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Does Lax Environmental Regulation Attract FDI when accounting for "third-country" effects?

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Abstract

This paper investigates if differences in environmental regulations can influence FDI flows in a multi-country setting taking into account the so-called "third-country" effect. We examine bilateral FDI flows using a new extended OECD investment database which covers great number of host countries and a long sample period (1981-2005). The findings based on a spatial gravity-like model are largely plausible across specifications and confirm the existence of a negative relationship between FDI and environmental stringency, once we correct for endogeneity and spatial dependence. The evidence of a positive "third-country" effect for FDI suggests the prevalence of complex FDI from developed to developing countries. The spatial structure of the model allows also to underline the possible existence of competition in environmental standards between countries to attract FDI.

Keywords: Complex FDI, Pollution Haven, Spatial Econometrics

JEL classification: Q56, F21, F18

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1 Introduction

The growing role of multinational enterprises associated with the progressive liberalization of foreign direct investment (FDI) regimes has brought attention toward their environmental consequences on host countries. One of the most controversial debate today is whether pollution-intensive industries relocate to countries with less stringent environmental policies, turning these countries into "pollution havens".

This paper investigates if differences in environmental regulations can influence FDI flows in a multi-country setting using bilateral data and taking into account the so-called "third-country effects". The pollution haven effect (PHE) refers to the possibility that FDI could be sensitive to weaker environmental regulation, especially when polluting firms want to avoid the costs associated with environmental standards compliance. While the intuitive logic behind the PHE is rather simple, moving from a theoretical hypothesis to testing in the real world has given rise to some difficulties. Empirical studies designed to test this hypothesis have so far shown little evidence, but suffer potentially from omitted variable bias, specification and measurement errors. Most empirical studies rely on a two-country framework, which ignore spatial dependence in multilateral FDI decisions. The inclusion of "third-country" effects, which capture the effect of proximity of other neighborhood host countries to a particular host country, is necessary to explain the emergence of new types of integrated FDI. As emphasized in the literature, failure to account for "third-country" effects in empirical studies of FDI may lead to biased inference. This may be particularly problematic in the context of empirical studies of the PHE for three interrelated reasons. First, the impact of environmental stringency is not homogenous across different types of FDI. Second, environmental policies have been shown to be spatially correlated. Finally, it has proven extremely difficult to find credible instrumental variables for environmental regulation. As a consequence, it is extremely important to control for relevant determinants of FDI.

We examine bilateral FDI flows using a new extended OECD investment database which covers a great number of host countries and a relatively long sample period (1981-2005). To our knowledge, it is the first attempt to analyze the pollution haven effect with bilateral FDI at the worldwide level from a "third-country" perspective. We estimate a spatial gravity like model controlling for relevant FDI's determinants and exploring spatial features of the data. The findings are largely plausible across specifications and confirm the existence of a negative relationship between FDI and environmental stringency (proxied by SO2 emission per capita, CO2 emission per capita and international environmental treaties). The evidence suggests the prevalence of complex vertical integrated FDI from high income OECD countries to less developed countries, where environmental stringency of the host and neighborhood countries are important.

The remainder of this paper is organized as follows. Section 2 discusses the different reasons that lie behind the inclusion of third-country effects and presents an overview of the previous empirical literature on FDI-PHE linkages. Section 3 describes the model specification, econometric procedure and the data used. Section 4 and 5 report the empirical analysis of the model and robustness check, respectively. Finally, section 6 concludes.

2 FDI-Pollution Haven-Spatial Linkages

Defined as "investment made to acquire a lasting interest in enterprises operating outside of the economy of the investor", foreign direct investment is characterized by a relationship between a parent enterprise and a foreign affiliate which together form a transnational corporation (TNC). One of the most important characteristic that sets FDI apart from other types of capital inflows is the element of control, by the foreign investor over acquired assets. However, FDI are not only made of capital or direct technology transfer but they can also include intangible assets such as technology and management skills.

2.1 Sources of FDI, Pollution Haven and Spatial Linkages

Analyzing FDI gives rise to two distinct questions. The first question, "why do FDI exist", is answered by determining the motives for which firms want to undertake FDI. Until recently, most multinational enterprises' (MNE) motivations illustrated in the literature relied on a two-country framework, where FDI between home country i and host country j was only affected by both countries' characteristics. The underlying assumption was that FDI allocation was spatially independent. However, new types of FDI have emerged in the last twenty years. Multinationals are involved in hybrid FDI, which are neither purely vertical nor purely horizontal. MNEs can allocate FDI in a host country but can also engage in trade or FDI in a third country. The location decision of these new type of FDI will not only depend on the home and host countries' determinants, but also on the factors of the host's neighborhood countries. These more complex integrated FDI are embedded in a multilateral decision-making process, which means that FDI decisions across various host countries are not spatially independent. Other elements may also lead to interdependent FDI decisions across host countries, including imperfect capital markets and agglomeration externalities (spillovers) which limit the necessary funds a multinational company has to commit abroad. From a theoretical viewpoint, spatial dependence follows directly from Tobler's first law of geography (1970), according to which "everything is related to everything else, but near things are more related than distant things". From an econometric point of view, this spatial dependence is measured by defining a spatial weight matrix which allows measuring the potential third-country effect between neighborhood locations. This spatial dependence is econometrically important because it can give rise to a problem of variables omission. Since previous research on FDI and pollution haven linkages disregards the spatial features of FDI decisions, the estimations and statistical inferences in the past research remain questionable. This estimation problem might be even more problematic, because most studies ignore also the fact that environmental stringency policies are spatially correlated (Davies et al. (2006), Fredriksson and Millimet (2002)). Empirical evidence suggests that environmental policies tend to be similar between countries with close trade relations (Eliste and Fredriksson (2002)).

Based on the theoretical work by Markusen (2002), Yeaple (2003) and Egger and Pfaffermayr (2004), Baltagi et al. (2007) derived a model of MNE activities that allows to distinguish four types of multinational strategies (see Table 1). Following these distinctions, Blonigen et al. (2007) proposed a simplified theoretical framework and empirical model to assess the four different spatial FDI relationships mentioned in the literature. The estimation procedure relies on a "spatial autoregression" model which includes two spatial variables: a spatial lag dependent variable (i.e. a spatially-weighted sum of bilateral FDI from a given host country to other host countries) and a market potential variable (i.e. a spatially-weighted sum of other host countries' market size). These distinctions are also important, because these four different categories of FDI respond differently to the host and neighboring countries' environmental stringency. Table 1 summarizes the four forms of MNE behavior in terms of spatial and environmental stringency responsiveness.

Table 1: Spatial and Environmental linkages in MNE Choices.

FDI Motivation	Horizontal FDI	Vertical FDI	Export Platform FDI	Complex FDI
Spatial Lag	0	$-$	$-$	$+$
Market Potential	0	0	$+$	$+/0$
Environmental Stringency	0	$-$	$-/0$	$-$
Spatial Environmental Stringency	0	$+$	$+/0$	$+$

Source: Blonigen et al. (2005, 2007), Baltagi et al. (2007), Garretsen et al. (2008)

Horizontal FDI aim at seeking opportunities to sell in foreigner markets. A MNE in home country i, which wants to serve foreign markets j and k, can export the products or launch a production unit in both host countries. Market seeking FDI is more likely to happen with sufficiently high trade costs between the home country i and countries j and k. In terms of third-country effects, the decision to undertake FDI in country j is more likely to be independent to the decision regarding country k and its market potential. In terms of environmental stringency, this type of FDI is *a priori* not especially sensitive to differences in environmental costs, although it has to meet some environmental standards to be authorized to sell the products on the host market.

Vertical FDI aim at obtaining low price resources or access to critical resources not available in the home economy. Since resource-seeking FDI is driven by factor cost differences between the home and host countries and not by market potential considerations, vertical FDI from home country i to country j will be undertaken at the expense of vertical FDI from i to another host country k. High environmental standards in country j will affect negatively FDI from home country i to country j, while higher environmental stringency in neighboring country k will have a positive effect on FDI from i to host j, other things being equal, i.e. the MNE might choose location j over location k.

The main objective of export platform FDI is to serve regional export markets through a platform for production and sales (Ekholm et al. (2003), Yeaple (2003), and Bergstrand and Egger (2004)). This type of FDI has elements of both vertical and horizontal FDI. The specific location within a region is defined by cost considerations, as in vertical investments, while the sales in an integrated market respond to horizontal FDI considerations. A MNE in home country i will engage in production-platform-seeking FDI in host country j if the trade cost between potential host countries j and k are lower than between country i with respect to j and k. This way, it can serve more efficiently the combined markets j and k from a single FDI location. The larger (and close to host j) markets in country k the more attractive country j is as a location for export platform motivated FDI. Since the establishment of a new production plant is costly (production is characterized by increasing returns to scale), an increase in export platform FDI from parent country i to third country k implies less FDI from i to host country j, other things being equal. In terms of environmental stringency, export platform FDI can be affected in two different ways. On one hand, if the purpose of FDI is to serve export markets in developed countries through a platform production in a developing country and the access to these markets depends on the environmental product standards of the developed countries, the host country j's environmental regulation is no longer important. In this case, FDI to country j is likely to be associated with new techniques, including the latest abatement technologies (California effect), making the environmental stringency in the host country j no longer relevant. On the other hand, if the multinational wants to serve neighboring developing countries, the environmental stringency in the host country still matters. The production-location decision in host country j will be negatively affected by higher environmental stringency in host j, but environmental standards between close countries (j and k) should be relatively close so the MNE can serve both markets using the same production process. If the company expects in the future an increase in environmental stringency in the host country j and its neighboring countries, it may choose today a production process that will meet higher standards in the future. In this case, the environmental regulation in country j would no longer matter, since the MNE no longer experience a comparative advantage when locating in country j with lower environmental regulation.

Complex (vertical) FDI is characterized by a multinational firm from home country i which owns not only a production plant in host country j but also one in third country k, in order to exploit the comparative advantages of various locations. This type of FDI is associated with exports of intermediate inputs from affiliates (j and k) to another third market for further (or final) processing, before being dispatched to its final destination. The search for (low cost) suppliers in multiple (close) countries leads to the "slicing-up of the value-chain" of the production process (e.g. Baltagi, Egger and Pfaffermayr (2007)). If both adjacent host countries j and k present similar supply network characteristics, the MNE may find it advantageous to launch production in host k given that it already owns production plants in (contiguous) host country j. Thus, complex FDI are characterized by a complementary relationship: complex FDI from home country i to third country k constitutes a complement for FDI from home country i to host country j. This positive relationship is strengthened if j and k are neighboring countries. Market potential in this type of FDI should not matter, although the level of industrial production in neighborhood countries should be positively correlated with higher opportunities for vertical suppliers (e.g. agglomeration incentives (Garretsen et al. (2008)). This last category of FDI is particularly sensitive to environmental stringency in a given host and its neighboring countries, because the most polluting stage of production is more likely to be located in the host country characterized by less environmental stringency. The intermediate input will then be exported to one or more third-country for further processing, in order for the final good to be shipped to its final destination (e.g. home market).

Once the motivations for different types of FDI are known, a second question arises: "why does a particular country attract FDI". The answer is given by identifying the most important host country's location factors. A variety of theoretical and empirical studies on FDI have tried to identify the elements of attractiveness that draw FDI to a country (Sethi et al. (2003), Blonigen (2005)). Some of these factors are encompassed in formal theories or hypotheses, while others are suggested on intuition ground. But so far, there is no consensus view defining an accepted set of explanatory variables considered as the true determinants of FDI. This problem of open-endedness theories could be explained by the lack of consensus to the wide differences in perspectives, methodologies, sample-selection and analytical tools (Chakrabarti (2001)). Moreover, most empirical results are sensitive to the model specification and lack robustness (Moosa et al. (2006)).

2.2 Literature Review

This study bases on two different types of empirical literature. The first one is related to complex FDI and spatial econometrics applications, while the second focuses on the linkages between FDI and the pollution haven effect. This section attempts to shed some light on both empirical literatures, with an emphasis on the most recent works.

Empirical FDI studies allowing for the impact of third-country effects and applying spatial econometrics are sparse. Despite mixed evidence, these studies highlight the importance of spatial interdependence. Coughlin and Segev (1999) were the first to apply spatial econometric techniques to study the geographic distribution of FDI. Their results indicate that FDI into one location within China is positively associated with FDI into other close Chinese locations. Blonigen, Davies, Naughton and Waddell (2005) consider inbound FDI from OECD countries to the US. They find strong and robust evidence for parent market proximity effects but it mainly depends on the sample selection. Hisarciklilar, Kayam and Kayalica (2006) consider the role of "market potential" in MENA countries by estimating a modified gravity model allowing for spatial autocorrelation in the disturbances with both spatial and time fixed effects. Their results indicate that FDI to MENA region are market oriented and aiming at the domestic market in the host economy. More recently, Baltagi, Egger and Pfaffermayr (2007) study the third-country effects associated with US outbound FDI for seven manufacturing industries across both developed and less-developed destinations. Their GMM results find substantial evidence of spatial interactions, though they cannot definitively conclude whether export-platform or complex vertical FDI is more prevalent. Blonigen, Davies, Waddell, and Naughton (2007) focus on aggregate U.S. outward FDI to OECD countries at the country-level. While the estimated relationships of traditional determinants of FDI are robust to the inclusion of spatial interdependence, export-platform FDI seem to have greater prevalence, although the results are quite sensitive to the sample of countries examined. Following Blonigen et al. (2007), Garretsen and Peeters (2008) estimate a spatial lag model for Dutch FDI to 18 host countries. Based on maximum likelihood estimations, third-country effects do matter, but are also sensitive to sample and model selection.

The existing empirical research on environmental regulations-and FDI linkages displays mixed results depending on the type of studies. The first strand of literature considers inflows of FDI to a single country at the regional and/or industrial level. The evidence suggests that stringer regional environmental regulation does influence negatively the location decision of inward FDI in the USA, India and China (List and Co (2001), Gamper-Rabindran and Jha (2004), Ljungwall and Linde Rahr (2005), Zhang (2006), He (2006) and Di (2007)). The evidence of pollution haven effect is however less clear and robust at the industrial level (Keller and Levinson (2002), Henderson and Millimet (2007), Millimet and Racine (2007), Waldkrich and Gopinath (2008)). In fact, environmental regulation can influence negatively the location decision of a specific polluting industry and have no effect whatsoever on another polluting industry. Interestingly, Dean et al. (2004) show that FDI from south-asian (OECD) countries to China are (not) attracted by low environmental stringency, regardless of the pollution intensity of the industry[1]. Following Blonigen et al. (2005), Drukker and Millimet (2007) assess the presence of "third-country" effects in the determination of the spatial distribution of inbound US FDI. Applying spatial econometrics to a spatial error model with spatially weighted covariates, the authors find that many neighboring states attributes, including environmental stringency, influence FDI location.

