cost of attracting FDI. Additionally, this study employs regional data from the 'Atlas of FDI in the State of São Paulo' to investigate the environmental effects of FDI in the periphery, where attractiveness levels are low. The results indicate that regions with higher attractiveness levels prepare a pollutant development strategy and that FDI in less-developed regions is harmful to the environment. The results point to new perspectives on the FDI–environment debate and suggest that attracting FDI is environmentally costly. Also, FDI is heterogeneous, with its presence in peripheral areas being harmful to the environment. To conclude, we discuss these results and present an agenda for future research.

Keywords: environment; CO_2; Foreign Direct Investment (FDI); econometrics; Data Envelopment Analysis (DEA); Brazil; Latin America

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1. Introduction

According to international business literature, Foreign Direct Investment (FDI) is recognized by many scholars as a valuable tool to boost development [1–3]. Accordingly, many countries (particularly in emerging regions) aim to increase their incoming FDI stock. Historical data show that many fast-growing countries in Latin America (e.g., Brazil, Chile, Colombia, Peru, Panama) presented a growing incoming FDI stock in more recent years [4]. From a regional perspective, another interesting example is the State of São Paulo, the richest and most developed region in Brazil, which hosts approximately 40% of all FDI in the country [5]. Potentially, these regions use foreign investments, among other tools, to advance their developmental process.

Here, it is important to note that the debate on the effects of FDI on the host presents no consensus [3,6], and some of the literature argues that FDI could be harmful to the host's development [7–9]. Still, considering the promised benefits of FDI (e.g., economic growth) and some positive empirical findings, policymakers are interested in understanding the FDI attraction process, as well as the foreign investors' location choices. In reality, FDI does not represent random investment decisions [10,11]. Although there are still discussions about the location choice of foreign investments, aspects such as infrastructure, market size, and industrialization, among others, are known to increase the inflow of foreign investments [12–14]. However, fast-growing regions may also display an environmentally costly development strategy [15]. As such, although previous evidence shows that FDI may bring environmental benefits (e.g., cleaner technologies, higher productivity, and green products) [16–18], FDI is arguably investing in polluted regions. In other words, to attract FDI, regions could look into boosting industrialization, services, and creating infrastructure to accelerate their growth process, which will result in greater environmental impacts.

Even so, the current international literature and its empirical studies are either interested in understanding how foreign investors choose their new investments' locations or in exploring the direct impacts of FDI. Accordingly, the literature presents interesting findings on the location choices of Multinational Companies (MNCs) [10,13], as well as on the effects of FDI on employment, economic growth, and the host's environment [1,19,20]. Yet to our knowledge, there is a gap in the literature concerning the level of 'FDI attractiveness' (i.e., the potential to attract FDI) and its effects on the environment. This is particularly worrisome for emerging economies such as Brazil, as FDI-related studies are limited [21]. To sum up, FDI can be beneficial, but if foreign investors are mainly attracted to polluted regions, the possible environmental benefits of FDI may be offset by these regions' accelerated development. Therefore, this study aims to investigate whether higher attractiveness levels indeed increase CO_2 levels.

This absence of studies linking attractiveness (and the potential to attract new foreign investments) and environmental impacts may be the result of a current lack of regional FDI data in Latin America [11]. Indeed, an analysis of FDI attractiveness will arguably demand that regional-level data and heterogeneity be considered, which is limited in country-level studies. To tackle this issue, this study will use a unique and new FDI dataset and mix both parametric and nonparametric techniques to investigate FDI attraction in Brazil, along with its environmental impacts. This novel dataset contains information on FDI in all municipalities (i.e., cities) of the State of São Paulo, Brazil, and its use will facilitate the development of a more in-depth analysis of FDI.

Particularly, this study's goals regarding the FDI-regional attractiveness nexus are twofold. Initially, this study will revisit the issue of the determinants of FDI to define which regional characteristics are significantly influencing the FDI agglomeration (i.e., intensity) in the municipalities of the State of São Paulo.

Second, with these results, the Data Envelopment Analysis (DEA) technique will be used to create two distinct composite indexes regarding the attraction of FDI. First, an 'FDI attractiveness' index will be calculated for each municipality and each year. As previously commented, we expect some of these regions' features (e.g., richness, productivity, infrastructure) to influence the location of FDI, while also affecting the environment. With this index, this study will then evaluate the environmental impact of regions with the increasing potential to attract FDI. The creation of a composite index of FDI attractiveness provides a different perspective of analysis, which the simple use of isolated variables cannot provide. With the composite index, we can verify whether the attractiveness of FDI, seen in aggregate, affects the environment.

