Pollution Haven and Corruption Paradise

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Abstract

In this paper we analyse theoretically and empirically the impact of institutions, environmental standards and trade costs on the location choice of polluting firms in countries with lax environmental regulations (called pollution havens). We ask the following questions: Does a better market access between countries with heterogeneous institutions makes these pollution havens more attractive? Is that bad governance is only a cost, making pollution havens unattractive? The short answers are: yes and no. We find that pollution havens attract activities when 1) bilateral trade costs are low between countries which present a gap in environmental standards, 2) corruption allows reducing the stringency of environmental regulations. We find evidence of these results by exploiting a unique database on the number (and turnover) of European affiliates located abroad (the outward Foreign Affiliates Statistics, FATS). Some simulations are performed based on our estimations. They show that an harmonization of environmental norms in Europe could reduce intra-European relocation towards pollution havens by 13%. Also, the protection of the European market access (e.g. carbon tax) to stop the PHH has to be high (a decrease of the European market access for Marocco and Tunisia equivalent to 15%) not to say prohibitive (37% for China).

Keywords: *Environmental Regulation; Europe; Institution; Trade.*

JEL: F12;Q5;Q53

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1 Introduction

"Although existing studies suggest little or no evidence of industrial relocation, arguments over pollution havens persist. Why?" Eskeland and Harrison (2003)

In the early 2000s, it was quite common to start an introduction on pollution havens by underscoring that there is no evidence of this hypothesis. Laxer environmental standards were not significant to explain the location choice of dirty plants. But failure to reject the null hypothesis does not ensure that the null hypothesis is always true and a growing number of articles have successfully found this effect for inward, outward and outbound foreign direct investments (FDI) in the United-States.[1] However, time to write that the Pollution Haven Hypothesis (hereafter PHH) is universal and timeless will certainly never come since it depends on various factors that continuously evolve making firms more or less footloose. While the PHH has been discussed a lot based on U.S. data, the analysis on Europe has been neglected which is surprising since the European environmental policy has been quite active over the past years. Furthermore Europe and its neighborhood have changed; post-communist economies (central and eastern countries, Russia and also China) but also partners in Maghreb (Tunisia, Marocco etc) have now a middle level of bad governance, enough good to make business (no risk of expropriations etc) and enough bad to pollute without too many worries. Lastly the European market access has been vastly improved thanks to multilateral, regional and preferential trade agreements which make relocation outside Europe and/or at its periphery less costly. As a result, Europe is the perfect playing field to analyse the PHH and its interaction with governance and trade integration.

Regarding the literature on the PHH, this hypothesis has been viewed as a "popular myth" (Smarzynska Javorcik and Wei, 2003) for at least two reasons. The former is that countries with stringent environmental rules have advantages that overtake the environmental cost (e.g. better infrastructures, larger market size, better endowment in human capital etc). The latter is that countries with lax environmental standards have repulsive characteristics such as poor institutions and bad governance which represent a cost for multinational firms.

However, globalization by improving the market access of developed countries from pollution havens erodes the advantage to locate plants close to the point of consumption. Furthermore, a pollution haven can be "a dirty secret" in the sense that bribes may allow dirty firms to obtain laxer environmental rules. In particular, Cole and Fredriksson (2009) find evidence

[1] See for instance Levinson (2008) who concludes its definition of the PHH by asserting that "recent studies using panel data to control for unobserved heterogeneity or instrumental variables to control for the simultaneity of regulations have found statistically significant, reasonably sized pollution haven effects". We also make a brief review of the literature in the first section of this article.

that environmental regulations are influenced by FDI, while Damania et al. (2003) show that corruption leads to less stringent environmental policies.

Based on Fujita and Thisse (2006),[2] our model displays these effects. When bad governance has no effect on environmental standards, then corruption is only a cost for multinational firms and deters relocation to pollution havens. By contrast, when corruption allows influencing environmental standards, then the PHH is verified. Furthermore, the model explicitly explains why the PHH can be hard to detect since it depends very much on agglomeration rent, market size and market access explaining that no relocation is observed until a critical threshold of environmental restrictions is reached.[3] In order to operate in the largest markets, firms agree to pay the highest environmental costs, but if these costs are too high then they move out of their 'green fortress', particularly if they can secure access to a core of consumers from a peripheral location and to laxer environmental standards.[4]

Turning to the empirical part of this paper, we look for the PHH in Europe, since to our knowledge no such analysis has ever been conducted before, at least not in the way we proceed. We have used data concerning the number of European affiliates that were operating in a foreign country (including European countries) for the years 2007, 2008 and 2009, as defined by industry. Thus, we have at our disposal bilateral data between each EU member and each of their worldwide destinations hosting relocated affiliates, together with related revenues, in 22 industries following the NACE classification. Then in line with the theory, we have assessed the impact of openness, environmental regulation and corruption on the number of affiliates. To measure trade openness, we have built an indirect measure of market access through the estimation of a gravity equation. Then we have used various indicators of environmental regulation in both origin and destination countries, as well as a measure of the environmental regulation gap in order to capture the effects of regulation on bilateral relocation of affiliates. To deal with the presence of zero values recorded, we have chosen count data models to fit our dependent variable and address two main issues over-dispersion

[2]Fujita and Thisse (2006) analyze the evolution of the international fragmentation of supply chains due to wage differentials in a context of trade and coordination integration between North and South. A simple change in the cost function of this model provides a good fit with the issue at hand. Instead of considering the wage differential (weighting on the variable costs in Fujita and Thisse, 2006), we analyze how firms slice up their supply chain in response to international gaps in environmental standards and bad governance.