The second strand of literature considers outflows of FDI from a single home country to one or more host countries at the aggregated or industrial level. Most results in this type of studies are mixed and sometimes not very robust across specifications. Evidence suggests that stringer environmental policy in the United State leaded to an increase in FDI outflows, but not necessarily toward developing countries and industries with

[1] This evidence is partially in line with Zeng and East (2007) who find that openness to trade and FDI allocation in China has lead to an improve in environmental quality trough technology spillovers.

high costs of pollution abatement (Xing and Kolstad (2002), Eskeland and Harrison (2003), Hanna (2006), Cole and Elliot (2005), MacDermott (2006), Kellenberg (2007)). Surprisingly, the evidence obtained by Kirkpatrick and Shimamoto (2007) suggest that outward Japanese FDI is attracted to countries which have a transparent, stable and stringent regulatory environment. This result was partially corroborated by Elliott and Shimamoto (2008), who find that stringer regulation in Japan has discouraged japanese pollution-intensive industries to allocate FDI to the Philippines and Malaysia. More recently, Wagner and Timmins (2008) find that the German chemical industry is the only pollution-intensive sectors in Germany to have relocated to countries with less stringent regulation once agglomeration effect are taken into account.

Last but not least, the third strand of literature analyzes inflows of FDI to different countries originating from various home countries at the aggregated, industrial or firm level. In this type of studies, the evidence of a pollution haven affect is quasi non-existent (Ratnayake and Widewald (1998), Smarzynska and Wei (2001), Eskeland and Harrison (2003), Mihci et al. (2005), Koop and Tole (2008)), although recent studies find a significant PHE (Sparatenu (2007), Dam and Scholtens (2008)). In order to validate the pollution haven effect, Hoffmann et al. (2005) study whether FDI / pollution Granger cause pollution / FDI using new techniques in Granger causality with short time series and panel data. Their results suggest that a pollution haven effect is more likely to happen in low-income host countries. More recently, Cole and Fredriksson (2006) and Cole, Elliot and Fredriksson (2006) examine whether the effects of FDI on environmental policies is conditioned on the structure of host countries' political institutions. They show that environmental policy should be treated as endogenous with respect to FDI in order to assess correctly the pollution haven effect. Their results suggest that the effects of FDI on the environmental policy are conditional on the government's degree of corruptibility and sensitivity to lobbies. More precisely, pollution havens are more likely to occur in countries with few legislative units and low government honesty, which characterizes most low-income countries. In line with this finding, Dam and Scholtens (2008) show that firms with good (poor) social responsibility[2] tend to invest less (more) in countries where environmental regulation is weak.

2.3 Weakness of Existing Empirical Literature

While most empirical papers find a negative pollution haven effect at the regional and industrial level, this little evidence disappears once data are considered in an inter-country analysis. Thus, the existing empirical studies on pollution haven effect can be summarized in two ways (Smarzynska and Wei (2001). Either the pollution haven effect is just a popular myth that does not hold in reality, or the pollution haven effect is valid but the empirical research has so far failed to uncover this "dirty secret". In reality, the existing empirical literature faces a number of limitations, which may partially explain the ambiguity in the results obtained (Ederington et al (2005), Elliott and Schimamoto (2008)). These limitations include:

[2] Corporate social responsability is viewed as the extent to which a firm internalizes market costs.

- **Conceptual frameworks**: most studies apply a different conceptual framework (gravity model, location decision model, reduced cost function, ...) but have a common feature: they don't distinguish between the different forms FDI can take. As mentioned earlier, some types of FDI are more sensitive to environmental stringency than other (see Table 1). Therefore assuming a homogenous response in environmental stringency may inadvertently mask the overall impact of more stringent regulations by pooling unaffected and affected FDI.

- **Data sources and proxies**: it is very hard to quantify environmental stringency in different host and home countries and most papers use different proxies. This difficulty is further exacerbated by the fact that the regulation in the book is not necessary the same as the one actually enforced (Smarzynska and Wei (2001). If strict environmental laws are not enforced, they are not effective and similar to lower regulation. More generally, most studies use cost-based measures of environmental stringency which usually raises a specification error due to unobserved foreign pollution taxes (Copeland and Taylor (2004), Levinson and Taylor (2008)). More generally, this data problem is important because, as pointed out by Wheeler (2001), the costs associated with environmental stringency constitute a small fraction of production costs in virtually every industry. Failure to measure accurately environmental stringency may mask the real negative pollution haven effect.

- **Differences in econometric methodologies**: while some papers apply cross-section regressions, logit and probit models, and others use GMM estimators with random or fixed effects, they all have to deal with unobserved heterogeneity, variable omissions, aggregation bias and endogeneity. Cross-section analyses cannot control for unobserved heterogeneity among countries (Keller and Levinson (2002), Levinson and Taylor (2008)). Failure to take into account important determinants, such as third-country effects, agglomeration effects and relative factor abundance will lead to omitted variables bias which can mask the true pollution haven effect. The estimations will be also biased, if one does not correct for the potential endogeneity of environmental with respect to FDI. Beside a high degree of corruptibility and lobby pressures, the endogeneity of pollution regulation might prevail if the host countries set their regulation strategically to stimulate FDI or if they impose stricter regulation once they receive too much investment in polluting industries. Therefore, the choice of the correct estimator is essential.

The conceptual framework, data and methodology used in this study are intended to address a number of these difficulties. First, we follow the third strand of literature by analyzing the pollution haven effect at the world-wide level. Since the pollution haven effect is more likely to be the result of differences in environmental stringency between developed and developing countries, we examine bilateral FDI flows using a new extended OECD investment database which covers a large number of developed and developing host countries as well as a long sample period (1981-2005). Second, following Blonigen et al. (2007), we consider a conceptual framework that allows us to highlight the potential importance of export-platform and complex FDI. Accounting for the presence of spatial dependence in FDI decisions and environmental stringency might be important to reduce variables omission in the model specification. Third, we use different complementary measures of environmental stringency. Each proxy used in this study relies on different underlying assumptions, which allows to take into account the different facets of environmental stringency. Last but not least, we provide a thorough treatment to simultaneity, endogeneity bias and spatial characteristics of the data, by applying GMM-SYS to a spatial gravity-like model.

To our knowledge, this is the first attempt to measure the pollution haven effect in an inter-country bilateral FDI panel setting which covers most developed and developing countries by controlling for relevant host country's FDI determinants and exploring spatial features of the data. This is also the first time, the prevalence of inflows of complex FDI is being estimated for more than one parent country. By focusing on a country's aggregated bilateral FDI, we are aware that results can sometimes be misleading and hard to prove by masking heterogeneous patterns at the firm or industry-level. Therefore, we should interpret our results cautiously even if we try to reduce this aggregation bias by exploiting fully the information available. In any case, an inter-country analysis remains relevant to get the "big picture" in terms of FDI's spatial allocation. It can also be of particular interests to policymakers in developing countries who compete to attract new FDI.

3 Model Specification

This section presents the baseline model and its spatial extension in order to account for third-country effects. The different spatial weight matrices are presented as well as the selected variables. Finally, the estimation procedure is discussed.

3.1 Gravity-Like Model

Given the relative success of the traditional gravity equation in explaining the trade flow between countries, recent theoretical models (Markusen et al. (1996), Head and Ries (2008)) suggest that location and size of bilateral FDI flows depend on country characteristics such as country size, population and factor endowments. According to Evenett and Keller (2002), the gravity model can support both assumptions of product differentiation (increasing returns to scale) and homogenous good production. This can explain why this approach has been widely used in empirical studies of FDI, see for example Benassi-Quéré et al. (2007) or Stein and Daude (2007). Therefore, we also model bilateral FDI flows in a gravity-like setting. We extend the set of standard gravity variables by adding classical FDI determinants, in order to capture all potentially relevant determinants of FDI (Blonigen (2005), Campos and Kinoshita (2003), Lall (2003)). However, given that our priority is to identify the presence of any pollution haven effect, we control for most variables related to cost-motivated (vertical) FDI.

Ignoring spatial dependences, the baseline model reads as follows

$$FDI_{ijt} = \delta FDI_{ijt-1} + P_{it}^{'}\alpha + H_{jt}^{'}\beta + X_{ijt}^{'}\gamma + \varphi_{ij} + \mu_t + u_{ijt} \tag{1}$$

where FDI_{ijt} is FDI flow from home country i to host country j at period t. P_{it} is a vector including parent country variables, H_{jt} includes host variables and X_{ijt} represent bilateral control variables. φ_{ij} is the individual effect, that captures unobserved characteristics related to country-pair, which do influence bilateral FDI but are fixed in the short and medium terms. The time fixed effect, μ_t, captures the business cycle common to countries. Finally, u_{ijt} is the error term.

We specify our model in log-linear form (except for dummies variables) because, as documented by Blonigen et al. (2004) and (2005), such a model more likely leads to well-behaved residuals given the skewness of most FDI data samples. Such a log-linear model also allows to interpret the coefficients associated with log variables as elasticities. A problem that arises when using a log-linear specification is how to deal with observations with negative and zero values. This the case for FDI inflows which are negative when the home country repatriates previous investments made in the host country. There are usually two ways to handle the presence of zero/negative FDI flows. The first one consists of discarding the zero and negative observations from the sample. This strategy is correct as long as the zero and negative values are randomly distributed. However, if they are not random, as is usually the case, then the problem of selection bias arises. This problem is often ignored in applied work, but could be handled by using sample selection correction. The second approach consists of transforming the variable by adding a constant factor to each observation on the dependent variable. This is what we do when we applied the following log transformation to variables with negative or zero values: $z = ln(x + \sqrt[2]{x^2+1})$ (Busse et al. (2007)). The sign of x is unchanged, but the values of x pass from a linear scale at small absolute values to a logarithmic scale at large values by using this transformation.

3.2 Spatial Gravity-Like Model

One potential drawback of equation (1) is the reliance on a two-countries framework. In order to account for the presence of more complex and integrated FDI, it is necessary to consider bilateral FDI as spatial data. A general spatial model can be described as follows:

$$\begin{aligned} FDI_{ijt} &= \rho\left[W_{1t}FDI_{it}\right]_{ijt} + \delta FDI_{ijt-1} + P_{it}^{'}\alpha + H_{jt}^{'}\beta + X_{ijt}^{'}\gamma + S_{jt}^{'}\eta + \varphi_{ij} + \mu_t + \varepsilon_{ijt} \\ \varepsilon_{ijt} &= \lambda\left[W_{2t}\varepsilon_{it}\right]_{ijt} + u_{ijt} \end{aligned} \tag{2}$$

where W_{1t} and W_{2t} are spatial weight matrices which are non-stochastic and exogenous to the model, $\left[W_{1t}FDI_{ijt}\right]_{ijt}$ represents the spatially weighted average of FDI flow from home country i to the neighborhood countries of country j, while$\left[W_{2t}\varepsilon_{it}\right]_{ijt}$ measures how bilateral FDI from home country i to host j can be affected by a shock to FDI from source i in surrounding host countries The vector S'_{jt} includes spatially weighted host variables to account for potential spillovers (e.g. market potential). By adding some restrictions to the parameters, two popular spatial model specifications can be derived from this general spatial model: the spatial lag model ($\lambda = 0$) and the spatial error model ($\rho = 0$).

Since we are particularly interested in the detection of a substitutive or complementary allocation of FDI between host countries, we follow Blonigen et al. (2007) and consider a spatial lag model which accounts directly for the spatial relationships between bilateral FDI flows. As mentioned by Garretsen et al. (2008), the inclusion of a spatial lag dependent variable as a foundation in economic theory (complex FDI), while FDI theory provides no real guidance whether or not to expect positive or negative spatial autocorrelation in a spatial error model. Moreover, from an econometric point of view, the omission of spatially weighted variables leads to variables omission and biased estimator. The spatial error model is of secondary interest, because, although it may improve standard errors, it does not affect point estimates. In other words, the omission of a spatial error structure has less implication in terms of biasness than the omission of a spatial dependent variable[3]. The spatial gravity-like model, also known as "time-space simultaneous model" (Anselin (1999)), reads as follows:

$$FDI_{ijt} = \rho \left[W_t FDI_{it}\right]_{ijt} + \delta FDI_{ijt-1} + P'_{it}\alpha + H'_{jt}\beta + X'_{ijt}\gamma + S'_{jt}\eta + \varphi_{ij} + \mu_t + u_{ijt} \quad (3)$$

The spatial lag term (ρ) allows to determine if FDI flow from country i to country j is (positively/negatively) affected by FDI from country i to other neighboring host countries. In other words, the spatial lag ρ captures the impact of FDI from third country k into j on FDI from home country i into j. The coefficient ρ is assumed to lie between -1 and +1.

Independently of the spatial model considered, the spatial linkages of the observations are measured by defining a spatial weight matrix, denoted by W_t for any year t. This spatial weight matrix allows to measure the potential third-country effects between neighborhood locations:

$$W_t = \begin{pmatrix} 0 & w_t(d_{k,j}) & \cdots & w_t(d_{k,l}) \\ w_t(d_{j,k}) & 0 & \cdots & w_t(d_{j,l}) \\ \vdots & \vdots & \ddots & \vdots \\ w_t(d_{l,k}) & w_t(d_{l,j}) & \cdots & 0 \end{pmatrix}$$

where $w_t(d_{j,k})$ defines the functional form of the weights between any two pair of location j and k. The diagonal elements of the square matrix W_t are set to zero so that no observation of bilateral FDI predicts itself. In the construction of the weights themselves, the theoretical foundation for $w_t(d_{j,k})$ is quite general and the particular functional form of any single element in W_t is, therefore, not prescribed. In fact, the determination of the

[3]We performed robust lagrange multiplier tests for the spatial error and spatial lag dependence specifications. In both cases, the tests were not conclusive.

proper specification of W_t is one of the most difficult and controversial methodological issues in spatial data analysis. Prior to discussing the weighting scheme used, it is important to note that a misspeficiation of the weighting matrix can bias the results. In practice, different weight matrices should be compared to find the most proper one.