Third, we advance this discussion by investigating the environmental effects of FDI in less-developed regions. As commented earlier, many scholars consider FDI as a driver of development for the host. However, FDI is not free of criticism from international literature. Another part of this debate argues that FDI could be particularly interested in regions with lower attractiveness levels (i.e., peripheral areas with lower development levels) to take advantage of natural resources, a cheaper workforce, and tax incentives [7,8,22,23]. As a result, some of the literature claims that FDI can be detrimental to the host's environment, and some empirical literature also supports this claim [24–26].

Considering this perspective, the employed FDI dataset (see Section 2 for more details) presents an interesting discovery. As shown in Figure 1, the MNCs coming to Brazil are spreading out to peripheral regions in the State of São Paulo.

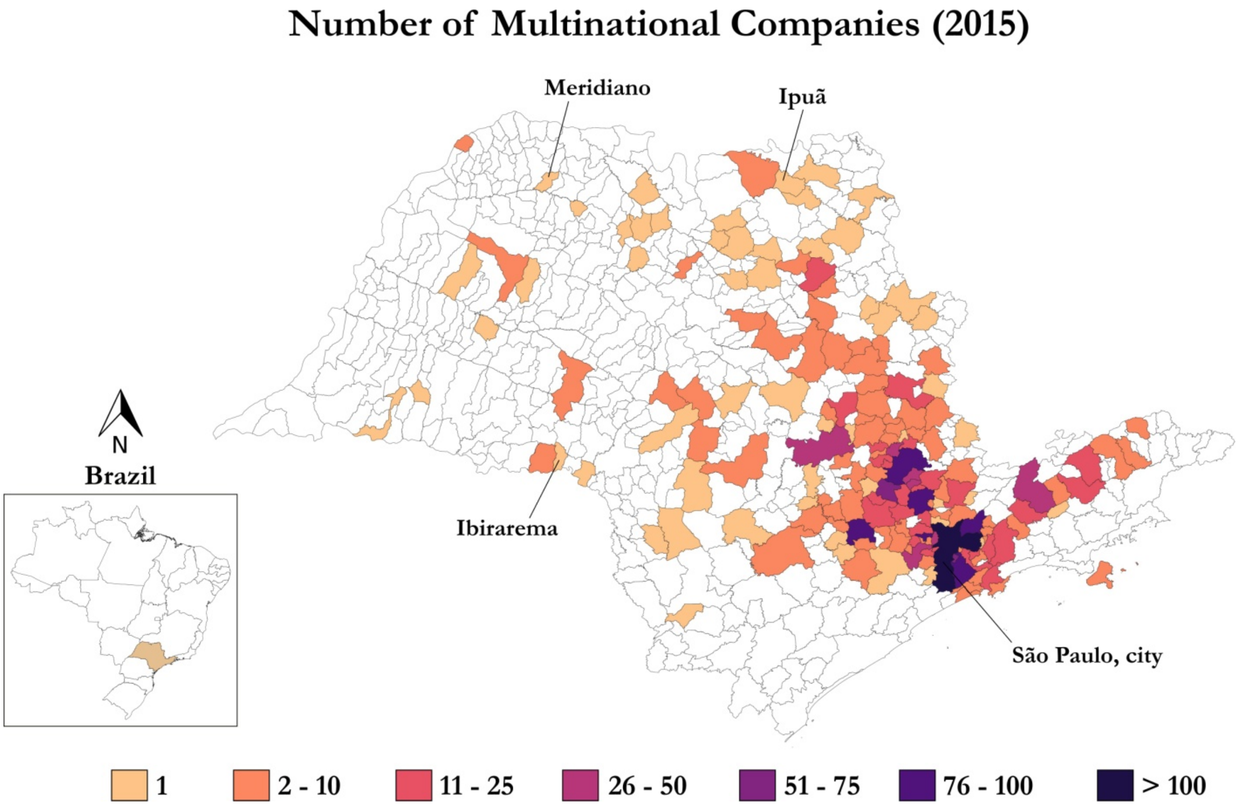

Figure 1. Number of Multinational Companies (MNCs) in each municipality in the State of São Paulo for the year 2015 (data from the 'Atlas of FDI in the State of São Paulo'—see Section 2).

Although the region close to the city of São Paulo still hosts the majority of foreign investments, smaller and less-developed regions are also hosting MNCs. These regions present lower levels of development, richness, and infrastructure, among other possible drivers of FDI. In many cases, although only a few MNCs operate in a specific municipality, they are of great importance for the regions' economies. To exemplify, the municipalities of Meridiano (approximately 3000 inhabitants), Ibirarema (approximately 7000 inhabitants), and Ipuã (approximately 16,000 inhabitants) all host one MNC each, despite presenting relatively less-developed characteristics. Arguably, the economic impact of these companies is significant for these developing regions.