[3]This result can find support in the study of Wagner and Timmings (2009) who find that once agglomeration economies are taken into account, robust evidence of a pollution haven effect for the outward FDI flows of the German chemical industry can be detected. This is also one of the main result of Ederington, Levinson and Minier (2003) showing on U.S. data that industries affected by environmental policies are less footloose than others, due to transportation costs and plant fixed costs, and thus are insensitive to differences in regulatory stringency.

[4]To our knowledge, only Zeng and Zhao (2009) provide a similar result with a different model in which the manufacturing sector generates cross-border pollution which reduces the productivity of the agricultural sector.

and the excess of zero. We find that market access fosters relocation from Europe to other destinations and more interestingly, we have highlighted its joint effect with the environmental regulation gap, which confirms our theoretical results. We also provide evidence of the existence of pollution havens, since countries with laxer environmental standards clearly attract European affiliates. Then, to deal with the potential endogeneity bias, a two-step procedure has been chosen based on the instrumentation of environmental regulation, which serves to control the potential reverse causality (Damania, Fredriksson, List, 2003) and the role of bad governance on environmental regulation. The indirect attractive effect of bad governance on environmental standards is clearly underlined. Finally, a number of checks for robustness have been conducted, including a confrontation of our predictions with a sector-based breakdown. Lastly some simulations based on our estimations have been performed; an harmonization of environmental norms in Europe could reduce relocation by 13%. Regarding trade and relocation in the rest of the world, the protection of the European market access to stop the PHH is shown to be high. The paper proceeds as follows. Section 2 discusses the literature. Section 3 outlines the theoretical model and explores the relationship between trade, regulation and choices of location. Section 4 presents the overall empirical strategy and Section 5 reports the results. In Section 6, simulations are performed on the basis of previous estimates and Section 7 concludes the paper.

2 A comment on the literature

> "While studies based on U.S. data provide us with some of the most convincing evidence for a regulatory impact on economic activity – i.e. a pollution haven effect – convincing evidence for or against the pollution haven hypothesis must employ international data" M. Scott Taylor (2004).

The literature on the PHH has been reviewed many times in details, making a new survey unnecessary. Thus we just make here a comment on the relative lack of analysis on European data. Excellent considerations of the literature can be found in Brunel and Levinson (2013), which discuss measures of environmental regulatory stringency, and in Millimet and Roy (2013) presenting empirical tests of the PHH, the econometric biases and methodological issues of this type of analysis. Lastly a meta-analysis has been performed by Rezza (2014). All these surveys consider two generations of analysis, a first one working on cross-section with exogenous environmental regulation finding no clue of the PHH, and a second one using panel data and IV techniques finding a significant PHH. These surveys are mainly based on the United States. Analyzing 32 articles published in prestigious journals (*Journal of Political*

Economy, *International Economic Review*, *Review of Economics and Statistics*, *Journal of International Economics*, *Journal of Public Economics*, *Journal of Environmental Economics and Management*, *Journal of Development Economics*, *Ecological Economics, Environmental and Resource Economics* etc) on the period 2000-2014, we find that 16 studies were based on U.S. data.

Almost all the studies that find a significant effect of environmental policies warn that this effect is limited to highly polluting firms and/or to particular partners.[5] To give only one example, Henderson and Millimet (2007) by analyzing FDI inflows with non-parametric methods, detect a negative effect of environmental stringency on capital flows but observe that "the impact of relative abatement costs is heterogeneous across states and generally of smaller magnitude than previously suggested". Outside the U.S., China has been the most studied country,[6] while many other countries have been examined only one time such as South Korea, Mexico[7], Norway, France and Germany.[8] Only the U.K. has been analyzed twice.[9]

To our knowledge the rare studies which have analyzed the PHH at the European scale

[5]For the U.S. we have considered that the following papers support the PHH: Becker and Henderson (2000) Cole and Elliot (2005) Ederington, Levinson and Minier (2003), Fredriksson, List and Millimet (2003) Greenstone (2002), Henderson and Millimet (2007), Kellenberg (2009), Keller and Levinson (2002), Levinson and Taylor (2008) List and Co (2000), List, Millimet, Fredriksson, and McHone (2003) Millimet and Roy (2013) Xing and Kolstad (2002). In contrast the three papers opposed to the PHH are: Eskeland and Harrison (2003), Hanna (2010), Javorcik and Wei (2003).

[6]Dean, Lovely, Wang (2009) finds that equity joint ventures in China in highly-polluting industries from Hong Kong, Macao, and Taiwan are attracted by weak environmental standards. He (2006) analyzes FDI entry decision to Chinese provinces and finds evidence of the PHH in industry with high SO2 emission. Poncet and Hering (2013) find a fall in exportation of dirty firms in cities with stricter regulations on sulfur dioxide emissions. Lu, Wu and Yu (2013) analyze with difference-in-differences estimations how Chinese cities with tougher environmental regulations attract less FDI.