A general spatial matrix W_t can be defined by a symmetric binary contiguity matrix. This weighting scheme assigns a weight of zero to non-contiguous countries and a weight of one to all contiguous countries (Drukker and Millimet (2007)):

$$w_t(d_{j,k}) = \begin{cases} 1 & \text{if } j \text{ and } k \text{ are contiguous} \\ 0 & \text{otherwise.} \end{cases}$$

Since the contiguity matrix cannot differentiate the degree of spatial linkages between adjacent locations, some more complex spatial weighting matrix can be used. For example, one can choose a simple inverse distance function, where each pair of location j and k declines to

$$w_t(d_{j,k}) = \frac{1}{d_{j,k}} \quad if\ j \neq k.$$

However, the inverse distance matrix has the disadvantage of always giving some positive weight to very remote countries (with weaker cultural, political and economic ties). A compromise can be reached by allowing the "third-country" effects to decay at a faster rate by giving more weight to locations within the same region[4] and almost zero to locations outside the region (Blonigen et al (2006)). This is done by dividing the distance between locations j and k by the minimum distance within the region r (where location j lies within region r):

$$w_t(d_{j,k}) = \exp\left(\frac{-d_{j,k}}{MIN_{r,j}}\right) \quad if\ j \neq k.$$

As distances are time-invariant, it will generally be the case that $W_t = W_{t+1}$. However, when dealing with unbalanced panel data, this is no longer true (Egger et al. (2005)). Missing neighborhood observations are problematic because they are treated as zeros. This may likely induce bias in the estimation and interpretation of the results. According to Baltagi et al. (2005), this constitutes an important issue for future research. However this "border problem" should be smaller with a distance-based weighting scheme and large averages distances between locations than for contiguity-based weighting schemes. Since this practical issue is usually neglected, there is no universal solution to overcome this practical problem. One solution is to only consider spatially weighted observations without any missing neighborhood locations (i.e. balanced panel). The main disadvantage of this approach is to reduce drastically the information available and the sample size. Another solution is to compare the results of different spatial tests (i.e. Moran I and Geary's C) with and without missing neighborhood locations. These spatial tests should be sensitive enough to detect any spatial bias due to the inclusion of zero-value observations. Thus, if both results give the same conclusion, one can include

[4] Six geographical regions are considered in this study: (1) North America; (2) Latin America and Caribbean; (3) Europe and Central Asia; (4) East Asia, Pacific and South Asia; (5) Sub-Saharan Africa; (6) Middle East and North Africa.

missing neighborhood locations observations, although some bias will remain. In an unbalanced panel setting, with a sample size of t to T periods, the full weight matrix, W, is given by:

$$W = \begin{pmatrix} W_t & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \mathbf{0} \\ \mathbf{0} & \cdots & \mathbf{0} & W_T \end{pmatrix}$$

As is standard in spatial econometrics, for ease of interpretation, the weighting matrix W is row standardized so that each row in W sums to one.

3.3 Variables Selection

The dependent variable of the model is the bilateral flows of FDI from 26 OECD countries to 146 host countries[5] for the period 1981 through 2005. The data, expressed in current US dollars, is taken from OECD International Direct Investment Statistics website. Working on flows rather than stocks provides several advantages including more available data and less error measurements, although stocks present less volatility than flows and constitute a better measure of capital ownership (Bénassy-Quéré et al. (2007)).

In developing an empirical model on FDI to test for the pollution haven effect (equation (1) and equation (3)), we need to consider three issues:

1. **What are the determinants of bilateral FDI**? This study emphasizes on the macro determinants of FDI. That is why, we focus on the factors that drive FDI to countries, abstracting from its sectoral division with an emphasis on vertical FDI factors. The classical determinants include market demand, growth rate, agglomeration effect, factor endowments, natural resources and trade and investment impediments.

2. **How to deal with the fact that the environmental quality is not directly observed**? To capture the strength of environmental regulations in host countries, we adopt three different measures that complement one another, SO2 per capita emission, co2 per capita emission and the number of ratified international environmental treaties.

2. **How to assess third-country effects associated with some determinants of FDI**? To account for these spatial interactions, we consider spatially weighted third-country determinants of FDI, since this spatial correlation among host countries is mainly related to MNE's activities between themselves.

[5] Appendix 7.A. lists the host and source countries. Note that countries with a population lower than a million of inhabitants have been dropped in order to exclude tax haven countries (e.g. Bahamas).

3.3.1 Classical FDI Determinants

As mentioned earlier, we include classical macroeconomic determinants of FDI in order to reduce any potential bias related to variables omission. The variables selection is mainly dictated by data availability. All monetary variables are expressed in US dollars. Appendix 7.B lists the variables considered and their sources.

The demand market size of a host country's allows multinationals to exploit economies of scale and specialize in standard productions, which ultimately lead to cost minimization and market growth. Therefore, market size influences positively inflows of FDI and is usually considered as the single most important factor in the investment location decision of the firm. Following Benassy-Quéré et al. (2007), market demand is measured by the host country's real GDP adjusted for purchasing power parity (PPP). We also include the source country's real GDP in PPP as in a standard gravity equation. The use of GDP in PPP instead of conventional GDP at exchange rates comes from the fact that the latter tends to understate the purchasing power of currencies in low-income economies.

FDI flows are part of a virtuous circle (Investment Development Path). FDI is attracted by fast economic growth and contributes significantly to economic growth, which in turn leads to higher economic growth rate and FDI attraction. Growth rate is measured by the growth rate of real (per capita) GDP, because it can indicate the future size of the host country's market, rising productivity and profitability.

FDI is usually characterized by agglomeration effects: more FDI in a host country seems to attract more FDI in this same host country. This persistence effect is partly due to the fact that FDI is often accompanied by physical investments that are irreversible in the short run. These agglomeration effects can also lead to congestion, when firms compete with one another through price bidding to downstream industries in the region. However, due to data limitations and difficulties in obtaining definite statistical specifications, empirical evidence measuring agglomeration effects is limited. In this study, agglomeration effect is measured by lagged FDI inflows, since the inclusion FDI stocks led to multicollinearity problems. The inclusion of the lagged dependent variable turns the model into a dynamic panel model (Waldkirch and Gonipath (2008), Wagner and Timmins (2008)). This lagged FDI can also partially capture infrastructure in the host country. High physical (e.g. roads and power) and social (e.g. health and education) infrastructure as well as urbanization influence positively inflows of FDI.

Since an important part of FDI is affected to service sectors (UNCTAD (2004)), we want to account for the structure of the economy. Following Cole and Fredriksson (2006), we include the manufacturing value-added as a percentage of total GDP, in order to capture the degree to which an economy consists of pollution intensive manufacturing industries. Keeping in mind that it is not necessarily the most polluting industries which will be affected by stringer environmental regulation (due to high sunk costs), the sign of the coefficient can be zero or positive, if the marginal pollution damage from domestic production rises.

Following Eskeland and Harrison (2003), which show the importance of the capital-labor ratio in determining the likeliness of a country to become a pollution haven, we also include a skill variable (factors endowment), namely the labor-capital ratio, taken from Penn World Tables.

According to FDI theory, natural resources generate macroeconomic uncertainty and as a consequence crowds out FDI for two reasons (Asiedu and Lien (2004)). First, an increase in natural resources will generate inflation by increasing the demand in the nontradeable sector. Second, natural resources (especially oil) are characterized by bursts and booms, which tends to increase exchange rate volatility. Higher inflation and exchange rate volatility increase macroeconomic uncertainty and as a consequence discourage inflows of FDI. The negative relationship between natural resources and FDI flows may also be explained by the fact that while natural resources exploration requires a large initial investment, the continuing operations requires a small cash flow. Thus, after the initial phase, FDI may be staggered. The natural resources variable is proxied by a dummy variable which takes the value of 1 for the 20 host countries with greatest oil reserves in 2006. Another dummy variable for countries with high reserve in natural gas was included in the initial model specification, but had to me dropped because of multicollinearity.

When proximity and contiguity advantages between source and host country (allowing to avoid transport costs) outweigh the concentration advantages (increasing returns to scale), firms will choose FDI. Close cultural environment (including old colonies) has also a positive effect on inflows of FDI (Benassy-Quéné et al. (2007)). Following Stein and Daude (2007), we consider the bilateral distance (defined as the great circle distance between the countries' capitals, as well as a contiguity (1 if both countries are adjacent), colony (1 for any colonial relationship) and common language (1 for common official of primary language) dummy variables. Note that the distance and contiguity variables are also used to create the 3 different spatial weight matrices (contiguity, inverse distance and exponential distance) defined in the previous section.

Trade barriers can affect FDI in multiple ways. In order to avoid obstacles in trade caused by a tariff, foreign firms can have an incentive to invest in the country to which it is difficult to export because of tariff barriers ("tariff jumping FDI"). Thus, a reduction of import barriers deters tariff-jumping FDI, but may encourage vertical FDI by making the imports of inputs and machinery easier. Vertical FDI and (non-tariff-jumping) horizontal FDI is also stimulated by lower export barriers, because the re-export of processed goods is facilitated and the expansion of the effective market size improves business climate and expectation of long-term economic growth. The economic integration is measured here by a dummy variable that takes the value of 1 if there is a ratified bilateral or regional agreement trade (RAT) between the source and host country, 0 otherwise (MacDermott (2006), Stein and Daude (2007)). Note that this dummy variable can vary over time. It will be 0 for the period before the conclusion of the trade agreement and 1 afterwards.

Capital barriers, by their very nature, are difficult to measure, since they can take many forms. Moreover, the effect of trade and capital controls depend of the kind of distortions they create (Asiedu et al. (2004)). One usually distinguishes between administrative or direct controls/barriers and market – based or indirect controls/barriers. While direct controls restrict capital transactions, market-based controls include multiple exchange rate systems, other indirect regulatory controls which affect trade and capital transactions indirectly by increasing the costs associated with trade and capital movements. Although there exist obvious difficulties in measuring capital liberalization, a general positive relationship between a liberal capital regime and FDI, is anticipated (Desai et al. (2006)), Urata et al. (2007)). Following Noy et al. (2007), we use the Ito-Chinn index, which measures the country's regulatory degree of capital account openness. It is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions.

FDI depends also on the country's marketing efforts to attract foreign investment. In order to capture this investment promotion effect, we create a dummy variables for bilateral investments treaties (BIT), which Egger and Pfaffermayr (2004) have found to affect FDI. The initial model specification also included a dummy variable accounting for the existence of a capital tax treaties between the source and host countries (di Giovanni (2005)). Unfortunately, the variable had to be dropped because of multicollinearity with BIT and RAT.

3.3.2 Environmental Stringency

As mentioned previously, simply stated, the pollution haven effect (PHE) refers to the result of profit-seeking multinational firms relocating their production processes to countries which have less stringent environmental regulations. Therefore, its focus is on the difference between environment policy instruments across countries and how this affects capital and trade flows (Ederington and Minier (2003), Bommer (1999)). In practice, measuring environmental stringency is the key problem in this literature (van Soest et al. (2006)). What one wants to know is how much more costly production is in a given country relative to others, due to the country's environmental regulations. These environmental compliance costs could take many forms (Levinson and Taylor (2008)): environmental fees or taxes, permitting costs, regulatory delays, emissions limits that require installation of costly technology, the threat of lawsuits, product or process redesign, forgone output, and so forth. The relative environmental stringency of a host country is proxied here by three complementary measures.

The level of sulphur dioxide SO2 emissions per capita constitutes a good measure of air pollution. The major limitation of this variable is that SO2 emissions may reflect environmental stringency in a narrow way. Moreover, just like CO2 emissions, SO2 series are constructed from fuel consumption data, rather than directly observed (Wagner and Timmins (2008)). Despite this, SO2 emissions constitutes a good proxy for environmental policy. First, SO2 per capita is one of the most significant pollutants worldwide. Milner et al. (2006) show that the reduction in SO2 emission is highly correlated with the level of environmental funds in former Soviet Union countries. Second, it is highly correlated with other pollutants (Xing and Kolstad (2002), MacDermott (2006)). Third, to the extend that pollution reduction is a public good, it suffers less from a "free-ride problem" and is available for a large number of host countries. That is the reason why, environmental stringency will be proxied by the log of SO2 per capita emissions multiplied by -1.

Air pollution can also be measured by the level of carbon dioxide CO2 emissions (Ratnayake et al. (1998), Hoffman et al. (2005)). Reductions in emissions may be viewed as proxies for a host country's effective enforcement of environmental policies. The use of CO2 emissions as a proxy relies on strong assumptions. Some critics argue that CO2 emissions do not reflect only environmental stringency, but also the energy intensity of production. Another problem lies in the fact that the pollution consequences of CO2 emissions are subject to the "free-ride problem" because the damages caused by CO2 emissions are global. There are fewer incentives for a government to modify its environmental policy, which makes it difficult to use CO2 emissions as a proxy for environmental stringency. Therefore, we expect to find less evidence of a PHE with CO2 per capita emissions.

The number of participation in international environmental treaties can also constitute a cross-country proxy, although its use relies on several strong assumptions. First, one implicitly assumes that a ratified treaty will automatically translate into stringer environmental stringency. This would probably be true if there were sanctions for the non-respect of the treaty. Second, each country which signs a treaty will implement the exact same instruments in terms of cost and mechanism to comply with the regulation, which is unrealistic. Therefore, we expect to find less evidence of a pollution haven effect when considering environmental treaties. Following Xing and Kolstad (1998) as well as Smazynska and Wei (2001) and Kirkpatrick and Shimamoto (2005) we construct a variable of environmental treaties that report the number of signed treaties.

Other measures of environmental stringency are used in the literature. Lead-content per gallon of gasoline is considered as a very good dynamic proxy for industry environmental regulations at the country level, not only for its data availability, but correlation with other measures of industry environmental regulations (Cole et al. (2006), Hilton (2006)). First, the authorized content of lead in gasoline is the result from a policy decision. Second, as a local air pollutant, lead emissions has significant health implications, and therefore control of such emissions constitutes an explicit environmental objective. The major drawback of this proxy is that it is only available for 1983-1995. Toward the end of the nineties, most countries including developing ones, switched to gasoline with zero lead content[6]. As a consequence lead is no longer a relevant comparison measure. Other environmental proxies can unfortunately not be considered because of their lack of availability in terms of time period or/and covered countries (e.g. pollution intensities;

[6]The countries that have phased out leaded gasoline, as of January 2002, includes most developed countries (United States, Canada, ...) but also less developed ones (Argentina, Brazil, Colombia, India, Bangladesh, Vietnam, Egypt, ... (source: http://www.unep.org/pcfv/resources/leaded.asp).

water pollution (BOD); fertilizer; WEF's environmental sustainability index (Wagner et al. (2007)); index of environmental sensitivity performance (Cagatay et al.(2006), Mihci et al. (2005)); number of deaths related to pollution; number of environmental NGOs, number of iso 14001 licences).