Yet, these MNCs do not operate in sophisticated sectors and represent investments in farming and other agribusiness-related activities (e.g., producing fuel from sugarcane). In other words, these regions present a less-developed business environment and industrial network but could still be able to offer cheap labor and natural resources for MNCs. Thus, it is important to evaluate the impact of FDI in peripheral regions on the environment, as the results may differ from previous and more generalized FDI studies. Here, we argue that the environmental cost of attracting FDI to lagging regions could be significant.

Appropriately, we expand the attractiveness-environment discussion by creating a Low-Attractiveness-High-Intensity index, and by including this index in the environmental model. Both indexes presented in this paper (and further discussed in the next section) will expand the discussion of FDI in Brazil, as well as influence future developmental policies, particularly concerning less-developed regions. Moreover, the presented approach fills a gap in the literature by using more micro-level data and by considering the possible heterogeneous effects of hosting FDI in the periphery.

The remainder of this paper is organized as follows: Section 2 presents the data and the parametric and nonparametric techniques employed in this study; Section 3 presents the results and discusses their implications; Section 4 concludes the presented discussion and introduces an agenda for future scholars.

2. Data and Method

To facilitate the reader's experience, this section is divided into four topics to present an orderly description of all the steps involved in this research. In short, we employ data regarding the municipalities in the State of São Paulo, Brazil, for the 2010–2016 period. Details on variables and data sources are presented in Appendix A, and the descriptive statistics are presented in Appendix B. Also, the State of São Paulo presents 645 municipalities but some regions were excluded due to a lack of regional data in both the FDI and environmental models presented in the remainder of this section.

2.1. The FDI Model

We start our empirical investigation by verifying which variables should be included in the DEA model regarding FDI attractiveness (see Section 2.2). To define which regional variables (e.g., infrastructure, market size) influence FDI concentration in specific regions in the State of São Paulo, we use FDI as the dependent variable. Accordingly, it is important to choose a measure for regional FDI. Figure 1 was built using the number of MNCs for each municipality, as it is an accessible way to visualize the distribution of FDI in the region. However, the number of MNCs is not an appropriate measure for this study, as it does not represent the relative importance of FDI for a given region's economy. Moreover, this measure would only demonstrate that São Paulo city still holds the majority of MNCs in the sample.

To deal with this issue, this study uses a measure for the 'intensity of FDI' for each municipality. Here, we use the 'Atlas of FDI in the State of São Paulo', a manually built unique dataset using information from the Brazilian Integrated System of Foreign Trade (SISCOMEX). As a result, we employ an export-related proxy for FDI in Brazil, as utilized by Moralles and Moreno [21]. In sum, SISCOMEX presented a list containing over 20,000 export companies operating in the State of São Paulo, and a research team manually verified the origins of these companies (i.e., domestic or foreign). With this, this Atlas presents information on all exporting MNCs' origins, size (i.e., export band value), and address.

Following previous regional studies [19,21], the intensity of FDI (*IFDI*) can be calculated as:

$$IFDI_{jt} = W_{jt} \times \left(\frac{MNC_{jt}}{TC_{jt}} \right) \tag{1}$$

and,

$$W_{jt} = \frac{SFE_{jt}}{STE_{jt}} \tag{2}$$

where W is the adjustment weight regarding exports from foreign companies in region j at time t, MNC is the number of MNCs, TC is the total number of export companies (national and foreign companies), SFE is the sum of foreign exports, and STE is the sum of all exports (regarding national and foreign companies). Similar to Moralles and Moreno [21], we used each company's export band value to calculate SFE and STE.

This FDI measure varies between 0 and 1. *IFDI* is equal to 0 in the absence of foreign companies and is equal to 1 when all exports are dependent upon foreign companies. As such, this measure demonstrates how important FDI is for a given region (i.e., municipality), which is particularly useful for this study's goals. In other words, this measure facilitates an understanding of the concentration and growth of FDI in a region's economy through time, and will not overestimate large cities' indexes (e.g., São Paulo city).

It is important to note that this dataset only includes export companies, yet this limitation does not diminish our findings. Scholars have commented that MNCs use Brazil as an base for export to other Mercosul (*Mercado Comum do Sul*) countries [19,27], which justifies the use of this list of export companies to study FDI in Brazil. Also, the data show that many Latin American countries receive a large porting of their imports from Brazil, such as Argentina (20%) and Paraguay (23%), including a variety of products (e.g., cars, chemical products, metals, polymers, produce) [28]. As a result, the employed dataset arguably presents a unique opportunity to study regional FDI-related issues.