[7]Chung (2014) examines South Korean FDI using a difference-in-differences type identification strategy and finds that polluting industries tend to invest more in countries with laxer environmental regulations both regarding the amount of investment and the number of new foreign affiliates. Waldkirch and Gopinath (2008) analyze FDI inflows into Mexico and find evidence of the impact of regulation in the case of the sulfur dioxide emissions.

[8]Rezza (2013) analyzes Norwegian MNEs' affiliates over the 1999-2005 period and finds affiliates located in countries with more stringent environmental standard receive less investment from their parents in terms of equity capital, capital stock and assets. Regarding French FDI outflows, Ben Kheder and Zugravu (2012) verify the PHH for Central and Eastern European Countries, but not for other developing countries. Wagner and Timmins (2009) study outward foreign direct investment (FDI) flows of various industries in the German manufacturing sector. They take the total stock of inward FDI as a control for agglomeration economies and find robustness of the PHH in sector like the chemical one.

[9]Manderson and Kneller (2009) use a database at the firm-level (FAME, Financial Analysis Made Easy) allowing determining where UK MNEs locate their foreign subsidiaries. By estimating a Probit and a Conditional Logit model they find that environmental regulations do not affect internationalization decision in general, however multinational firms with intense pollution are affected by environmental standards of the host country. They also find that the PHH is conditioned by corruption. Martin, de Preux, Wagner (2014) find that the carbon tax has no statistically significant impact on plant exits in the UK.

are Cave and Blomquist (2010) and Jug and Mirza (2010). Such a scale of analysis is important because environmental and international economics are the typical subjects where the European Union has a legitimacy to lead public policies. Cave and Blomquist (2010) work on imports into the EU of dirty goods at the 2-digit industry level. They reject the deterrent effect of environmental regulation by finding that there is no significant increase in the amount of EU toxic intensive trade with poor countries. This is not so surprising since we can expect that the relocation of dirty plants is not in the poorest regions but in emerging markets. Actually despite their conclusion that goes against the PHH, Cave and Blomquist (2010) document some evidence of increasing EU imports of toxic goods from "poor" OECD countries. Jug and Mirza (2010) propose to use a gravity equation on importing and exporting countries from the EU15 over the period 1996-1999. This study is to our knowledge the first to verify the PHH by using a structural gravity equation.

However, working with importations has some limits. In particular, the thesis that importation of dirty goods and relocation of dirty firms are equivalent are based on an idea of perfect substituability between trade and capital flows. While this view can be defended in a simple model of trade with perfect competition, it is likely that market size, increasing returns and trade costs interplay to modify this equivalence.[10]

For all these reasons we present a model of imperfect competition with increasing returns and fragmentation and we work on European data with relocation of affiliates as our main variable of interest.

3 Theoretical model

To analyze the evolution of the supply chain in the case of pollution havens, the model is based on Fujita and Thisse (2006) only slightly modified.

On the demand side, each individual consumes an industrial good M, which is a composite of different varieties of manufacturing and service activities i, and an agricultural good A. The utility function is represented by:

$$U = M^{\mu} A^{1-\mu} \tag{1}$$

[10] In its comment of Copeland and Taylor (2003), Anderson (2005) put it differently "The Copeland and Taylor model is one in which capital flows and trade flows are substitutes, although there are respectable models in which the two are complements. In a world of complementarity, Green pessimism may well be more warranted. If FDI flows to take advantage of lower abatement cost, and if FDI is stimulated by trade liberalization, the factor proportions model mechanism that locates polluting industries in the rich North is reversed".

with M a CES aggregation taking the form:

$$M = \left(\int_0^n q(i)^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where n is the number of varieties consumed, $q(i)$ is the demand of a variety i. Lastly $\sigma > 1$ is the constant elasticity of substitution among these varieties. A share μ of nominal income, denoted Y, is spent on manufacturing, and $1 - \mu$ on the agricultural product. The budget constraint is then given by $PM + p_A A = Y$, where p_A is the price of the agricultural good and P the price index of varieties:

$$P = \left[\int_0^n p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}} \tag{3}$$

with $p(i)$ is the price of a typical variety.

The total demand to a firm producing a variety i is then given by:

$$q(i) = \mu Y P^{\sigma-1} p(i)^{-\sigma} \tag{4}$$

Varieties are exchanged between countries under transaction costs which take the form of iceberg costs denoted τ. The agricultural good is costlessly traded between countries, and its price is the same everywhere. This good is the numéraire and its price is set to unity.

To present analytical results, we consider a model with two countries. We follow the tradition in international economics by naming these two countries North and South, designated according to subscript N (S).

There are two kinds of factors, skilled and unskilled labor. There are skilled and unskilled workers in Northern countries and only unskilled workers in the South. Then incomes are given by:

$$Y_N = H_N w_N^H + w_N^L L_N, \; Y_S = w_S^L L_S \tag{5}$$

where L and H are the number of unskilled and skilled workers that earn w^L and w^H. In the following we normalize the total population of skilled and unskilled to one ($H_N = 1$,$L_N + L_S = 1$)

Each firm has one Headquarter (HQ) and one plant. Headquarters (HQ) use only skilled workers; plants use only unskilled workers. The location of skilled workers in the North implies that all HQs are located in northern countries while plants can be located in the North or in the South. The aim of this paper is to analyze the choice of location of these plants.