Independently of the proxy used, we hypothesize a negative relationship between environmental stringency and FDI. Higher environmental standards (ambient quality standards, emission standards, production process standards and products standards) leading to higher environmental costs can deter inflows of FDI. However, it is also possible that environmental stringency can attract FDI in order to gain a competitive advantage through higher standards, which would validate the factor endowment hypothesis (Chudnovsky and Lopez (1999)). As mentioned in the literature review, previous studies (Ederington et al. (2003), Fredriksson et al. (2006), Kellenberg (2007), He et al. (2007)) suggest that not only FDI is sensitive to environmental stringency, but also that environmental policy can be affected by FDI, when the level of corruption and lobby pressures are high or when environmental standards are used as a strategic trade policy. In both cases, this could lead the government to set higher or lower level of environmental policy than it is socially efficient. As a result, environmental stringency has to be treated as (potentially) endogenous.

3.3.3 "Third-Country" Effects

In order to account for the role of spatial dependence and interaction in the data, we include spatially weighted variables. Each spatial variable is computed using the same spatial weight matrix (contiguity, inverse distance or negative exponential distance). For sake of brevity, we only present the results associated with negative exponential distance.

Following Blonigen et al. (2007), the estimation of complex integration strategies of multinationals is done by including a spatial lag bilateral FDI and a variable capturing market potential in neighboring host countries. To capture the fact that FDI from home country i to host country j affects FDI from i to host k and vice-versa, we include a spatial autoregression term: $[W_t FDI_{it}]_{ijt} = \sum_{k \neq j} w_t(d_{k,j}) \cdot FDI_{ikt}$.

The second variable is a measure of the host country proximity to its neighborhood markets. According to Head and Mayer (2004), which applied different measures of host country market proximity in their analysis of Japanese outbound FDI into Europe, a distance-weighted sum of close countries' GDPs yields the best fit for the data. Thus, for a given host country j in year t, the market potential variable is defined as the spatially weighted sum of GDPs of all other countries: $[W_t GDP_t]_{jt} = \sum_{k \neq j} w_t(d_{k,j}) \cdot GDP_{kt}$.

To account for the fact that countries do not define environmental regulation independently (Eliste et al. (2001), Drukker et al. (2007)), we also include a spatially weighted environmental stringency that capture the spatial interdependence of environmental stringency: $[W_t Env.Stringency_t]_j = \sum_{k \neq j} w_t(d_{k,j}) \cdot Env.Stringency_{kt}$. The inclusion of this additional spatial variable is particularly important when one considers SO2 per capita emission as a proxy. According to the geographical location and prevailing wind patterns, levels of acid deposition from SO2 in one country is partially determined by emissions in neighboring countries. As a consequence, any country will have an incentive to behave strategically with respect to emissions originating in neighboring countries (Perkins et al. (2008)). Empirical evidence suggests also that the propensity of a given host country to ratify treaties is positively correlated with the number of treaties signed in the neighborhood countries (Davies et al. (2006)).

To check the presence of spatial correlation (i.e. coincidence of value similarity and locational similarity), we perform two of the most popular global spatial indicators: Moran I (1948) and Geary's C (1954) statistics[7] (Anselin (1999)). Appendix 7.E. provides the results of the Moran and Geary tests for bilateral FDI, GDP and environmental stringency (proxied by SO2 per capita and international treaties). The null hypothesis of no spatial correlation is rejected by both tests for most years for each variable across different spatial weight schemes. More precisely, the results suggest the presence of positive spatial autocorrelation for each variable. In order to account for this significant presence of spatial dependence in each variable, it seems justify to include their spatially weighted counterparts.

Based on the prevailing type of FDI, the expected sign of the spatially weighted variables will be different (see Table 1). Note that the use of data at the country level can only capture net effects. For instance, the spatial lag coefficient may be on average not different from zero but this could simply be the result of export-platform and complex vertical FDI effects cancelling out.

3.4 Econometric Issues

The spatial lag model (equation (3)) is usually estimated using maximum likelihood (ML) or generalized method of moments methods (GMM) (Anselin (1999), Elhorst (2003), (Kapoor et al. (2007)). In fact, one can analytically demonstrate that the spatial lag term $W \cdot FDI$ is correlated with the disturbances, even if u are independently and identically distributed[8]. Each element of *FDI*, depends on a linear combination of all of the error terms. Equation (3) faces simultaneity and endogeneity problems, which in turn means that OLS estimation will be biased and inconsistent. Therefore, the spatial lag term must be treated as an endogenous variable and proper estimation methods must account for this endogeneity.

Spatial econometrics suggest to solve this problem by estimating a reduced form of the model using maximum likelihood. Elhorst (2003) developed a first-differenced model

[7] The Getis and Ord (1992) statistics cannot be computed for all variables of interest in our study, since they can only be applied to positive attribute value (FDI inflows can be negative for instance).

[8] To see this point more formally, note that equation (3) can be rewritten as follows in matrix notation:

$$FDI = (I - \rho W)^{-1} (\delta FDI_{-1} + S\alpha + H\beta + X\gamma + S\eta + \varphi + \mu + u)$$

to eliminate fixed effects and then derived an unconditional likelihood function. He claims that his estimation method is superior to GMM estimator. The main drawback of his method is that, while the serially lagged variable is considered endogenous, other explanatory variables are not. Hence, if other FDI determinants are endogenous or potentially endogenous, which is likely the case in our study[9], no instrumental treatment is applied to control for this econometric problem.

In this trade-off situation, the system GMM estimator, developed by Arellano and Bover (1995) and Blundell and Bond (1998), appears to be the best estimator, since it can deal with the endogeneity of a big number of regressors at the same time. In particular, it corrects for the endogeneity of the spatial lagged dependent variable and other potentially endogenous explanatory variables (Madriaga and Poncet (2007)). GMM-SYS allows also to take into consideration some econometrics problems such as measurement error and weak instruments. It also controls for time-invariant country-specific effects such as distance, culture and political structure. On a practical ground, it also avoids the inversion of the high dimension spatial weights matrix W and the computation of its eigenvalues, which can be sometimes computationally unfeasible to estimate the model[10].

The system GMM estimator consists of estimating equation (1) and (3) as a system of two equations, one in levels and the other one in first-differences. Lagged first-differences are treated as instruments for equations expressed in levels, while lagged levels are used as instruments for equations in first-differences. The consistency of the GMM-SYS estimator relies on the validity of the moment conditions, which depends on the assumption of absence of serially correlation of the level residuals and the exogeneity of the explanatory variables. Therefore, it is necessary to apply specification tests to ensure that these assumptions are justified. Arellano and Bond (2001) suggest two specification tests in order to verify the consistency of the GMM estimator. First, the overall validity of the moment conditions is checked by the Sargan/Hansen test. The null hypothesis is that instruments are not correlated with the residuals. The validity of the moment conditions can also be evaluated with the Sargan/Hansen-difference test, which checks the validity of extra moment conditions over that of weak exogeneity. If the Sargan-difference test rejects the validity of these extra moment conditions, then the strong assumption of strict exogeneity will be in doubt. Aware that too many instrument variables (exceeding the number of groups) tend to validate invalid results through the Hansen J test for joint validity of those instruments, as well as the difference-in-Sargan/Hansen tests for subsets of instruments, we will estimate GMM-SYS using the "collapse" option of `xtabond2` in Stata 10 (Roodman (2006) and (2007)), which does not separate the instruments for each period.

[9] Beside the endogeneity issue related to omitted variables and the inclusion of a lagged dependent variables (lagged FDI), estimation might also be biased, if one does not take into account the likely endogeneity of environmental stringency and other explanatory variables (GDP, trade and capital barrier,...) with respect to FDI flows (especially in developing countries where FDI can play a key role in the national economic development (Cole and Fredrikson (2006)).

[10] In our setting, the spatial weights matrix W is 20'435 $\times$20'435.

In this study, the system-GMM estimation will rely on the following instruments structure. The variables considered as endogenous (lagged FDI, environmental stringency, spatial variables) are instrumented by their second and third lag as well as their two and three lagged first-difference. The variables potentially endogenous and predetermined (host GDP, growth of GDP, country's risk) receive the same treatment. To account for the fact that the capital openness index is relatively constant over time, we instrument it using its 5 first lags only for the equation expressed in first-difference. The capital-labour ratio and manufacturing variables are used as additional external variables and treated as predetermined. GDP of the source country is treated as strictly exogenous. The time fixed effects, the natural resources dummy as well as the gravity variables (distance and colonial links) are also treated as strictly exogenous, but used only in the first-difference specification. Following Xing and Kolstad (2002), we include population density as an external exogenous variable. The latter is an indicator of congestion and the ability of pollutants to naturally disperse away from population centers. This instrument is unlikely to be correlated with the error term, that is why they are used in level and first-difference. We also correct the standard errors for small sample bias by applying the Windmeijer correction and using a two-step procedure.

4 Panel Estimation Results

Before performing tests and estimating the model, it is always interesting to proceed at a graphical exploratory analysis of the relationship between inflows FDI and environmental stringency. Figure 1 depicts the spatial location of OECD's outbound FDI to host countries and their level of environmental stringency proxied by the number of international environmental treaties. First, it is interesting to note that most OECD's FDI happen among OECD countries. Only a small fraction of FDI is allocated to less developed countries. Among these countries, some countries like Brazil or China can be considered as potential pollution haven countries, since they display a relatively low environmental stringency but attract a large amount of FDI from OECD countries.

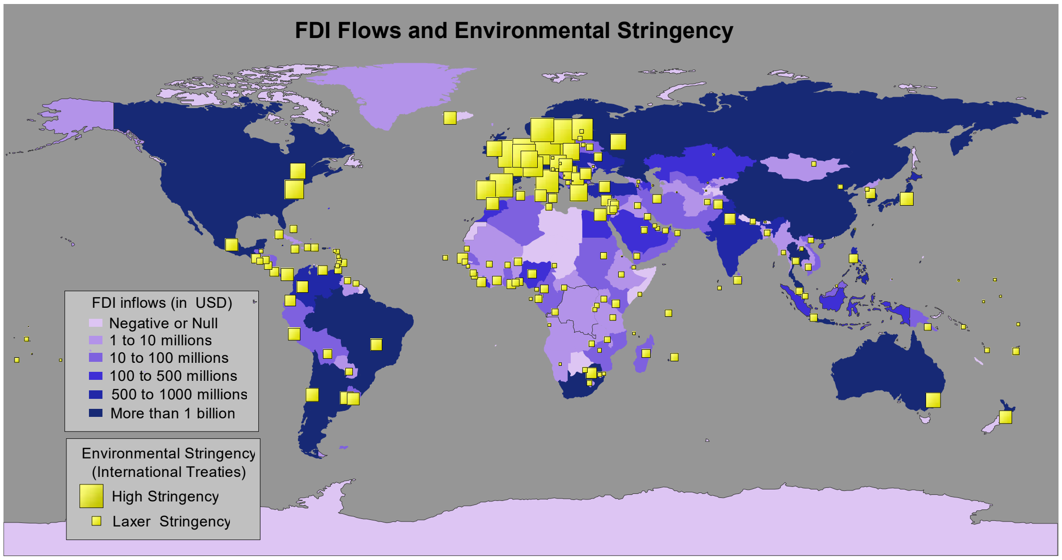

Figure 1: Average inflows FDI and environmental stringency (1981-2004)

Although most empirical FDI panel studies ignore the problem of non-stationarity, we decide to check for stationarity of the variables included in the main regression performing panel unit root tests. The need to exercise caution is emphasized when dealing with panels of relative short time dimension as in our case. We perform first-generation (Im, Pesaran and Shin (2003), Levin, Lin and Chu (2002), Maddala and Wu (1999)) and second-generation (Pesaran (2004), Bai and Ng (2003), Choi test (2001)) panel unit roots[11] since the Pesaran's error cross-section dependence test (2004) indicates that the bilateral FDI display cross-section dependence[12]. All panel unit root tests considered here have non-stationarity for all individual series as a null hypothesis, but different alternatives. The results, given in appendix 7.G, reject the null hypothesis of non-stationarity for all individual series in most cases. The rejection of the null does not imply that the entire panel is stationary. A Kao cointegration test (1999) was also performed based test (appendix 7.F). It clearly rejects the hypothesis of non-stationarity in the residuals. These results should however be considered cautiously, since there can be considerable size distortions in panel unit root tests when spatial dependence exists (Baltagi et al. (2007)). In any case, the use of GMM-SYS partially corrects for the non-stationarity when estimating the first-difference equation. Moreover, when the number of groups exceeds the sample period, the problems associated with non-stationarity are mitigated.

[11] All panel unit root tests have been performed using Matlab. A lag of 5 was used for the tests requiring the specification of the number of lags. All variables tested are expressed in logarithm and level.

[12] The test statistic computed using residual from a model with individual effects is equal to 12.04 and its p-value is 0.00. With a model including individual effects and a trend, the CD statistic is 13.856 with a p-value of 0.00.

We first present the results associated with the full sample to determine potential biases caused by omitting the spatial structure of the data and by not instrumenting for environmental stringency (proxied by SO2 per capita emissions) and other potential endogenous variables. Then, since the motivation behind investment to developed and developing countries may be quite different, we estimate models for OECD and non-OECD host countries samples. The baseline model deliberately includes a limited number of explanatory variables in order to avoid multicollinearity problems and a decrease in the sample size. The robustness check in the next section investigates the inclusion of additional FDI determinants and the use of other proxies for environmental stringency.

4.1 Baseline Results

Table 6 reports the results for the full sample (OECD and nonOECD host countries). The first three columns display the results without any spatial features for fixed effects, random effects and system-GMM respectively. The other four remaining columns present the system-GMM estimations including third-country effects (using a negative inverse exponential distance). More precisely, we first add the spatial lag dependent variable, we then include separately the spatially weighted environmental stringency and market potential variable, to finally consider the three spatially weighted variables together. This sequence of specifications allows us to study the sensitivity of the results to the assumption of exogenous environmental stringency and the inclusion of third-country effects.