Following this, we revisited previous studies [12,14,29–31] to identify possible drivers of FDI to be tested econometrically. Namely, we included each municipality's population density (*DEN*), GDP per capita (*GDPPC*), industry share of GDP (*IND*), service's share of GDP (*SERV*), education level (*EDU*), productivity (*PROD*), and infrastructure, which was represented by the construction (*CONSTR*) and transport (*TRANSP*) sectors. All explanatory variables were employed in their natural log form. Again, details about the variables are presented in Appendix A. The model can be expressed as:

$$IFDI_{jt} = \beta_0 + \beta_1 \mathbf{X}'_{j,t-1} + \alpha_j + e_{jt} \tag{3}$$

where β_0 is the intercept, β_1 represents the parameters to be estimated, $\mathbf{X'}$ is the set of explanatory variables included in this model, α_j is the regional fixed-effect, and e is the error term. It should be noted that all explanatory variables were lagged to ensure theoretical consistency.

We first verified if collinearity was an issue using the Variance Inflammation Factor (VIF) to estimate such a model. Furthermore, we used the Wooldridge test for autocorrelation [32], the modified Wald test for heteroscedasticity [33], and the Pesaran test for cross-sectional dependence [34]. The results suggest that all these non-spherical disturbances should be treated. Thus, we employed the fixed-effects Driscoll–Kraay (DK) estimator, as used in previous regional studies [19,35,36]. The results, which will be displayed in Section 3, will be used to build an 'FDI attractiveness' index, as explained in the next section.

2.2. The FDI Attractiveness Index (FAI)

The first index built in this study is called the "FDI Attractiveness Index" (*FAI*). The *FAI* is a composite index (CI) in which the main goal is to quantify the municipalities' potential to attract foreign investments or FDI. It is noteworthy that this potential is defined by the municipal characteristics that were considered significant determinants of FDI, according to the results of the regression carried out in Equation (3) (see Table 1). With the *FAI*, it will be possible to verify how much the most attractive characteristics of foreign capital can penalize the environment.

In the construction of this first index, the Benefit of Doubt (BoD) method was employed. The BoD was presented in Cherchye et al. [37] and detailed and expanded by Mariano et al. [38]. In short, the traditional BoD method is derived from the input-oriented CCR model of Data Envelopment Analysis (DEA) [39]. In BoD, however, a single constant input equal to 1 is adopted for all units, which makes the DEA result a CI and not an efficiency index.

Using the BoD method, each compared municipality will assign the weights that are most advantageous to them for the aggregated indicators in the index. This approach makes it possible to build an indicator in which the unit's strengths are taken more into account and the weaknesses are taken less into account. This is an interesting and nonarbitrary way of assigning weights to an FDI attractiveness index, in which there is no theoretical prioritization among the indicators to be aggregated.

Each municipality usually specializes in a specific set of characteristics to attract FDI (which can be considered heterogeneous investment decisions), so it is coherent that the *FAI* allows municipalities to assign more weights to these characteristics. Furthermore, an investor may consider different combinations of factors in his decision, placing more emphasis on one aspect or another and these combinations will be different for different investors. Given the uncertainty present in the decision process of a foreign investor, the use of BoD becomes a very interesting alternative to building FDI Attractiveness. In fact, Gong et al. [40] argue that in a setting in which objective knowledge of the true policy weights is usually lacking or incomplete, the BoD model derives for each object a set of optimal weights from the observed subindicator values themselves.

Table 1. The potential drivers of FDI.

Variables	Dependent: Intensity of FDI
	(1)
LN_DEN_{t-1}	0.0628 ***
	(0.0095)
LN_GDPPC_{t-1}	0.0104 **
	(0.0049)
LN_IND_{t-1}	−0.0022
	(0.0031)
LN_SERV_{t-1}	0.0339 **
	(0.0151)
LN_EDU_{t-1}	0.0136
	(0.0090)
LN_PROD_{t-1}	0.0050 ***
	(0.0009)
$CONSTR_{t-1}$	0.0001 **
	(7.75×10^{-5})
$TRANSP_{t-1}$	−0.0001
	(0.0004)
Constant	−0.426 ***
	(0.0232)
F	7535.20 ***
Wooldridge (Autocorrelation)	6.65 **
Mod. Wald (Heteroskedasticity)	1.60×10^{9} ***
Pesaran CD	322.41 ***
Mean VIF	1.73
Observations	3549
Number of municipalities	592

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$.