The owners of firms face a tradeoff: on the one hand, in choosing an agglomeration of HQs and plants in the North, they directly have access to the highest demand since richer consumers live in the North (skilled workers). Moreover, producing in the South involves dealing with poor governance and may imply various costs linked to the level of corruption. However the great advantage of producing in the South is that environmental standards are laxer.

To model this, we assume that environmental standards, e_i ($e_i \geqq 1$), affect the variable costs of production. This is a classical assumption considering that expenditures on control and monitoring equipment necessary to bring a plant into environmental compliance varies with production. In addition, we assume that the fixed cost of production in the South bears corruption costs, denoted c. This fixed cost can be viewed as the number of procedures, time and bribes that a firm must bear and pay before it can operate legally. These costs of entry have been first documented by Djankov, La Porta, Lopez-de-Silanes and Shleifer (2002) and have been used in various studies as a proxy for bureaucratic and corruption-related cost of starting a business (e.g. Do and Levchenko, 2013).

These assumptions can be reversed without affecting location choice at the equilibrium i.e. it is tantamount to consider corruption as a variable cost and environmental standards as a fixed cost.[11] In the following, the reader can verify that fixed costs and variable costs can be considered as a single parameter (see 12). Furthermore we also consider an extension where environmental standards are influenced by corruption.

Formally, the total cost of producing q units of a typical manufactured item for an HQ located in the North varies according to the location of its plant. For a northern firm, the total cost is equal to:

$$TC_N = fw_N^H + ae_N w_N^L q_N \tag{6}$$

with a and f respectively the variable and fixed costs of production.

In contrast, a multinational with its HQ in the North but that relocate its plant to the South bears the following total cost:

$$TC_S = cfw_N^H + ae_S w_S^L q_S \tag{7}$$

Because each firm produces a distinct variety of product, the number of firms is also the number of varieties consumed. Thus each firm is a monopolist for the production of its

[11] In a previous version of this paper all the analysis has been done by considering that environmental standards affects the fixed cost while corruption was assumed to represent a variable cost. All the results were identical, this is obvious by considering Equation (12) where the two costs affect in the same way location choice at the equilibrium.

variety. However because there is a continuum of firms, each one is negligible in the sense that its action has no impact on the market. This is a key feature of the Dixit-Stiglitz monopolistic competition; firms ignore the effects of their action on income Y and on price index P. Hence by maximizing its profit a typical firm sets the following prices according to the location of the plant: $p_N = aw_N^L \sigma e_N/(\sigma - 1)$ and $p_S = aw_S^L \sigma \tau e_S/(\sigma - 1)$. Thus, prices differ spatially in reason of geography (trade costs) and institutions (environmental standards and corruption when environmental standards are influenced by corruption).

3.1 Analytical results regarding environmental standards and corruption

Before to pursue, we make standard normalization to present compact expressions, in particular with $a = \frac{\sigma-1}{\sigma}$ and given the choice of the numéraire, the price of a typical variety in the North and in the South are $p_N = e_N$ and $p_S = \tau e_S$. We also set $f = 1$.

Normalizing the world number of firms to one, the price index under full employment becomes:

$$P_N^{1-\sigma} = \frac{s_N}{E_N} + \frac{\phi(1 - s_N)}{cE_S} \tag{8}$$

and

$$P_S^{1-\sigma} = \frac{\phi s_N}{E_N} + \frac{(1 - s_N)}{cE_S} \tag{9}$$

where the term $\phi \equiv \tau^{1-\sigma}$ is the degree of trade openness (which varies from 0 to 1 with $\phi = 0$ autarky and $\phi = 1$ free trade), $E_i \equiv e_i^{\sigma-1}$ a measure of environmental standard.

The profit of a firm which keeps its plants in the North and those of a multinational firm that slices up its supply chain are given by:

$$\pi_{NN} = \frac{\mu}{\sigma} \frac{1}{E_N} \left(\frac{Y_N}{P_N^{1-\sigma}} + \phi \frac{Y_S}{P_S^{1-\sigma}}\right) - w_N^H \tag{10}$$

$$\pi_{NS} = \frac{\mu}{\sigma} \frac{1}{E_S} \left(\phi \frac{Y_N}{P_N^{1-\sigma}} + \frac{Y_S}{P_S^{1-\sigma}}\right) - cw_N^H \tag{11}$$

Two effects drive these expressions. On the one hand, large markets generate more profits and attract plants because firms find significant outlets there (i.e., market-access effect). In this model, the North always has the largest market and consequently a northern location is intrinsically attractive. On the other hand, the concentration of plants exacerbates local competition and fosters a dispersion of activities (i.e., market-crowding effect).

Under the equilibrium conditions $\pi_{NN} = \pi_{NS}$, using equations (8), (9) and (5) yields an explicit expression of the share of plants :

$$s_N^* = \frac{\zeta c^{-1}}{c^{-1}\zeta - \phi} \frac{2c^{-1}\zeta\phi - 1 - \phi^2 - \frac{\mu}{\sigma}(1-\phi^2)}{2(c^{-1}\zeta\phi - 1)} \tag{12}$$

with $\zeta \equiv E_N/E_S$ the relative northern environmental norm (with $\zeta = 1$ there is no differential in environmental standards).