Despite the fact that most variables are significant and display the expected sign in the random effect regression, the Hausman specification test suggests that the fixed effect model is preferred over the random effect specification. Overall, the estimates associated with fixed effect are relatively poor. Only a few variables are significant. This should not come as a surprise since the fixed effect estimator does not correct for the endogeneity of the lagged dependent variable and environmental stringency. When this issue is taken into account by instrumenting the lagged dependent variable and environmental stringency, as GMM-SYS allows it, the results clearly improve. The estimated coefficients usually lie between the ones from random and fixed effect. The lagged bilateral FDI becomes significant, while the coefficient of environmental stringency switches from positive to negative. The evidence suggests a positive endogenous bias in the pollution haven effect.

Table 6: Full Sample Results

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.012	0.199***	0.069***	0.064***	0.065***	0.062***
	[0.012]	[0.011]	[0.022]	[0.022]	[0.022]	[0.022]
GDP Host	0.885**	0.557***	0.644***	0.634***	0.560***	0.578***
	[0.449]	[0.033]	[0.143]	[0.131]	[0.146]	[0.146]
GDP Source	4.648***	0.802***	0.973***	0.597***	0.560***	0.588***
	[0.824]	[0.033]	[0.065]	[0.121]	[0.125]	[0.130]
GDP growth	0.021	0.089***	0.065	0.01	0.011	-0.009
	[0.013]	[0.031]	[0.071]	[0.074]	[0.073]	[0.072]
V.A. Dirty Shares	-0.23	-0.137	0.376	-0.152	-0.238	-0.062
	[0.213]	[0.133]	[0.360]	[0.383]	[0.375]	[0.379]
Risk Index	-2.092***	-1.001***	-2.382***	-1.650*	-1.082	-1.386
	[0.547]	[0.340]	[0.868]	[0.875]	[0.800]	[0.863]
Capital Openness	-0.015	0.151***	0.071	-0.027	0.011	0.035
	[0.089]	[0.048]	[0.146]	[0.146]	[0.146]	[0.145]
Oil Resources		-0.116	-0.233	-0.455*	-0.345	-0.303
		[0.111]	[0.300]	[0.274]	[0.296]	[0.293]
Colonial Links		0.859***	1.005***	1.021***	0.977***	0.935***
		[0.146]	[0.267]	[0.279]	[0.282]	[0.279]
Distance		-0.575***	-0.624***	-0.474***	-0.445***	-0.541***
		[0.039]	[0.071]	[0.086]	[0.090]	[0.111]
Environmental Stringency	0.356**	-0.305***	-0.670***	-0.437**	-0.485***	-0.512***
	[0.172]	[0.044]	[0.174]	[0.178]	[0.181]	[0.182]
Spatial Lag FDI				0.512***	0.537***	0.513***
				[0.148]	[0.155]	[0.158]
Market Potential					0.131	0.069
					[0.184]	[0.190]
Spatial Stringency						0.441
						[0.306]
Observations	8680	8680	8454	8454	8454	8454
Groups	699	699	678	678	678	678
R-squared	0.033	.	.	.	.	.
Instruments	.	.	145	148	151	151
Arrellano-Bond AR(2)	.	.	0.706	0.631	0.617	0.652
Sargan test	.	.	0.249	0.587	0.637	0.627
Hansen Test	.	.	0.501	0.63	0.531	0.566

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations. Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

More generally, the different specifications associated with system-GMM seem appropriately specified, since the Hansen test of the overidentifying restriction is passed without any difficulties, the null hypothesis being robust estimator, but possibly weakened by many instruments. The Sargan test of over-identification tests the null hypothesis of absence of robustness but not weakened by too many instruments. As discussed in Roodman (2006, 2007), having too many instruments in the regression can overfit the model and, at the same time, weakens the power of the Hansen test to detect overidentification. Since we deliberately limited the number of instruments to be always significantly smaller than the number of groups (rule of thumb), we pay less attention to the Sargan test. The Arellano-Bond test for second-order serial correlation in the residuals (m_2) cannot reject the null of no correlation by any standard levels of significance for all specifications. The different model specifications are, therefore, correctly specified and instrumented.

The results show that the most important classical determinants of FDI have the expected sign and are significantly different from zero. In particular, the measure of agglomeration effect (lagged bilateral FDI) is significant in all SYS-GMM specifications which is consistent with other empirical studies (Wagner and Timmins (2008) among others). The host and source countries' GDP are significant across all specification which is fairly intuitive and in line with the claim that market size is the single most important factor in the investment location decision. In other words, large home countries are more likely to invest abroad, while large host countries are more likely to receive FDI. The standard gravity variables (distance and colonial links) are clearly significant across specifications, which is corroborated by Stein and Daude (2007). The negative coefficient for the distance variable is supportive of the prevalence of vertical-type of FDI.

The last three specifications allow us to highlight the most prevailing type of FDI from OECD countries (see Table 1). Since the spatial lag is positive and significant and the market potential is insignificant, complex FDI seem to be the most prevailing type of FDI. However, one should be careful with the interpretation of these results. As noted by Blonigen and Davies (2004) combining rich and poor countries in FDI data can lead to implausible coefficient estimates. The next section takes this issue into account.

4.2 OECD vs. Non-OECD Host Countries

Since the motivation behind investment to developed and developing countries may be quite different, especially in the case of the PHE (Hoffmann et al. (2005)), combining FDI destined to developed and developing countries may introduce undesirable noise into the data. In line with this consideration, we reestimate separately the different model specifications for two subsamples. Table 7 and 8 display the results for FDI to high-income OECD and to non OECD countries[13], respectively.

[13] Only high income OECD countries are dropped. Mexico, Turkey, Korea, Hungary, Poland, Czeck Republic and Slovak Republic remain in the sample, since they can be considered as potential pollution haven (Cole and Elliott (2005)) (see Appendix 7.A.).

Overall, the comments made in the previous section can be reiterated for both tables. Based on the Hausman test, the fixed effect model is preferred over the random effect model. The classical determinants of FDI are in most cases significant with the expected sign. Not correcting for potential endogeneity of environmental stringency yields a different conclusion in each sub-sample. In the OECD host sample, the environmental stringency has initially a positive effect, but after correction it is no longer significant. In the non-OECD host sample, the endogeneity problem tends to mask the presence of a negative and significative pollution haven effect. The fact that the pollution haven effect is always significant for less developed countries is in line with the theory (Taylor (2005)). It is further corroborated by the fact that the most prevailing type of FDI is complex vertical integrated. Following Edgerington et al. (2005), the non-significant coefficient of the value-added share of dirty industries can be attributed to the fact that the most polluting industries are not necessarily the most likely to react to stringer environmental regulation (due to high sunk costs for instance).

A positive and significant spatial lag coefficient and not significant market potential rule in favour of a higher prevalence of complex FDI from OECD countries toward less developed host countries. There is also evidence of a complementary relationship in the allocation of FDI to high income host countries. Note that these results differ from the findings of Blonigen et al. (2005). They found strong evidence of vertical FDI from the United States to non-OECD countries and export platform FDI to developed European countries. However, our findings are in line with Garresten and Peeters (2008), who highlight the presence of complex FDI for Dutch outbound FDI to developed and developing host countries. In any case, one should be careful with comparisons, since we consider not only one but several parent countries.

Table 7: OECD Host Sample Results

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.013	0.189***	0.065**	0.058**	0.060**	0.060**
	[0.015]	[0.014]	[0.026]	[0.026]	[0.026]	[0.026]
GDP Host	0.907	0.555***	0.597***	0.634***	0.668***	0.668***
	[0.913]	[0.047]	[0.117]	[0.106]	[0.107]	[0.106]
GDP Source	5.831***	0.812***	0.949***	0.650***	0.615***	0.596***
	[1.089]	[0.042]	[0.072]	[0.149]	[0.152]	[0.145]
GDP growth	-0.002	0.046	-0.049	-0.073	-0.051	-0.062
	[0.026]	[0.064]	[0.094]	[0.097]	[0.098]	[0.098]
V.A. Dirty Shares	-0.384	0	-0.209	-0.609	-0.594	-0.577
	[0.338]	[0.268]	[0.434]	[0.490]	[0.471]	[0.486]
Risk Index	-1.931	-1.405	-2.528	-3.194	-3.445	-2.848
	[1.629]	[1.275]	[2.741]	[2.623]	[2.571]	[2.587]
Capital Openness	-0.025	0.102	0.287	0.202	0.17	0.178
	[0.148]	[0.132]	[0.227]	[0.223]	[0.212]	[0.219]
Oil Resources		0.021	0.21	-0.263	-0.232	-0.004
		[0.176]	[0.378]	[0.383]	[0.365]	[0.403]
Colonial Links		0.972***	1.036**	0.932**	0.854*	0.962**
		[0.213]	[0.444]	[0.468]	[0.448]	[0.439]
Distance		-0.712***	-0.781***	-0.711***	-0.721***	-0.729***
		[0.052]	[0.099]	[0.099]	[0.096]	[0.097]
Environmental Stringency	0.843***	-0.366***	-0.276	-0.378**	-0.307	-0.17
	[0.246]	[0.078]	[0.191]	[0.184]	[0.188]	[0.190]
Spatial Lag FDI				0.455**	0.496**	0.527***
				[0.201]	[0.205]	[0.187]
Market Potential					-0.181	-0.203
					[0.227]	[0.230]
Spatial Stringency						0.564
						[0.421]
Observations	5038	5038	5016	5016	5016	5016
Groups	330	330	329	329	329	329
R-squared	0.031	.	.	.	.	.
Instruments	.	.	144	147	150	153
Arellano-Bond AR(2)	.	.	0.699	0.794	0.782	0.769
Sargan test	.	.	0.0576	0.198	0.253	0.226
Hansen Test	.	.	0.446	0.462	0.524	0.552

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations. Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 8: Non-OECD Host Sample Results

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	-0.006	0.197***	0.088**	0.074*	0.074*	0.077*
	[0.018]	[0.017]	[0.037]	[0.038]	[0.038]	[0.041]
GDP Host	0.171	0.759***	0.807***	0.599***	0.621***	0.500**
	[0.545]	[0.061]	[0.204]	[0.199]	[0.219]	[0.232]
GDP Source	2.296*	0.802***	0.859***	0.440***	0.432***	0.377***
	[1.257]	[0.052]	[0.091]	[0.130]	[0.132]	[0.146]
GDP growth	0.045***	0.044	0.111	0.066	0.065	0.063
	[0.015]	[0.036]	[0.071]	[0.072]	[0.071]	[0.072]
V.A. Dirty Shares	-0.488*	-0.186	-0.128	-0.495	-0.533	-0.66
	[0.287]	[0.153]	[0.345]	[0.355]	[0.403]	[0.445]
Risk Index	-0.708	-1.543***	-0.274	-0.49	-0.687	-1.092
	[0.656]	[0.475]	[0.987]	[0.969]	[0.891]	[0.911]
Capital Openness	0.163	0.277***	0.253**	0.188	0.189	0.149
	[0.115]	[0.061]	[0.127]	[0.128]	[0.134]	[0.138]
Oil Resources		-0.516***	-0.665	-0.542	-0.593	-0.417
		[0.164]	[0.422]	[0.402]	[0.439]	[0.460]
Colonial Links		0.773***	0.984***	0.602**	0.597**	0.609**
		[0.196]	[0.338]	[0.299]	[0.296]	[0.306]
Distance		-0.478***	-0.365***	-0.187	-0.198	-0.134
		[0.077]	[0.131]	[0.131]	[0.132]	[0.179]
Environmental Stringency	-0.295	-0.339***	-0.745***	-0.549***	-0.528***	-0.430**
	[0.293]	[0.066]	[0.187]	[0.201]	[0.200]	[0.203]
Spatial Lag FDI				0.549***	0.557***	0.607***
				[0.140]	[0.136]	[0.151]
Market Potential					-0.033	-0.006
					[0.222]	[0.246]
Spatial Stringency						-0.155
						[0.336]
Observations	3642	3642	3438	3438	3438	3438
Groups	369	369	349	349	349	349
R-squared	0.062	.	.	.	.	.
Instruments	.	.	145	148	151	154
Arrellano-Bond AR(2)	.	.	0.857	0.55	0.546	0.518
Sargan test	.	.	0.262	0.275	0.316	0.28
Hansen Test	.	.	0.619	0.745	0.769	0.709

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations.
Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

5 Robustness Check

It is obviously relevant to ask to what extent our results are sensitive to the use of SO2 per capita as a proxy for environmental stringency[14]. Therefore, we re-estimate the model using CO2 emission per capita and the number of international environmental treaties as complementary proxies for the environmental stringency. Finally, we consider the initial model specification and include additional FDI determinants to make sure that the level of SO per capita emission does not capture other factors.

5.1 Additional Environmental Stringency Proxies

As mentioned previously, the use of CO2 per capita and international environmental treaties as a proxy relies on stronger assumptions than SO2 per capita. Therefore, we expect to find less evidence of a pollution haven effect when considering these two proxies. Table 9 and 10 display the estimation results for the non-OECD host country sample[15]. Note that the same instruments and lags structure as in the main results is used to estimate the spatial model.

Most results found previously are also confirmed in table 9. One major difference in table 10 is the fact that the country risk index and the distance are now significant. In both tables, the results suggest the prevalence of complex FDI from OECD countries to less developed countries. As table 9 documents it, the environmental stringency is negative and significant, only when we take into account the spatial structure of the data. In other words, ignoring spatial dependence can mask the pollution haven effect. The reason why this happens for CO2 and not SO2 emissions is probably related to the fact that carbon dioxide emissions are a more global air pollutant. The same kind of pattern happens with international treaties. The PHE becomes significant only when the spatial model includes the spatially weighted environmental stringency variable. More precisely, the allocation of FDI to a given host country is not only determined by the environmental regulation in the host economy, but also by the environmental stringency in the neighborhood countries. This finding is in line with the results of Davies and Naughton (2006). They show that the participation to international environmental treaties for non-OECD countries depends, among other factors, on the participation of proximate similar countries. In any cases, this confirms once again the prevalence of complex vertical FDI among OECD home countries. In order to integrate the different intermediate production processes, the MNE considers a system of close countries rather than a single host economy.

[14] We also estimated the model using SO2 per GDP to account for the economic activity. The results were similar (i.e. significant pollution haven effect), although multicollinearity problems arose with host and source's GDP.