2.3. The Low-Attractiveness-High-Intensity Index (LAHI)

The second index built in this study, also with the help of DEA, is called the Low-Attractiveness-High-Intensity Index (*LAHI*). This index, unlike the previous one (which was an IC), measures the efficiency of a municipality, that is, its ability to convert inputs into outputs. *LAHI*, specifically, seeks to verify which municipalities most efficiently convert their FDI (input) attractiveness into effective foreign investment (output). Thus, regions that, despite having a low attractiveness, still manage to attract FDI will stand out with this indicator. Similar to the econometric FDI model, the 'intensity of FDI' (see Equations (1) and (2)) is used to check the relative importance of FDI for each municipality's economy, while avoiding overestimating indexes for large regions such as São Paulo, city.

The *LAHI* was built from the output-oriented BCC model [41] of the DEA. The reason the output orientation was chosen is the fact that the interest was in maximizing the FDI and not in reducing the attractiveness of the municipalities. Also, the use of the BCC model occurred because it adopts the assumption of variable returns to scale, considered the most representative of reality since an increase in the attractiveness of the municipality will not necessarily generate a proportional increase in attracted FDI (the use of logarithms in the regression of Equation (3) supports this hypothesis).

Accordingly, the *LAHI* was constructed using a single output, which is the effective amount of FDI attracted by the municipality and inputs the same as the outputs used to construct the *FAI* indicator in the previous section. A point that deserves to be highlighted is that many municipalities had FDI equal to zero, which hinders the construction of the index since the DEA does not deal well with this type of data. To avoid this problem, and to be able to discriminate between municipalities with zero FDI, as a municipality with zero FDI and high attractiveness is considered less efficient than one with zero FDI and low attractiveness, the zeros in the inputs were replaced by 1×10^{-5}, as suggested by

Thompson et al. [42]. It should be noted that 1×10^{-5} is an arbitrary number, but low enough to bring consistent results.

With *LAHI*, it is possible to verify whether the presence of FDI in municipalities with low attractiveness, and which are therefore highly efficient (inland municipalities, for example), has a more positive or negative effect on the environment. The hypothesis for this analysis is that the FDI attracted to unattractive places could be of worse quality in terms of sustainability.

2.4. The Environmental Model

To evaluate the environmental cost of attracting FDI, as well as the environmental impact of FDI increases in less-developed areas, an environmental model is employed. For this model, the dependent variable is the energy-related CO_2 per capita for each municipality and year. It is important to note that other variables could lead to interesting findings (e.g., waste, water footprint, agricultural burning) but Brazil is currently lacking a detailed dataset containing firm-specific and region-specific information on such issues. Also, studies focusing on these variables would arguably demand a case-study framework. Furthermore, CO_2 is widely recognized as a major pollution variable as it causes issues worldwide (i.e., global warming) and has been widely used in developmental studies including research regarding the effects of FDI. Hence, this study focuses on CO_2 and a more generalized discussion.

Following the protocol presented by previous environmental studies [19,42,43], the CO_2 emissions were calculated using the energy consumption from electricity and fossil fuels (gasoline, diesel, liquefied petroleum gas, fuel oil, aviation gasoline, and aviation kerosene). Also, the guidelines of the Intergovernmental Panel on Climate Change (IPCC) [44] were considered, and a more detailed discussion of Brazilian legislation is presented by Polloni-Silva et al. [19].

For this model, the previously presented indexes (*FAI* and *LAHF*) are employed as the main explanatory variables. Additionally, the literature was revisited to include alternative control variables. As a result, the environmental model can be expressed as:

$$EE_{jt} = \beta_0 + \beta_1 \mathrm{FAI}_{jt} + \beta_2 \mathrm{LAHF}_{jt} + \beta_3 \mathbf{Z}'_{jt} + \alpha_j + e_{jt} \quad (4)$$

where *EE* represents the energy-related CO_2 emissions per capita, *FAI* and *LAHF* are the indexes generated by DEA, and $\beta_{1\text{–}3}$ and $\mathbf{Z}'$ represent the set of alternative control variables, namely urbanization (*URB*), population growth (*POPGROWTH*), and employment levels (*EMPLOY*).

As this model presents disturbances similar to the FDI model (i.e., autocorrelation, heteroscedasticity, and cross-sectional dependence), the fixed-effects Driscoll–Kraay estimator [45] was used again. By using the DK estimator and alternative control variables, we ensure the consistency of our results.

3. Results and Discussion

Initially, we selected the possible drivers of FDI from international literature. With these drivers, we built a model using the intensity of FDI (*IFDI*) as the dependent variable, and the results are displayed in Table 1. As previously explained, Table 1 was estimated using the Driscoll–Kraay (DK) technique to avoid biased results.

In sum, the majority of the employed variables returned significant and positive coefficients. According to the results, population density (*DENS*), GDP per capita (*GDPPC*), the service sector (*SERV*), labor productivity (*PROD*), and the construction sector (*CONSTR*), representing infrastructure, are significant predictors of the intensity of FDI, meaning that FDI gains relative importance (i.e., participation in the regions' economies) in fast-growing areas.