To close the model, we also have to analyze $\pi_{NN} = 0$, which gives the following wage:

$$w_N^H = \frac{b\left[2\phi s_N^* + c^{-1}\zeta(1-s_N^*)(1+\phi^2)\right]}{2([b - s_N^* - c^{-1}\zeta(1-s_N^*)\phi]\left[c^{-1}\zeta(1-s_N^*) - \phi s_N^*\right]}$$

with $b = \mu/\sigma$, however by using the number of firms at the equilibrium (12), this expression becomes only a function of parameters:

$$w_N^H = \frac{b}{1-b}$$

As shown by Fujita and Thisse (2006, Lemma 3, Appendix C) the fact that wage is not a function of trade costs comes from two opposite effects that just cancel out, on the one hand a decrease of trade costs leads the firm to be more competitive but because all multinational firms benefits in the same way of this gain, the net effect is null.

Lastly we have to verify that the wage of skilled workers in the North w_N^H obtained via $\pi_{NN} = 0$ is higher than the one w_S^H that could be obtained in the South $\pi_{SS} = 0$. We verify that this condition of agglomeration of HQs in the North always holds here.

By simple inspection of the share of firms in the North at the equilibrium (12), an interesting result is that ζc^{-1} can be treated as a single parameter (denoted Γ when necessary): good governance in the South c^{-1} has the same effect than the relative northern environmental standards ζ on choice of location. In other words, relative environmental standards in the North and good governance in the South generated costs that are substitutes. The following result analyzes their effects on location.

Proposition 1 *Under partial agglomeration of firms ($\Gamma \epsilon \left] \frac{2\phi}{1-b+\phi^2(1+b)}, \frac{1-b+\phi^2(1+b)}{2\phi} \right[$), better governance in the South c^{-1} and/or higher relative environmental standard in the North ζ lead to relocation of firms to the South.*

Proof. From equation (12), differentiation gives:

$$\frac{\partial s_N}{\partial \Gamma} = -\frac{NUM}{2(\Gamma - \phi)^2(\Gamma\phi - 1)^2} \tag{13}$$

because the denominator is always positive we focus on the numerator NUM given by:

$$NUM = \phi \left[b(1-\Gamma^2)(1-\phi^2) + (1-\Gamma\phi)^2 + \phi(\phi - 2\Gamma) + \Gamma^2 \right]$$

with $b = \mu/\sigma$ (it is noteworthy that $b < 1$ because $\mu < 1$ and $\sigma > 1$ by definition). Observing that NUM can be concave upward with respect to Γ and resolving $\partial NUM/\partial\Gamma = 0$ for Γ one gets a unique solution:

$$\underline{\Gamma} = \frac{2\phi}{1 - b + \phi^2(1+b)}$$

thus NUM attains its minimum at $\underline{\Gamma}$ and this minimum is positive:

$$NUM(\underline{\Gamma}) = \frac{(1-b^2)\phi(\phi^2-1)^2}{1-b+\phi^2(1+b)}$$

because $b = \mu/\sigma < 1$. Thus with a positive numerator, the derivative $\partial s_N/\partial\Gamma$ is negative (see eq. (13)).

Interestingly $\underline{\Gamma}$ is also the critical point after which full agglomeration becomes unstable. Indeed resolving the definition of agglomeration in the North $s_N = 1$ with s_N given by (12) we also get $\underline{\Gamma}$. We have already shown that for $\Gamma > \underline{\Gamma}$ there is a gradual relocation of firms from North to South. This relocation stops when $s_N = 0$, resolving this equation using (12), gives the critical level of Γ after which there is full agglomeration in the South, this critical value is:

$$\overline{\Gamma} = \frac{1-b+\phi^2(1+b)}{2\phi}$$

■

So far we have considered a general case in which bad governance represents a cost heading for multinational firms when they decide to produce in the South. As a result it would seem natural to observe that less corruption is attractive. Smarzynska Javorcik and Wei (2003) clearly defend this point of view by writing:

> "Host country S[12] may have less stringent environmental protection than country N, which might make country S more attractive than country N to foreign direct investment, particularly from the "dirty" industries. On the other hand, country S may also have a more severe corruption problem, which tends to discourage inward foreign investment, including those from the "dirty" industries. [...] Several studies have demonstrated that corruption in a host country is a significant deterrent to inward FDI."

[12]Smarzynska and Javorcik Wei (2004) speak about country A and B, we use S and N for reading convenience

However in the particular case of dirty firms, arguments can be found against this proposition. In particular Cole and Fredriksson (2009), starting from an evidence which suggests that foreign affiliates bribe the governments in order to influence policy to their advantage, defend the idea that environmental regulation can be endogenously determined.

Indeed, corruption may be a cost for clean industries, but it can also be a way to buy environmental concessions for dirty plants. Thus, let us assume that bad governance is not a sunk fixed costs (i.e. consider $c = 1$) but a way to negotiate less stringent environmental standards, or put differently that the environmental norm in the South is a negative function of corruption, now denoted c^{comp}, such as:

$$E_S = g(c^{comp}) \tag{14}$$

with by assumption:

$$\partial g(c^{comp})/\partial c^{comp} < 0$$

A micro-founded function where, like here, the environmental norms in the South is a decreasing function of corruption can be obtained by adding to the model a lobby that offers brides to the government in the South. Available on request we have done such an extension considering the southern government maximizes brides and the welfare of its citizen who are affected by pollution[13] using the Grossman and Helpman (1994) objective function. Like Damania et al. (2003) which is the seminal article introducing political game to analyse pollution havens, we find conditions that verify the assumption done here in Equation (14) i.e. $\partial E_S/\partial c^{comp} < 0$. The upper script "comp" is used to model that southern country characteristics (corruption and environmental costs) are no longer equivalent/substitute but may be considered as complement to attract firms. More corruption means less stringent environmental rule and thus quite logically according to the previous proposition, if the direct negative cost of corruption is neutralized, this implies more relocation to pollution haven. In short, considering a "pure corruption paradise", where there is no direct negative cost of corruption ($c = 1$) but where in contrast corruption is used to buy environmental standards (indirect positive effects of c^{comp}) then firms flee to pollution haven.