[15] Appendix 7.E and 7.F report the results for OECD countries.

Table 9: Non-OECD Host Sample Results with CO2 per capita

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.001	0.189***	0.084**	0.068**	0.068**	0.067**
	[0.017]	[0.016]	[0.034]	[0.034]	[0.034]	[0.034]
GDP Host	1.078**	0.691***	0.804***	0.544***	0.453**	0.402*
	[0.542]	[0.058]	[0.196]	[0.202]	[0.217]	[0.229]
GDP Source	1.531	0.784***	0.838***	0.380***	0.405***	0.462***
	[1.135]	[0.049]	[0.099]	[0.137]	[0.136]	[0.138]
GDP growth	0.118***	0.070**	0.089	0.062	0.054	0.05
	[0.037]	[0.035]	[0.075]	[0.077]	[0.074]	[0.073]
V.A. Dirty Shares	-0.198	-0.059	-0.031	-0.402	-0.175	-0.001
	[0.268]	[0.141]	[0.357]	[0.350]	[0.395]	[0.432]
Risk Index	-1.432**	-1.901***	-2.128**	-1.372	-1.169	-1.553
	[0.612]	[0.464]	[1.051]	[1.023]	[0.958]	[0.956]
Capital Openness	0.215**	0.177***	0.101	0.078	0.039	0.002
	[0.098]	[0.056]	[0.143]	[0.133]	[0.133]	[0.136]
Oil Resources		-0.413***	-0.678	-0.345	-0.177	-0.077
		[0.155]	[0.436]	[0.427]	[0.449]	[0.473]
Colonial Links		0.864***	0.936***	0.550*	0.562*	0.476
		[0.184]	[0.288]	[0.302]	[0.299]	[0.326]
Distance		-0.493***	-0.513***	-0.201	-0.169	-0.204
		[0.074]	[0.134]	[0.139]	[0.136]	[0.225]
Environmental Stringency	-0.019	-0.290***	-0.326	-0.393	-0.445*	-0.436*
	[0.386]	[0.068]	[0.234]	[0.247]	[0.249]	[0.256]
Spatial Lag FDI				0.615***	0.590***	0.540***
				[0.143]	[0.139]	[0.138]
Market Potential					0.207	0.272
					[0.222]	[0.244]
Spatial Stringency						0.087
						[0.360]
Observations	4236	4236	4012	4012	4012	4012
Groups	385	385	365	365	365	365
R-squared	0.065	.	.	.	.	.
Instruments	.	.	145	148	151	154
Arellano-Bond AR(2)	.	.	0.875	0.903	0.91	0.938
Sargan test	.	.	0.454	0.679	0.702	0.703
Hansen Test	.	.	0.299	0.412	0.5	0.577

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations. Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

Table 10: Non-OECD Host Sample Results with Environmental Treaties

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.012	0.180***	0.071**	0.05	0.048	0.054*
	[0.016]	[0.015]	[0.031]	[0.031]	[0.032]	[0.032]
GDP Host	0.994**	0.709***	0.829***	0.568***	0.648***	0.641***
	[0.475]	[0.056]	[0.196]	[0.198]	[0.238]	[0.231]
GDP Source	2.407**	0.782***	0.893***	0.424***	0.411***	0.449***
	[1.038]	[0.047]	[0.092]	[0.133]	[0.134]	[0.130]
GDP growth	0.046***	0.023*	0.093	0.057	0.052	0.041
	[0.014]	[0.013]	[0.080]	[0.082]	[0.082]	[0.078]
V.A. Dirty Shares	-0.161	-0.025	-0.209	-0.377	-0.509	-0.392
	[0.249]	[0.138]	[0.355]	[0.358]	[0.408]	[0.398]
Risk Index	-1.997***	-2.458***	-1.887**	-1.494**	-1.590**	-1.645**
	[0.424]	[0.325]	[0.834]	[0.731]	[0.704]	[0.692]
Capital Openness	0.14	0.236***	0.135	0.067	0.106	0.105
	[0.090]	[0.058]	[0.153]	[0.141]	[0.144]	[0.138]
Oil Resources		-0.459***	-0.614	-0.199	-0.323	-0.226
		[0.152]	[0.431]	[0.413]	[0.455]	[0.459]
Colonial Links		0.902***	0.815***	0.688***	0.695***	0.709***
		[0.180]	[0.308]	[0.266]	[0.261]	[0.263]
Distance		-0.527***	-0.640***	-0.307**	-0.340**	-0.257*
		[0.068]	[0.133]	[0.138]	[0.155]	[0.153]
Environmental Stringency	-0.28	0.059	-0.189	-0.221	-0.246	-0.363**
	[0.678]	[0.070]	[0.181]	[0.156]	[0.176]	[0.178]
Spatial Lag FDI				0.618***	0.631***	0.595***
				[0.137]	[0.139]	[0.130]
Market Potential					-0.138	0
					[0.261]	[0.262]
Spatial Stringency						0.679*
						[0.405]
Observations	4756	4756	4496	4496	4496	4496
Groups	385	385	365	365	365	365
R-squared	0.06	.	.	.	.	.
Instruments	.	.	157	160	163	166
Arellano-Bond AR(2)	.	.	0.855	0.865	0.885	0.821
Sargan test	.	.	0.202	0.429	0.474	0.559
Hansen Test	.	.	0.24	0.277	0.295	0.297

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations.
Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

The fact that there is less evidence of pollution haven effect using international environmental treaties should not come as a surprise. As mentioned previously, this last proxy relies on stronger assumptions, which are less likely to hold for less developed countries. The enforcement is weak because monitoring is lax or non-existent. Recent empirical evidence suggests that MNEs are more sensitive to the enforcement of the environmental policy than the level of stringency itself (Kellenberg (2007)). This finding might even be more relevant, if we take into account the fact that decentralized local governments tend to set or implement lower environmental standards in order to attract mobile capital. This could partially explain why the correlation between SO2 per capita emissions and the number of international treaties is not robust across the different subsamples. For instance, it is positive for the OECD sample, while for the non-OECD and full sample it is weakly negative. The use of environmental treaties leads also to high collinearity with several variables (capital openness index and country risk index among others), which could explain why environmental stringency is not significant. It is interesting to note that capital openness and ratification of international environmental treaties are related, especially for small countries, in terms of diplomacy and willingness to comply with international standards.

5.2 Additional FDI Determinants

Since the evidence of pollution haven effect is less clear when we consider the levels of CO2 per capita or the number of international environmental treaties as a measure of environmental stringency, we have to make sure that the use of the level of SO2 per capita emission does not capture other FDI determinants. The next table reports the system-GMM estimations for the non-OECD sample by adding one by one additional control to the set of the regressors[16]. This way we can detect any multicollinearity problem. Note that the inclusion of some explanatory variables decreases significantly the sample size of the panel. Therefore, one should be cautious when comparing the different results.

Overall, the inclusion of the remaining additional FDI determinants leave the results unchanged. Most of theses additional explanatory variables have the expected sign but are not significantly different from zero. The fact that environmental stringency, proxied by SO2 per capita emission, remains negative and significant, clearly indicates that it does not capture any other factors. More precisely, the first variable considered is phone in order to capture the infrastructure level of the host economy. Its inclusion does not alter the results. School Enrollment is used to account for human capital. This variable is only available every 5 years. That is why it has been interpolated. This variable is only available every 5 years. That is why it has been interpolated.

[16] Appendix 7.G reports the results for OECD countries.

Table 11: Non-OECD Host Sample Results with Additional FDI Determinants

	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.082**	0.114***	0.067*	0.084**	0.071*	0.110***
	[0.037]	[0.040]	[0.036]	[0.039]	[0.039]	[0.037]
GDP Host	0.961***	0.724***	0.946***	0.748***	0.774***	0.754***
	[0.181]	[0.223]	[0.189]	[0.191]	[0.204]	[0.198]
GDP Source	0.862***	0.972***	0.892***	0.821***	0.921***	0.861***
	[0.091]	[0.099]	[0.099]	[0.095]	[0.105]	[0.098]
GDP growth	0.148**	0.063	0.096	0.132*	0.133*	0.133*
	[0.070]	[0.098]	[0.077]	[0.078]	[0.077]	[0.072]
V.A. Dirty Shares	0.028	0.083	-0.082	-0.376	-0.234	0.246
	[0.337]	[0.361]	[0.313]	[0.342]	[0.360]	[0.356]
Risk Index	-0.439	-0.601	-1.023	0.148	-0.48	0.087
	[0.960]	[1.170]	[1.028]	[1.076]	[1.029]	[1.017]
Capital Openness	0.129	0.159	0.241**	0.191	0.310**	0.181
	[0.151]	[0.139]	[0.122]	[0.139]	[0.142]	[0.130]
Oil Resources	-0.855**	-0.42	-0.862**	-0.556	-0.539	-0.537
	[0.395]	[0.465]	[0.389]	[0.390]	[0.422]	[0.395]
Colonial Links	1.065***	1.150***	1.038***	0.951**	0.843**	1.009***
	[0.304]	[0.404]	[0.368]	[0.379]	[0.365]	[0.354]
Distance	-0.394***	-0.375***	-0.400***	-0.402***	-0.469***	-0.345***
	[0.126]	[0.143]	[0.138]	[0.136]	[0.164]	[0.133]
Environmental Stringency	-0.468**	-0.828***	-0.535***	-0.663***	-0.723***	-0.804***
	[0.221]	[0.191]	[0.182]	[0.177]	[0.208]	[0.191]
Phone	0.284					
	[0.219]					
School Enrollment		-0.313				
		[0.717]				
Bilateral Investment Treaties			-0.134			
			[0.278]			
Capital Tax Agreements				-0.550*		
				[0.285]		
Regional Agreement Trades					-0.174	
					[0.510]	
Openness						0.014
						[0.232]
Observations	3438	2787	3438	3438	3438	3250
Groups	349	342	349	349	349	334
Instruments	148	121	233	227	199	148
Arrellano-Bond AR(2)	0.897	0.337	0.953	0.889	0.988	0.631
Sargan test	0.359	0	0.155	0.053	0.10	0.066
Hansen Test	0.536	0.52	0.811	0.697	0.813	0.561

Two-Step System-GMM estimations. Time dummies and constant not reported.
Standard errors incorporating the Windmeijer correction in brackets.
*** significant at 1, ** significant at 5, * significant at 10.

Table 11: Non-OECD Host Sample Results with Additional FDI Determinants (continued)

	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.068*	0.077**	0.087**	0.046	0.080**	0.079**
	[0.036]	[0.037]	[0.038]	[0.059]	[0.039]	[0.040]
GDP Host	0.885***	0.819***	0.799***	0.815***	0.951***	0.912***
	[0.279]	[0.181]	[0.187]	[0.287]	[0.216]	[0.214]
GDP Source	0.850***	0.877***	0.882***	0.899***	0.874***	0.899***
	[0.096]	[0.093]	[0.096]	[0.109]	[0.097]	[0.094]
GDP growth	0.125*	0.089	0.085	-0.028	0.016	0.024
	[0.075]	[0.072]	[0.072]	[0.116]	[0.082]	[0.080]
V.A. Dirty Shares	0.106	0.169	0.004	0.089	-0.179	-0.208
	[0.426]	[0.369]	[0.361]	[0.505]	[0.366]	[0.366]
Risk Index	-0.96	0.216	-0.519	-1.368	-0.99	-0.875
	[1.025]	[0.964]	[0.989]	[1.668]	[1.027]	[1.029]
Capital Openness	0.139	0.126	0.249*	0.208	0.255*	0.293**
	[0.150]	[0.143]	[0.150]	[0.184]	[0.137]	[0.133]
Oil Resources	-0.942**	-0.641	-0.673	-0.089	-0.908**	-0.778*
	[0.443]	[0.390]	[0.413]	[0.577]	[0.446]	[0.448]
Colonial Links	1.049***	0.956***	0.906***	1.087*	0.962**	1.356***
	[0.326]	[0.337]	[0.335]	[0.579]	[0.412]	[0.407]
Distance	-0.410***	-0.436***	-0.403***	-0.503***	-0.426***	-0.472***
	[0.132]	[0.131]	[0.139]	[0.172]	[0.141]	[0.130]
Environmental Stringency	-0.628***	-0.629***	-0.714***	-0.756***	-0.620***	-0.667***
	[0.201]	[0.189]	[0.221]	[0.227]	[0.174]	[0.175]
Exports	0.075					
	[0.266]					
Free Trade Index		1.507*				
		[0.856]				
Tariff Index			0.012			
			[1.095]			
Corruption Index				-0.214		
				[0.500]		
Contiguity					1.074*	
					[0.567]	
Common Language						-0.528
						[0.427]
Observations	3261	3433	3432	1769	3069	3069
Groups	348	348	348	338	348	348
Instruments	148	148	148	73	141	141
Arrellano-Bond AR(2)	0.917	0.948	0.854	0.756	0.636	0.645
Sargan test	0.008	0.243	0.185	0.003	0.019	0.019
Hansen Test	0.365	0.576	0.486	0.234	0.289	0.329

Two-Step System-GMM estimations. Time dummies and constant not reported.
Standard errors incorporating the Windmeijer correction in brackets.
*** significant at 1, ** significant at 5, * significant at 10.

Its estimated coefficient is significantly positive but extremely high with respect to other coefficients. This usually happens when the variable doesn't exhibit a lot of time variation. This can also be caused by the fact that we already indirectly account for the labour skill in the host economy when we use the capital-labor ratio as a GMM instrument. In any case, the pollution haven effect remains negative and significantly. This is also the case with the inclusion of a bilateral investment treaties and capital tax agreements dummies, in order to account for the host country's marketing efforts to attract foreign investments. The literature considers the openness to trade as an important FDI determinant, that is why we consider several measures. The first proxy is a dummy variable for the existence of regional agreements trade. The ratio of exports to GDP and total exports are also used. An index to assess the level of free trade of the economy and another one for the importance of trade tariff are considered. In all specifications, the associated coefficient is not significant. Despite the fact that the baseline model already accounts for the level of corruption, through a country's risk index financial, economic and political risks), we include an index of corruption. Note that the inclusion of this index decreases the sample size by half. This could explain why the agglomeration effect is no longer significant. The last two additional explanatory variables are part of the classical gravity variables. Just like the other control variables, the contiguity and common language dummies don't change the result of the other coefficients. Therefore, the evidence of the pollution haven effect seems to be robust across specifications.