As such, these results are aligned with the literature on this topic. As commented by previous scholars [10,11,13], FDI does not seem to be a random investment decision, and foreign investors search for regions with the potential for growth. Still, this potential could represent major increases in these regions' environmental impacts. Hence, using these results, the FIA index can be calculated using DEA.

Yet, before calculating and using an attractiveness index to check the effects on CO_2, we validate the use of these variables in an environmental model. In other words, we validate these variables by including them in a model with CO_2 as the dependent variable. The results in Table 2 demonstrate that many of our selected variables are in fact significant predictors of CO_2. Although model 2 displays the results for all variables, model 3 uses only the significant predictors of FDI (see Table 1). In both cases, the Brazilian regions' development seems to be having a significant effect on the environment.

Table 2. The effects of regional development on CO_2 levels.

Variables	**Dependent: Energy-Related CO_2 Emissions per Capita**	
	(2)	**(3)**
LN_DEN	1.658 *	0.982
	(0.893)	(1.162)
LN_GDPPC	1.250 ***	1.181 ***
	(0.0840)	(0.0895)
LN_IND	0.284 ***	
	(0.0633)	
LN_SERV	1.825 ***	1.427 ***
	(0.180)	(0.171)
LN_EDU	−0.314 ***	
	(0.0648)	
LN_PROD	−0.133 ***	−0.103 ***
	(0.0390)	(0.0373)
CONSTR	−0.0012	0.0020
	(0.0019)	(0.0019)
TRANSP	0.0415 ***	
	(0.0102)	
Constant	−5.27 ***	−10.65 **
	(4.182)	(4.938)
F	33.42 ***	84.56 ***
Wooldridge (Autocorrelation)	85.84 ***	82.69 ***
Mod. Wald (Heteroskedasticity)	1.00×10^7 ***	2.30×10^7 ***
Pesaran CD	94.73 ***	159.86 ***
Mean VIF	1.72	1.53
Observations	3927	3927
Number of groups	561	561

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

Here, it is interesting to note that some factors (e.g., higher education levels, higher productivity) are negatively associated with CO_2 levels, which is positive for the environment. However, many previous environmental studies (e.g., studies using the STIRPAT model) have discussed the isolated effect of such variables on the environment. Accordingly, this study will not further develop the discussion of individual variables. Indeed, the novelty of this paper is to check whether the overall attractiveness of foreign investments is negatively associated with CO_2. Arguably, creating an attractiveness index and including it in an environmental model represent a new perspective within the debate about FDI and its effects on the host.

Finally, Table 3 displays the results regarding the relationship between the calculated *FAI* and *LAHI* indexes and the environment. In other words, Table 3 shows the environmental impact of regions with increasing potential to attract FDI, along with the effects of FDI in peripheral regions.

Table 3. The effects of the *FAI* and the *LAHI* indexes on CO_2 emissions.

Variables	Dependent: Energy-Related CO_2 Emissions per Capita			
	(4)	**(5)**	**(6)**	**(7)**
FAI	0.910 *	0.755 **		
	(0.529)	(0.339)		
LAHI			2.446 *	1.840 *
			(1.458)	(1.073)
LN_URB		4.822 ***		5.069 ***
		(1.827)		(1.903)
POPGROWTH		0.0148 *		0.0150 *
		(0.0078)		(0.0079)
LN_EMPLOY		1.192 ***		1.171 ***
		(0.163)		(0.160)
Constant	1.506 ***	−23.44 ***	0.0636	−25.51 ***
	(0.377)	(8.407)	(1.252)	(9.307)
F	2.81 *	82.21 ***	2.81 *	220.16 ***
Wooldridge (Autocorrelation)	75.21 ***	82.41 ***	75.97 ***	82.78 ***
Mod. Wald (Heteroskedasticity)	2.50×10^7 ***	2.20×10^7 ***	1.70×10^7 ***	9.60×10^6 ***
Pesaran CD	320.46 ***	158.09 ***	324.65 ***	159.18 ***
Mean VIF	1	1.09	1	1.07
Observations	3913	3913	3913	3913
Number of municipalities	559	559	559	559

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

The *FAI* index, which was used to investigate how the potential to attract foreign investments could impact the environment, demonstrates that this potential attractiveness is environmentally costly. Here, the results suggest that this growth process significantly increases the energy-related CO_2 emissions. Thus, FDI targets polluted regions.