Corollary 2 *(Corruption Paradise Hypothesis): If corruption is not a sunk cost ($c = 1$), but a way to reduce southern environmental standards, then dirty plants are attracted by bad*

[13] We have assumed that pollution, O_i (which depends on production q_i, on the number of firms s_i, and on emission r_i such as $O_i = s_i q_i r_i$), affects linearly the utility function, $U_i = M_i^{\mu} A^{1-\mu} - \gamma O_i$ and we have considered that environment standards allow to reduce the emission of pollution with dismissing returns considering that the emission rate is an inverse function of the environmental policy $r_S = e_S^{-\chi}$ where $\chi > 1$ is the abatement technology (this function is for instance used by Haupt (2006) and Anouliès (2013) with $\chi = 1$).

governance.

Proof. This can be shown simply by replacing $\zeta = E_N/E_S$ and $E_S = g(c^{comp})$ in equation (12), with $c = 1$, which gives the new expression for location choice of dirty plants:

$$s_N^{comp} = \frac{E_N g(c^{comp})^{-1}}{g(c^{comp})^{-1}E_N - \phi} \frac{2g(c^{comp})^{-1}E_N\phi - 1 - \phi^2 - b(1-\phi^2)}{2(g(c^{comp})^{-1}E_N\phi - 1)} \tag{15}$$

And thus as a corollary of the previous proof, the result is obvious. The term $g(c^{comp})$ enters in (15) in a similar way than c in (12). Remembering that $\Gamma = c^{-1}\zeta$, the main difference between (15) and (12) comes from that $\partial\Gamma/\partial c < 0$ while here $\partial g(c^{comp})^{-1}/\partial c^{com} > 0$. Thus whereas the previous proof demonstrates that $\partial s_N/\partial\Gamma < 0$ implying $\partial s_N/\partial c > 0$ here we obtain the reverse $\partial s_N^{comp}/\partial c^{com} < 0$. ■

Obviously in the reality, pure corruption paradise certainly not exist ($c \neq 1$) and thus its likely that countries with intermediate levels of bad governance that just mitigate the negative costs of corruption are the most attractive for polluting firms.

3.2 Numerical examples regarding environmental standards and trade costs

The impact of trade costs is more significantly involved than with the previous comparative analysis because relocation responds in a non-linear way (see Fujita and Thisse, 2006). Thus, we propose numerical simulations of our model as a first step toward a quantitative assessment of the existence of pollution havens when trade is liberalized.

3.2.1 Parametrization

As shown in Proposition 2, the existence of the PHH depends on corruption, so to distinguish between North and South we have taken the index of corruption used by Kaufmann, Kraay and Mastruzzi (2010).[14] All countries with a positive index are considered as southern countries.[15] Then by computing the average value of this index for this category of countries, we obtain the parameter of corruption $c = 1.02$. Regarding the share of income spent on industrial goods, using OECD data, Bosker et al. find $\mu = 0.335$. We follow this estimation and NEG literature in general by setting $\mu = 0.4$. Concerning environmental

[14] For more details see our empirical analysis in which this index is described.

[15] In order to capture a corruption cost, we rescale the notation of Kauffman *et al.* (2010) so that the highest value corresponds to the highest level of corruption while the lowest one refers to good governance.

standards, we have considered the Environmental Performance Index of Esty, Levy, Srebotnjak and de Sherbinin (2010) as a relatively good approximation since this index allows us to rank countries according to various environmental results (environmental health, air quality, biodiversity and habitat etc).[16] We compute the average value of this index for North and South and subsequently we obtain $e_N = 58.9$ and $e_S = 49.3$. We also need the elasticity of substitution between varieties, for instance to evaluate $E_i = e_i^{\sigma-1}$. We set $\sigma = 4$ following Broda and Weinstein (2010) who show that the elasticity of substitution between varieties decreased from 6.8 between 1972 and 1988 to 4.0 (with a standard error of 0.5) over the period 1990-2001.

3.2.2 Results

To illustrate non-linearities between the relocation of dirty plants and trade integration, we have plotted the Northern proportion of plants (12) with respect to ϕ for different values of environmental standards (Figure 1). The thick black line represents the impact of trade integration using parameters described previously. Clearly, there is a drastic relocation of plants into peripheral regions, with a proportion of firms from 60% in the North with $\phi = 0$ to 0% with $\phi = 0.67$. In short, pollution havens become more attractive with the integration of trade.