6 Conclusion

This paper has examined whether environmental stringency in a host country has an influence on inflows of FDI. In addition to traditional determinants of FDI, the model included spatially weighted variables in order to account for "third-country" effects. The estimations were carried out on a sample of bilateral FDI from OECD countries to a large number of host countries over the period 1981-2003. The use of System-GMM allowed us to apply a thorough treatment to potential simultaneity, endogeneity bias and spatial characteristics of the data. We showed the importance of correcting for the endogeneity of the environmental regulation. Most specifications yield a significant negative relationship between environmental stringency and inflows of FDI, once endogeneity and spatial dependence are taken into account. This finding is robust across specifications but also using different environmental stringency proxies. The findings suggest the prevalence of complex FDI between OECD countries and lower income countries. There is also some evidence of a positive "third-country" effect for environmental stringency. Multinationals consider the environmental stringency of the host country as well as the ones of the neighborhood countries. This can be interpreted as potential competition between host countries in terms of environmental standard in order to attract FDI.

The policy implications are not necessarily straightforward. Environmental stringency can be used as an instrument to attract manufacturing multinationals. However, the host country should be aware that they will mainly attract intermediate goods production through complex FDI. In other words, they will be part of only a small part of the production process, the most polluting one. In terms of economic development, this is not necessarily the best way to ensure long term economic growth.

Although the findings are largely plausible across specifications, they should, be taken with cautious. The proxies for environmental stringency are unfortunately still imperfect and scarce. The use of a more reliable proxy for environmental stringency would reduce the bias associated with the omission of variables. Another possible extension would be to estimate the specification using bilateral data at the industry level in order to control more accurately for the polluting intensive composition effect. Unfortunately, disaggregated bilateral FDI is scarce. It is only available for a few countries and a few years. These are probably the main challenges the study of FDI-Pollution Haven linkages at the world-wide level faces.

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7 Appendices

7.A Country Lists

Host Countries

Afghanistan; Albania; Algeria; Angola; Argentina; Armenia; Australia; Austria; Azerbaijan; Bangladesh; Belarus; Belgium-Luxemburg; Benin; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Bulgaria; Burkina; Faso; Burundi; Cambodia; Cameroon; Canada; Central African Republic; Chad; Chile; China; Colombia; Congo Rep.; Costa Rica; Croatia; Cuba; Czech Republic; Côte d'Ivoire; Denmark; Dominican Republic; Ecuador; Egypt; El Salvador; Eritrea; Estonia; Ethiopia; Finland; France; Gabon; Gambia; Georgia; Germany; Ghana; Greece; Guatemala; Guinea; Haiti; Honduras; Hong Kong; Hungary; India; Indonesia; Iran; Iraq; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Korea Dem. Rep.; Korea Rep.; Kuwait; Kyrgyz Republic; Lao; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Macedonia; Madagascar; Malawi; Malaysia; Mali; Mauritania; Mauritius; Mexico; Moldova; Mongolia; Morocco; Mozambique; Myanmar; Namibia; Nepal; Netherlands; New Zealand; Nicaragua; Niger; Nigeria; Norway; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Romania; Russian Federation; Rwanda; Saudi; Arabia; Senegal; Sierra Leone; Singapore; Slovak Republic; Slovenia; Somalia; South Africa; Spain; Sri Lanka; Sudan; Sweden; Switzerland; Syrian Arab Republic; Tanzania; Thailand; Togo; Trinidad and Tobago; Tunisia; Turkey; Turkmenistan; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Uzbekistan; Venezuela; Vietnam; Yemen;.Yugoslavia Former; Zambia; Zimbabwe.

Source Countries (OECD countries)

Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Ireland; Italy; Japan; Korea, Rep.; Mexico; Netherlands; New Zealand; Norway; Poland; Portugal; Spain; Sweden; Switzerland; Turkey; United; Kingdom; United States.

High Income OECD countries

Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Ireland; Italy; Japan; Netherlands; New Zealand; Norway; Portugal; Spain; Sweden; Switzerland; Turkey; United Kingdom; United States.

7.B Data Description

FDI Determinant	Theory/Hypothesis	Proxy Variable (Source)	Effect
Market demand	Market size hypothesis	GDP (World Development Indicator)	+
Growth rate	Differential rates of return	Real GDP Growth (World Development Indicator)	+
Agglomeration effect	Other	Lagged FDI (OECD Database)	+
Industrial Structure	Other	Share of Manufacturing in total GDP (World Development Indicator)	+/-
Factor Endowments	Factor endowments hypothesis	Capital/ Labour ratio (World Penn Tables)	+
Trade Barriers	Tariff jumping hypothesis	Dummy for Regional Trade Agreement (WorldTradeLaw.net)	+/-
Capital Openness	Other	Ito-Chinn index `http://web.pdx.edu/ito/`	+
Investment Promotion	Other	Dummy for Bilateral Investment Treaties (UNCTAD)	+
Country Risk		ICRG index (World Development Indicator)	-
Natural Resources	Other	Dummy for largest oil rich countries (www.eia.doe.gov)	-
Proximity	Gravity hypothesis	Capitals distance Contiguity, Colonies, Common Language (CEPII)	- +
"Third-Country" Effect	Spillovers hypothesis	Spatially weighted variables (Negative exponential distance matrix)	+/-
Environmental Stringency	Pollution haven hypothesis	SO2emission per capita (Stern (2005)) International environmental treaties (ENTRI)	- -

7.C Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
FDI	13555	3.29	4.06	-10.97	12.75
Lagged FDI	12211	3.39	4.02	-10.97	12.75
Spatial Lag	13555	3.14	2.29	-7.93	11.4
GDP	13415	26.41	1.47	21.16	30
Market Potential	13415	25.22	0.9	21.94	27.79
GDP Growth	13487	2.2	4.29	-50.49	89.83
V.A. Dirty Shares	12074	-1.21	0.32	-5.59	-0.1
Manufacturing Share (%GDP)	10791	2.94	0.36	-0.54	3.77
Risk Index	13386	-4.29	0.2	-4.62	-2.67
Capital Openness	12723	0.64	1.13	-1.33	1.68
Bilateral Investment Treaties	13555	0.26	0.44	0	1
Regional Agreement Trades	13555	0.38	0.49	0	1
Capital Tax Agreements	13555	0.42	0.49	0	1
Oil Resources	13555	0.2	0.4	0	1
Colonial Links	13555	0.08	0.27	0	1
Distance	13555	8.17	1.11	4.09	9.88
Environmental Stringency (SO2pc)	11299	11.36	1.03	5.68	15.53
Spatial Stringency (SO2pc)	11299	11.53	0.58	9.55	14.18
Environmental Stringency (Treaties)	13549	4.4	0.81	0	5.82
Spatial Stringency (Treaties)	13549	4.04	0.48	2.16	4.88
Phone	13474	5.26	1.32	-0.16	6.64
School Enrolment	11168	4.4	0.42	1.61	5.18
Openness	13106	3.36	0.6	1.19	5.26
Exports	13050	24.65	1.53	18.22	27.77
Free Trade Index	13182	1.96	0.2	0.43	2.28
Tariff Index	13110	1.42	0.24	-2.07	1.63
Corruption Index	9282	-2.07	0.19	-2.29	-1.13

All variables are expressed in logarithm, except for the dummies variables.

7.D Correlation Matrix

	FDI	Lagged FDI	Spatial Lag	GDP	Market Potential	GDP Growth	V.A. Dirty	Manuf. Share	Risk Index
FDI	1								
Lagged FDI	0.28	1							
Spatial Lag	0.25	0.23	1						
GDP	0.16	0.18	-0.02	1					
Market Potential	0.04	0.04	0.16	0.24	1				
GDP Growth	0.03	0.02	0.07	-0.1	0.11	1			
V.A. Dirty Shares	-0.01	-0.01	0.07	-0.07	0	0.01	1		
Manuf. Share	0.06	0.07	0.11	0.15	0.33	0.16	0.05	1	
Risk Index	-0.07	-0.07	-0.09	-0.2	-0.43	-0.26	0	-0.1	1
Capital Openness	0.07	0.08	0.06	0.27	0.3	0.03	0.05	-0.02	-0.64
BIT	-0.06	-0.05	-0.06	-0.2	-0.09	0	-0.02	-0.01	0.42
RAT	0.05	0.04	0	-0.13	0.18	0.04	-0.05	0.09	-0.29
KTA	0.05	0.04	0.01	-0.07	0.13	-0.01	-0.03	0.05	-0.21
Oil Resources	0.04	0.04	0.05	0.34	-0.09	-0.06	0.13	-0.2	0.01
Colonial Links	0.1	0.09	0.07	0.03	-0.05	-0.02	0.05	0	0.03
Distance	-0.12	-0.11	-0.07	0.12	-0.25	-0.03	0.01	-0.08	0.27
-(SO2pc)	-0.05	-0.05	-0.01	-0.1	0.12	-0.08	-0.06	0.05	0.07
Spatial -(SO2pc)	-0.02	-0.02	-0.08	-0.1	-0.18	0.08	-0.15	0.01	0.23
Treaties	0.12	0.11	0.05	0.29	0.17	-0.01	0.03	0.17	-0.43
Spatial Treaties	0.08	0.09	0.09	-0.08	0.19	0.08	-0.08	-0.03	-0.32
Phone	0.1	0.11	0.08	0.3	0.4	0.01	-0.03	0	-0.71
School Enrolment	0.11	0.11	0.07	0.25	0.36	0.06	-0.06	0.04	-0.66
Openness	-0.03	-0.04	0.1	-0.57	0.21	0.16	0	0.08	-0.16
Exports	0.17	0.19	0.04	0.85	0.46	-0.02	-0.06	0.17	-0.53
Free Trade Index	0.12	0.12	0.09	0.04	0.28	0.12	0.01	0.06	-0.57
Tariff Index	0.1	0.11	0.05	0.21	0.25	-0.03	-0.02	-0.02	-0.45
Corruption Index	-0.06	-0.07	-0.05	-0.19	-0.35	-0.07	0.17	-0.01	0.67

	Capital Open.	BIT	RAT	KTA	Oil Ress.	Col. Links	Distance	-(SO2pc)	Spatial -(SO2pc)
Capital Openness	1								
BIT	-0.36	1							
RAT	0.23	-0.12	1						
KTA	0.2	-0.02	0.5	1					
Oil Resources	-0.02	-0.13	-0.24	-0.05	1				
Colonial Links	-0.03	-0.02	-0.12	-0.08	0.03	1			
Distance	-0.18	0.11	-0.83	-0.54	0.19	0.03	1		
-(SO2pc)	0.11	0.03	0.09	0.18	-0.21	-0.04	-0.15	1	
Spatial -(SO2pc)	-0.31	0.18	-0.23	-0.17	-0.14	0.02	0.26	0.11	1
Treaties	0.37	-0.35	0.44	0.3	0	-0.02	-0.39	-0.02	-0.37
Spatial Treaties	0.25	-0.11	0.51	0.32	-0.17	-0.05	-0.47	-0.01	-0.18
Phone	0.56	-0.33	0.38	0.21	-0.01	-0.06	-0.32	-0.24	-0.41
School Enrolment	0.53	-0.28	0.37	0.21	-0.09	-0.06	-0.27	-0.2	-0.31
Openness	0.1	0.09	0.33	0.17	-0.28	-0.04	-0.32	0.07	0.11
Exports	0.54	-0.31	0.1	0.08	0.23	0	-0.1	-0.05	-0.16
Free Trade Index	0.62	-0.21	0.42	0.23	-0.17	-0.04	-0.33	-0.13	-0.17
Tariff Index	0.43	-0.24	0.34	0.15	-0.07	-0.08	-0.22	-0.13	-0.22
Corruption Index	-0.44	0.28	-0.25	-0.16	0.01	0.02	0.2	0.14	0.07

	Treaties	Spatial Treaties	Phone	School Enrol.	Open.	Exports	F. T, Index	Tariff Index	Corr. Index
Treaties	1								
Spatial Treaties	0.57	1							
Phone	0.49	0.47	1						
School Enrolment	0.54	0.48	0.83	1					
Openness	-0.13	0.23	0.08	0.09	1				
Exports	0.37	0.12	0.59	0.5	-0.14	1			
Free Trade Index	0.3	0.45	0.65	0.6	0.52	0.45	1		
Tariff Index	0.35	0.37	0.71	0.62	0.09	0.44	0.64	1	
Corruption Index	-0.33	-0.34	-0.62	-0.54	-0.14	-0.46	-0.54	-0.31	1

All variables are expressed in logarithm, except for the dummies variables.

7.E Spatial Dependence Tests

	Bilateral FDI		GDP		SO2per capita		Treaties	
year	Moran I	Geary C	Moran I	Geary C	Moran I	Geary C	Moran I	Geary C
1981	0.12***	0.89***	0.23***	0.74***	0.08*	0.91*	0.39***	0***
1982	0.07***	0.94**	0.12**	0.86**	0.14***	0.84***	0.36***	0***
1983	0.11***	0.89***	0.1**	0.85**	0.11**	0.91*	0.33***	0***
1984	0.1***	0.93***	0.2***	0.77***	0.21***	0.79***	0.34***	0***
1985	0.19***	0.81***	0.25***	0.72***	0.26***	0.73***	0.33***	0***
1986	0.11***	0.91***	0.31***	0.67***	0.24***	0.74***	0.31***	0***
1987	0.13***	0.88***	0.16***	0.78***	0.22***	0.75***	0.33***	0***
1988	0.15***	0.86***	0.26***	0.71***	0.23***	0.77***	0.29***	0***
1989	0.2***	0.8***	0.32***	0.67***	0.31***	0.7***	0.32***	0***
1990	0.19***	0.84***	0.31***	0.67***	0.29***	0.72***	0.31***	0***
1991	0.14***	0.87***	0.35***	0.63***	0.25***	0.76***	0.18***	0***
1992	0.14***	0.89***	0.34***	0.65***	0.27***	0.75***	0.07**	0.37
1993	0.12***	0.89***	0.3***	0.69***	0.25***	0.76***	0.03	0.21
1994	0.24***	0.76***	0.21***	0.75***	0.2***	0.8***	0.04*	0.15
1995	0.15***	0.84***	0.25***	0.71***	0.21***	0.79***	0.09***	0.2
1996	0.17***	0.84***	0.28***	0.68***	0.27***	0.73***	0.13***	0***
1997	0.18***	0.82***	0.31***	0.66***	0.16***	0.84***	0.15***	0***
1998	0.09***	0.91***	0.28***	0.68***	0.18***	0.82***	0.16***	0***
1999	0.12***	0.89***	0.26***	0.69***	0.18***	0.81***	0.18***	0***
2000	0.15***	0.86***	0.26***	0.69***	0.16***	0.84***	0.17***	0***
2001	0.14***	0.86***	0.28***	0.68***	0.33***	0.66***	0.18***	0***
2002	0.14***	0.86***	0.33***	0.65***	0.2**	0.83*	0.22***	0***

Both tests performed in logarithm with an inverse exponential distance matrix.
significant at 10, ** significant at 5, *** significant at 1.