This is an interesting finding, as previous scholars have commented on the possible environmental benefits of FDI. Even some recent discoveries in Latin America suggest that FDI could benefit the environment, as demonstrated by Polloni-Silva et al. [19] and Xu et al. [46]. Part of the literature defends the idea that FDI brings innovation, green technologies, and higher productivity levels to emerging economies [16–18]. Our results do not contradict these claims but demonstrate that these companies—despite bringing new technologies—invest in increasingly polluted regions. As such, more traditional growth policies aiming to simply increase the FDI inflows might not be in the host regions' best interest, at least from an environmental standpoint.

Still, on the technological benefits of hosting FDI, and therefore benefiting from cleaner and more productive technological solutions, the results suggest that the impact of FDI is limited. As previously commented, the State of São Paulo hosts the majority of foreign investments in the country. Yet recent studies suggest that the promised environmental benefits of São Paulo's development (e.g., sophistication, higher productivity) were not achieved. Gandhi et al. [47] and Geller et al. [48] comment that the energy intensity (i.e., the energy needed to produce one unit of GDP) did not fulfill the optimism predictions. In reality, São Paulo is arguably a development benchmark for Brazil, but the region still presents an energy trend unlike those in developed economies [47]. As such, any positive effects coming from the presence of MNCs in these regions may be neutralized due to the regions' growth.

In short, this growth process is environmentally costly. Considering these results, local policymakers should revisit their economic growth process. Arguably, bringing FDI to these regions might not be enough to genuinely boost economic sophistication and reduce emissions. The results of the *FAI* index, along with the control variables, suggest that the growth process of the municipalities in the State of São Paulo has a great impact on the environment. Urbanization levels, for example, represent a great source of CO_2, along with employment levels.

Consequently, when discussing how to attract FDI to a region to modernize its economy, the debate should include the regions' history and economic growth to evaluate what other measures should be accounted for. As discussed by Adeel-Farooq et al. [49], local policymakers should stop blaming foreign investors and foreign governments for their environmental issues and instead take an active role in their energy-related policies. It implies that the policymakers should also pay attention to clean energy technologies such as solar, photovoltaic, biomass, and wind in peripheral areas since their current development path tends to be environmentally harmful.

In addition, Table 3 displays the results regarding the relationship between the *LAHI* index and the environment, with *LAHI* representing the FDI in less-developed areas. Here, *LAHI* represents an efficiency-type of measure calculated using DEA, as previously explained. The results suggest that less-developed regions with greater participation of FDI in their economies (i.e., regions in which the MNCs have a prominent role in the economy, at least concerning the regions' exports) present an environmentally costly development. In other words, when these peripheral regions host MNCs, the effect on the environment is negative, as the estimated coefficient for the *LAHI* index is significant and positive to the energy-related CO_2 emissions.

This is an interesting finding as several scholars have commented on the environmental benefits of hosting FDI, even in the case of Latin America [19]. However, more recent scholars point to FDI being heterogeneous in many aspects, including technologically [3,50]. As a result, many results coming from generalized datasets (e.g., country-level studies) or studying the general effect of FDI on emissions may result in an incomplete analysis of FDI on the environment.

Our results suggest a distinction between FDI in larger and better-developed areas, which arguably involves a large number of MNCs in distinct areas including high-technology sectors, and the FDI choosing the periphery. As commented earlier, many regions in the countryside can be seen as a valuable source of natural resources and workforce. Indeed, the FDI in regions that are not considered the benchmark for fast growth, along with other desirable aspects (e.g., infrastructure), may not represent an environmentally friendly investment decision.

On this heterogeneity, several regions with high levels for the *LAHI* index are home to agribusiness-related MNCs. According to the employed Atlas, these companies represent activities regarding cereal cultivation, seeds, sugarcane, poultry, corn, and vegetable oils, among others. This is the case for municipalities in the countryside of São Paulo, such as Santa Cruz das Palmeiras, Meridiano, Ibirarema, Itaí, Ipuã, and Palmital. Accordingly, these companies represent a segment of FDI that differs from the traditional 'technologically advanced multinationals' constantly discussed in the literature.

Nevertheless, it is important to declare that our results do not conflict with previous findings. Alternatively, we argue that it is necessary to include technological heterogeneity and variables such as sector in FDI studies. In sum, the 'one size fits all' approach regarding FDI seems to limit many empirical studies. For example, some recent investigations have started to include the quality of FDI and these investments' sectors in the econometric models to further investigate how heterogeneity may influence the effect of FDI on the host [3,50,51]. Our results are aligned with these scholars' claims.

To sum up, local policymakers in the 'FDI tournament' [52] should analyze the type of investments their regions host, and arguably seek high-technology MNCs to benefit from higher productivity levels, more frequent knowledge, and technology spillovers, whilst also reducing the energy intensity and the local CO_2 emissions.