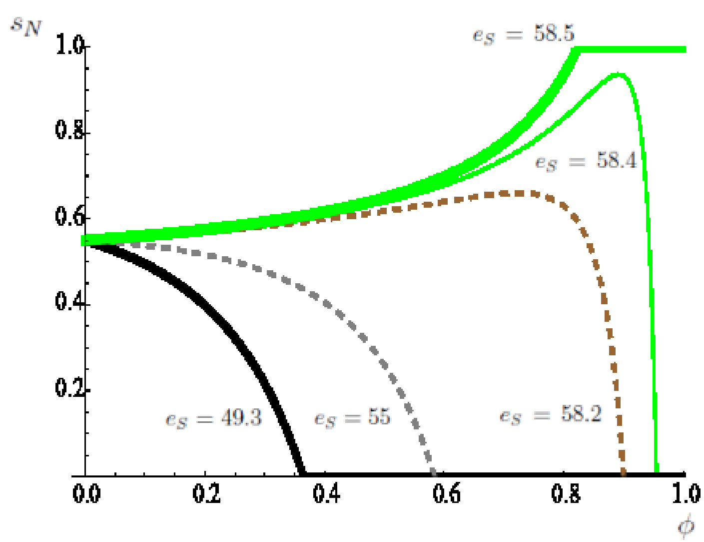


Figure 1: Northern share of plants, openness and environmental regulation

This result is further verified with a higher level of norm in the South ($e_S = 55$). However, if this standard increases again ($e_S = 58.2$) agglomeration occurs gradually in the North before

[16]For more details see our empirical analysis where this index is described.

falling into deeper integration. This bell-shaped curve is exacerbated by smaller differences in environmental standards ($e_S = 58.4$). Lastly at $e_S = 58.5$, there is always agglomeration in the North despite the higher environmental standards (remember that $e_N = 58.9$ in all these simulations). Corruption in the South and market size in the North provide a partial shield against competition (market-crowding effect) and standards differentials. The North is able to maintain higher environmental standards and becomes even more attractive when trade costs decrease. The PHH is not verified.

We retain the following result.

Proposition 3 *(Pollution Haven Hypothesis): Trade integration always leads to the relocation of dirty plants to the South if* $\zeta > \sqrt{(1+b)/((1-b)c^{-2})}$.

Proof. The sufficient condition to ensure that trade integration always leads to relocation consists in evaluating the derivative of location choice with respect to trade integration at autarky. If positive, then despite the environmental gap the North is still attractive (see Figure 1). On the contrary if negative, there is an agglomeration of plants in the South from autarky to free trade. Thus by resolving:

$$\left.\frac{\partial s_N}{\partial \phi}\right|_{\phi=0} < 0$$

we obtain the critical value of the environmental gap:

$$\zeta > \sqrt{\frac{1+b}{(1-b)c^{-2}}}$$

■

This result confirms, in a different framework, Zeng and Zhao's (2009) third proposition, in which they argue that sufficiently lax environmental policies in the South and lower trade costs likely promote pollution havens. It is also a reminiscence of Fujita and Thisse (2006). It should be clear that this proposition only provides a parameter restriction such that when trade costs decrease, the number of firms in the South always increases. As it is obvious from Figure (3.2.2), there exists non-monotonicities in the effect of a reduction in trade frictions on firm location, thus the previous proposition is only an extreme case where the PHH is verified whatever the level of trade integration.

4 Empirical strategy

The theoretical work emphasizes interactions between market access, environmental norms and bad governance. While results are obtained with two countries, it is likely that in a multi-country model these interactions would remain important under some new parameter conditions. Thus we turn here on the empirical side and we investigate the existence of the PHH for European firms. The next subsection describes the database used for this empirical investigation, sub-section (4.2) proceeds to a description of explanatory variables and sub-section (4.3) details our econometric model following the core features of the data. Results and robustness checks are presented in Section (5).

4.1 Descriptive statistics on European *outward Foreign AffiliaTes Statistics* (o-FATS)

This empirical analysis is based on an original database which records the activities of European affiliates. This database, called *outward Foreign AffiliaTes Statistics* (o-FATS) covers the period 2007-2009 and provides the number of affiliates from each European country to each destination, recorded at industrial level (NACE classification). Thus, while literature uses data for FDI flows, themselves very heterogeneous (including mergers, acquisitions, new facilities, profits reinvestment etc...), we focus on the affiliates that are majority-owned by a single investor or by a group of associated investors acting in concert and owning more than 50% of ordinary shares or voting rights. As a result, the sample is more homogeneous, especially in terms of capital mobility, which help us to reduce estimation bias. The other advantage of this data set is that it fits our theoretical analysis, presenting the stock of affiliates instead of flows.

In more detail, the database reports the affiliated originated from 25 European countries[17] towards 145 countries of destination (including European ones) for each NACE industry.[18] Germany has the major share of foreign affiliates with 30.39%[19] of the total, followed by Italy (16.69%), France (12.75%) the United Kingdom (11.04%), and Sweden (10.93%). We report in Table (7) of Appendix A the detailed figures regarding the EU members which record more than 1000 affiliates abroad. Now, what are the main destinations with the fragmentation process? First of all, 30% of European affiliates are located in another E.U.

[17] Austria, Belgium, Bulgaria, Cyprus, Denmark, Germany, Espana, Estonia, Finland, France, Greece, Hungary, Irland, Italia, Littuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Sweden, United Kingdom.