7.F Panel Cointegration Test

Specification	Lag	Statistic	p-value
individual intercept	2	-39.757	0
individual intercept and trend	2	-47.429	0
individual intercept	5	-39.717	0
individual intercept and trend	5	-47.311	0
individual intercept	8	-39.533	0
individual intercept and trend	8	-46.836	0

Residuals are computed from the following fixed effect panel estimation.
FDI = lagged FDI + GDP source + GDP host + Growth GDP + Capital Openness + Colony + Distance + Contiguity + Common Language + Oil + BIT + RAT + SO2 per capita + Years

7.G Panel Unit Root Tests

Test	Null Hypothesis	Specification	Bilateral FDI		GDP		Growth GDP		SO2 per capita	
			Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
Levin, Lin and	Common unit	No individual effects	-1.01	0.16	29.08	1.00	-8.78	0.00	10.77	1.00
Chu (2002)	root process	Individual effects	9.28	1.00	-3.13	0.00	4.76	1.00	-0.35	0.36
		Individual effects and trend	32.33	1.00	-1.65	0.05	12.68	1.00	5.34	1.00
Maddala and	Individual unit	No individual effects	579.73	0.00	1.79	1.00	308.07	0.00	7.34	1.00
Wu (1999)	root process	Individual effects	914.33	0.00	44.83	1.00	380.42	0.00	48.18	0.38
		Individual effects and trend	853.39	0.00	165.92	0.00	346.68	0.00	49.74	0.33
Choi test	Individual unit	No individual effects	12.41	0.00	-7.09	1.00	13.88	0.00	-4.03	1.00
(2001)	root process	Individual effects	26.45	0.00	-4.10	1.00	18.85	0.00	0.23	0.41
		Individual effects and trend	23.89	0.00	4.29	0.00	16.53	0.00	0.39	0.35
Pesaran	Unit root with one	No individual effects	2.43	0.01	-1.14	0.35	-2.64	0.01	1.12	0.37
(2004)	common factor	Individual effects	-2.65	0.01	-2.25	0.01	-2.75	0.01	-1.75	0.48
		Individual effects and trend	-3.01	0.01	-2.13	0.79	-2.97	0.01	-2.59	0.13
Bai and Ng	Unit root with	1 common factor	7.82	0.00	6.64	0.00	6.58	0.00	2.54	0.01
(2003)	common factors	2 common factors	7.01	0.00	6.94	0.00	6.49	0.00	4.69	0.00
		3 common factors	7.12	0.00	8.45	0.00	6.76	0.00	3.84	0.00

All panel unit roots test are performed in levels with variables expressed in logarithm.

7.H OECD Robustness Check with CO2 per capita

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.014	0.193***	0.063**	0.058**	0.057**	0.061**
	[0.015]	[0.014]	[0.025]	[0.026]	[0.026]	[0.026]
GDP Host	0.437	0.527***	0.541***	0.580***	0.633***	0.689***
	[0.905]	[0.047]	[0.114]	[0.105]	[0.112]	[0.116]
GDP Source	5.644***	0.801***	0.948***	0.647***	0.602***	0.529***
	[1.089]	[0.042]	[0.077]	[0.148]	[0.148]	[0.147]
GDP growth	-0.011	0.102	0.001	-0.023	-0.001	-0.028
	[0.065]	[0.063]	[0.088]	[0.093]	[0.094]	[0.095]
V.A. Dirty Shares	-0.139	-0.1	-0.309	-0.683	-0.71	-0.535
	[0.327]	[0.268]	[0.424]	[0.480]	[0.464]	[0.471]
Risk Index	-2.116	1.639	0.213	0.098	0.119	0.074
	[1.674]	[1.130]	[0.226]	[0.221]	[0.214]	[0.205]
Capital Openness	-0.02	0.154	-3.501	-3.083	-3.19	-3.459
	[0.15]	[0.133]	[2.535]	[2.537]	[2.567]	[2.587]
Oil Resources		0.066	0.02	-0.524	-0.425	-0.456
		[0.195]	[0.471]	[0.463]	[0.459]	[0.463]
Colonial Links		1.023***	1.098**	0.949**	0.880**	0.792*
		[0.213]	[0.453]	[0.475]	[0.441]	[0.424]
Distance		-0.700***	-0.733***	-0.676***	-0.688***	-0.647***
		[0.053]	[0.096]	[0.099]	[0.097]	[0.108]
Environmental Stringency	1.461*	-0.563***	-0.465	-0.776	-0.598	-0.41
	[0.762]	[0.206]	[0.529]	[0.516]	[0.544]	[0.555]
Spatial Lag FDI				0.455**	0.521***	0.603***
				[0.193]	[0.195]	[0.191]
Market Potential					-0.191	-0.433
					[0.240]	[0.283]
Spatial Stringency						-0.371
						[0.547]
Observations	5038	5038	5016	5016	5016	5016
Groups	330	330	329	329	329	329
R-squared	0.029	.	144	147	150	153
Instruments	.	.				
Arrellano-Bond AR(2)	.	.	0.72	0.792	0.819	0.789
Sargan test	.	.	0.0459	0.197	0.233	0.176
Hansen Test	.	.	0.418	0.479	0.565	0.563

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations. Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

7.I OECD Robustness Check with Treaties

	Fixed Effect	Random Effect	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.039***	0.197***	0.062**	0.063**	0.068**	0.066**
	[0.014]	[0.014]	[0.028]	[0.030]	[0.029]	[0.029]
GDP Host	-0.727	0.532***	0.625***	0.629***	0.698***	0.723***
	[0.799]	[0.050]	[0.141]	[0.135]	[0.132]	[0.136]
GDP Source	7.618***	0.820***	0.936***	0.594***	0.576***	0.558***
	[1.014]	[0.042]	[0.083]	[0.138]	[0.140]	[0.138]
GDP growth	0.014	0.058**	0.06	0.03	0.025	-0.002
	[0.027]	[0.025]	[0.099]	[0.100]	[0.098]	[0.096]
V.A. Dirty Shares	0.101	-0.146	-0.617	-0.941**	-0.790*	-0.808*
	[0.319]	[0.253]	[0.404]	[0.436]	[0.418]	[0.425]
Risk Index	-1.28	1.773	-0.911	-0.738	-2.093	-1.357
	[1.616]	[1.091]	[3.002]	[2.922]	[2.677]	[2.793]
Capital Openness	-0.003	0.276**	0.462**	0.374	0.271	0.324
	[0.148]	[0.129]	[0.235]	[0.238]	[0.228]	[0.248]
Oil Resources		0.415***	0.295	-0.106	-0.189	-0.125
		[0.159]	[0.360]	[0.339]	[0.317]	[0.314]
Colonial Links		0.970***	0.971**	1.092**	0.992**	1.001**
		[0.212]	[0.449]	[0.464]	[0.451]	[0.437]
Distance		-0.617***	-0.819***	-0.720***	-0.740***	-0.691***
		[0.059]	[0.146]	[0.147]	[0.142]	[0.138]
Environmental Stringency	-1.024	0.317	-0.741	-0.416	-0.504	-0.657
	[2.198]	[0.260]	[0.916]	[0.865]	[0.834]	[0.878]
Spatial Lag FDI				0.493***	0.524***	0.557***
				[0.168]	[0.174]	[0.172]
Market Potential					-0.239	-0.247
					[0.216]	[0.216]
Spatial Stringency						0.536
						[0.607]
Observations	5550	5550	5526	5526	5526	5526
Groups	330	330	329	329	329	329
R-squared	0.032	.	.	.	.	.
Instruments	.	.	155	158	161	164
Arrellano-Bond AR(2)	.	.	0.194	0.267	0.247	0.261
Sargan test	.	.	0.274	0.497	0.594	0.671
Hansen Test	.	.	0.37	0.33	0.398	0.396

Exponential inverse distance as spatial weighting scheme. Two-Step System-GMM estimations.
Time dummies and constant not reported. Standard errors incorporating the Windmeijer correction in brackets. *** significant at 1%, ** significant at 5%, * significant at 10%.

7.J OECD Robustness Check with Additional FDI Determinants

	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.065**	0.060**	0.051*	0.051*	0.052*	0.064**
	[0.026]	[0.029]	[0.028]	[0.028]	[0.028]	[0.025]
GDP Host	0.607***	0.652***	0.575***	0.561***	0.612***	0.718***
	[0.118]	[0.126]	[0.123]	[0.123]	[0.149]	[0.161]
GDP Source	0.954***	1.014***	0.976***	0.966***	1.005***	0.943***
	[0.072]	[0.080]	[0.074]	[0.085]	[0.100]	[0.069]
GDP growth	-0.069	-0.187*	-0.127	-0.133	-0.128	-0.042
	[0.094]	[0.109]	[0.115]	[0.117]	[0.117]	[0.092]
V.A. Dirty Shares	-0.221	0.181	0.054	0.09	0.103	-0.263
	[0.434]	[0.495]	[0.499]	[0.508]	[0.497]	[0.435]
Risk Index	-2.621	-1.207	-2.992	-4.906*	-2.887	-2.239
	[2.561]	[3.615]	[3.005]	[2.979]	[3.051]	[2.513]
Capital Openness	0.22	-0.029	0.36	0.28	0.44	0.266
	[0.220]	[0.264]	[0.264]	[0.254]	[0.270]	[0.220]
Oil Resources	0.182	-0.021	0.144	0.087	0.288	0.201
	[0.413]	[0.418]	[0.420]	[0.452]	[0.470]	[0.381]
Colonial Links	1.096**	0.922*	0.982**	0.953**	1.018**	1.051**
	[0.444]	[0.492]	[0.464]	[0.462]	[0.478]	[0.442]
Distance	-0.797***	-0.938***	-0.828***	-0.744***	-0.634	-0.722***
	[0.102]	[0.116]	[0.111]	[0.213]	[0.426]	[0.111]
Environmental Stringency	-0.299	-0.637***	-0.279	-0.341	-0.373*	-0.301
	[0.198]	[0.226]	[0.222]	[0.225]	[0.222]	[0.187]
Phone	-0.211					
	[0.676]					
School Enrollment		-1.123				
		[0.860]				
Bilateral Investment Treaties			-0.817			
			[3.426]			
Capital Tax Agreements				0.335		
				[0.809]		
Regional Agreement Trades					0.669	
					[1.289]	
Openness						0.55
						[0.495]
Observations	5017	4218	5017	5017	5017	5017
Groups	329	329	329	329	329	329
Instruments	147	121	143	169	138	147
Arellano-Bond AR(2)	0.698	0.881	0.847	0.874	0.855	0.708
Sargan test	0.043	0.027	0.059	0.053	0.034	0.077
Hansen Test	0.475	0.268	0.292	0.64	0.146	0.513

Two-Step System-GMM estimations. Time dummies and constant not reported.
Standard errors incorporating the Windmeijer correction in brackets.
*** significant at 1%, ** significant at 5%, * significant at 10%.

(continued)

	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM	SYS-GMM
Lagged FDI	0.056**	0.060**	0.060**	0.045	0.063**	0.062**
	[0.026]	[0.026]	[0.026]	[0.030]	[0.025]	[0.026]
GDP Host	0.097	0.655***	0.604***	0.718***	0.593***	0.620***
	[0.394]	[0.126]	[0.114]	[0.156]	[0.115]	[0.115]
GDP Source	0.962***	0.944***	0.966***	1.042***	0.943***	0.944***
	[0.073]	[0.071]	[0.073]	[0.090]	[0.071]	[0.072]
GDP growth	0.024	-0.084	-0.03	-0.257*	-0.037	-0.04
	[0.091]	[0.093]	[0.092]	[0.134]	[0.093]	[0.094]
V.A. Dirty Shares	-0.677	-0.143	-0.284	-0.629	-0.209	-0.219
	[0.441]	[0.438]	[0.464]	[0.491]	[0.435]	[0.431]
Risk Index	-0.426	0.386	-4.386*	-12.736**	-2.641	-2.547
	[3.007]	[2.549]	[2.440]	[6.146]	[2.676]	[2.679]
Capital Openness	0.356	0.083	0.153	1.097*	0.286	0.263
	[0.224]	[0.242]	[0.211]	[0.641]	[0.222]	[0.222]
Oil Resources	0.361	0.207	0.122	-0.432	0.17	0.123
	[0.392]	[0.380]	[0.387]	[0.478]	[0.373]	[0.379]
Colonial Links	1.101**	1.014**	1.087**	1.212**	0.972**	0.632
	[0.460]	[0.416]	[0.467]	[0.516]	[0.434]	[0.497]
Distance	-0.745***	-0.753***	-0.806***	-1.081***	-0.719***	-0.766***
	[0.116]	[0.107]	[0.113]	[0.150]	[0.105]	[0.101]
Environmental Stringency	-0.247	-0.337*	-0.258	-0.802***	-0.269	-0.262
	[0.194]	[0.200]	[0.199]	[0.250]	[0.193]	[0.193]
Exports	0.555					
	[0.469]					
Free Trade Index		4.797**				
		[1.958]				
Tariff Index			-2.436			
			[5.845]			
Corruption Index				1.275		
				[1.167]		
Contiguity					0.485	
					[0.322]	
Common Language						0.727*
						[0.378]
Observations	5005	5017	5017	2298	5017	5017
Groups	329	329	329	326	329	329
Instruments	147	147	147	73	145	145
Arellano-Bond AR(2)	0.741	0.745	0.758	0.266	0.715	0.724
Sargan test	0.0696	0.156	0.0274	0.098	0.0651	0.0712
Hansen Test	0.344	0.479	0.486	0.632	0.478	0.466

Two-Step System-GMM estimations. Time dummies and constant not reported.
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*** significant at 1%, ** significant at 5%, * significant at 10%.