4. Conclusions

This study investigates the environmental cost of attracting FDI through two distinct perspectives. First, as FDI is not represented by random investment decisions, this study analyzed how the attractiveness levels (i.e., the potential to attract FDI) of the municipalities in the State of São Paulo impact the environment. Following, considering that the literature presents no consensus on the effects of FDI, and recent investigations point to the heterogeneous qualities of FDI, we investigate the environmental effects of the FDI in the periphery of the State of São Paulo. In short, this study employed robust panel data techniques coupled with Data Envelopment Analysis to contribute to the literature on growth strategy and the role of FDI in emerging regions.

Our results suggest that FDI mostly concentrate in fast-growing areas and that these regions' recent development strategies are environmentally costly. Also, the FDI in peripheral regions (e.g., the countryside of the State of São Paulo) does not present the technological capabilities to benefit the host regions' environments, as predicted by previous studies. FDI in the periphery seems to be concentrated in agriculture. Although these regions present lower levels of attractiveness (e.g., smaller economies, weaker infrastructure), they still host MNCs. Yet the presence of these MNCs is not capable of positively influencing the environment.

Previous studies have commented on how Brazilian growth is highly polluting [19,47,53,54]. Therefore, policymakers should revisit their growth strategies. Moreover, as the periphery might represent unique investment opportunities where foreign investors can access cheap labor and natural resources, local policymakers should create ways to attract MNCs to more developed areas. For example, some empirical evidence shows that FDI in dirty sectors is harmful to the host [55], whereas investments in high-technology sectors could be advantageous [56,57]. Thus, following this idea, policymakers may incentivize more environmentally friendly sectors, especially in high LAHI areas, since modern and technology-intensive FDI will concentrate on developed regions.

Conclusively, future research should consider these possible heterogeneous effects of FDI and include sector-specific data in econometric models. Also, alternative econometric techniques (e.g., threshold regression, quantile regression) could facilitate an understanding of the effects of FDI under distinct development levels. Alternatively, the use of regional heterogeneity and cluster analysis could advance the discussion on regional heterogeneity and FDI/growth. To sum up, Brazil and other Latin American countries could benefit from a larger dataset and a longer timeframe.

Finally, as commented earlier, future case studies could use other measures of pollution, including more local measures (e.g., water footprint), to better compare foreign and Brazilian companies.

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Appendix A

Table A1. Variables and sources.

Variable	Description	Source
IFDI	Intensity of FDI	Calculated with data from the Atlas of FDI in the State of São Paulo
EE	Energy-related CO_2 emissions per capita	Calculated with data from the Ministry of Science, Technology, Innovation, and Communications (MCTIC), the National Agency for Petroleum, Natural Gas and Biofuels (ANP), and the Brazilian Energy Research Office (EPE).
FAI	FDI Attractiveness Index	Calculated with Data Envelopment Analysis (DEA)
LAHI	Low-Attractiveness-High-Intensity Index	Calculated with Data Envelopment Analysis (DEA)
DEN	Population density (inhabitants per square kilometer)	Brazilian Institute of Geography and Statistics (IBGE)
GDPPC	Real GDP per capita	IBGE
IND	Industry's share of GDP (%)	IBGE
SERV	Services' share of GDP (%)	IBGE
PROD	Manufacturing labor productivity (value added by manufacturing/total jobs in manufacturing)	Calculated with data from IBGE and the Annual Social Information Report (RAIS)
CONSTR	Jobs in the construction sector (% of total jobs)	RAIS
TRANSP	Jobs in the transport sector (% of total jobs)	RAIS
URB	Urbanization rate (%)	IBGE
POPGROWTH	Population growth (%)	IBGE
EMPLOY	Employment rate (%)	RAIS

Appendix B

Table A2. Descriptive statistics.

Variable	Mean	Std. Dev.	Min	Max
IFDI	0.047	0.144	0.000	1.000
EE *	2.127	2.587	0.105	34.413
FAI	0.672	0.138	0.265	1.000
LAHI	0.841	0.054	0.630	1.000
DENS *	4.118	1.446	1.650	9.470
GDPPC *	2.861	0.546	1.580	5.691
IND *	2.739	0.725	0.992	4.454
SERV *	4.010	0.257	2.460	4.479
EDU *	2.516	0.337	1.015	4.120
PROD *	4.372	1.045	0.486	13.645
CONSTR	2.883	4.167	0.000	75.934
TRANSP	3.554	3.388	0.000	30.048
POPGROWTH	1.024	2.605	−23.724	31.754
URB *	4.438	0.196	3.216	4.605
EMPLOY *	3.020	0.473	1.685	5.395

* Presented in the natural-log form.

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