[18] The detailed lists are reported in Appendix A

[19] for the year 2009

member state. Emerging markets are represented by China, India, Brazil, Mexico, Turkey, Argentina and Thailand, reaching 16% of firms located abroad. China accounts for 6.63% of the total, mainly in the machine engineering sector (24%), chemical industry (17.74%), metallurgy (15.66%), transportation equipment (8.67%) and textiles (7.02%). Like emerging markets, developing countries present a special interest in the analysis of the pollution haven hypothesis. Indeed, small economies usually draft slacker regulating standards due to a lack of resources and/or poor governance. Furthermore, other developing countries (once emerging and eastern countries are excluded) also represent a significant share, accounting for 23.62% of total affiliates. This mainly concerns African countries, 35 destinations among the 145 available in the data set. [20] However, these lines of data may suffer from a shortage of detailed information, namely at the industrial level, and are potentially responsible for many zero counts. This last point may induce a severe estimation bias if the relevant econometric model is not adopted. For this reason, Sub-section (4.3) is dedicated to a discussion about the choice of the relevant estimator, dealing with these data issues.

4.2 Descriptive statistics of explanatory variables

Following Redding and Venables (2004) we extend the economic geography model to pursue a gravity regression framework with many countries in order to measure bilateral market access at the sector level k at time t, hereafter denoted ϕ_{NS}^{kt}. Following theory, market access is positively correlated with wages and presents a considerable advantage in our case to capture spatial wage disparities. To obtain an accurate measurement of it, we have chosen to work at a highly dis-aggregated level of data to calculate this index of market access. We work specifically on trade data dis-aggregated at the 2-digit level (SITC rev 2.) from UN Comtrade. A particular attention was paid to the establishment of correspondence tables between sector classifications, especially to match the SITC rev 2 classification to the Eurostat NACE rev 1.[21] Appendix B gives the technical details of this now standard measure of market access which to our knowledge has never been used in environmental economics.

Concerning environmental regulation data, we need a variable reflecting the environmental regulation differential (ζ_{NS}^{t}). It is noteworthy that homogeneous statistical data at the world scale are sparse in particular if we look for an exogenous instrument concerning environmental regulation. Cole et al., (2006) and Damania et al. (2003) use data for lead content in gasoline, but our panel data has the advantage of being formed over a more recent period and as a result, this variable is inadequate since lead contents in gasoline have reached a

[20] Italy is the most implicated country in Africa, the Netherlands in South-East Asia.

[21] All data sources are presented in Table (8) of Appendix A.
Correspondance tables are available upon request.

standardized level in most countries. Alternatively, we suggest using pollution regulation from the *Environmental Performance Index* (EPI) data set (an initiative of Yale University), considering regulation on Persistent Organic Pollutants (POPs). POPs regulation is a measure of how the 'Dirty Dozen' pollutants defined under the Stockholm Convention are regulated. It gathers twelve toxic chemicals used in agriculture, industry, and some household products. Among these twelve pollutants, five are a by-product of industrial production and seven are generated by pesticides. This POPs regulation is used in regressions to capture the level effect of the standards (denoted E_N^t and E_S^t hereafter). The bilateral environmental regulation differential is obtained on the basis of these standards, $\zeta_{NS}^t = E_N^t - E_S^t$.

Moreover, we will distinguish *de jure* and *de facto* environmental standards in robustness checks. Indeed, the variable of POPs regulation is an appreciation of *de jure* environmental policy in that it directly concerns the legislation and not its application. This is a restrictive choice since one can question the application of the environmental standards, especially in developing countries. This restriction to *de jure* norms has two advantages. One hand, it enables us to not improperly validate the hypothesis of pollution havens, on the other hand, we avoid a bias of endogeneity between environmental standards and levels of productivity. But for the sake of empirical verification , we proceed to an additional estimation by using *de facto* standards.[22] For this we introduce into the set of regressions the overall Environmental Performance Index (EPI). This additional test also helps to measure the variability of environmental standards, which eases the use of countries fixed effects as controls. These regressions are reported in Table (10) of Appendix C but confirm our main conclusions.

To obtain the industrial effect of green regulation at the NACE level, we use environmental expenditures incurred in each industry (denoted E_N^{kt}). This variable allows capturing the time varying dis-aggregated effect of environmental regulation.

Good governance is complex to grasp, especially in the case of a panel study. As a result we are conservative and we use the classical database of Kaufmann, Kraay and Mastruzzi (2010) of institutional quality available for 209 countries to build an indicator of corruption .[23] This data set contains notations, the lowest note representing poor governance. To directly capture the estimated coefficient of corruption costs, we rescale these notations to obtain

[22]Bazillier, Hatte and Vauday (2015) also use the two types of regulation. They find contradictory results between *de jure* and *de facto* measures, interpreting this result by a strategic choice of firms. We do not expect the same sign reversal since our dependent variable is a stock of affiliates, falling under count data models.

[23]Kaufmann et al. (2009) have processed data in order to make cross-country comparisons. All country scores are accompanied by standard errors which reflect the multiplicity of available data sources (to build the corruption scores) and the potential differences of opinion among those sources. In order to capture the corruption effect highlighted in the economic model, we use the index of corruption but have also proceeded to regressions including other governance indicators, in particular the rule of law. Results are very similar.

that the highest values represent poor governance, while negative values proportionally refer to a low level of corruption.

Concerning other controls, we regress the dependent variable on time and industry-specific fixed effects. To check the robustness of our estimates, we also add countries fixed effects (origin and destination) to address the potential omitted variables bias, in Appendix C. Most coefficients remain stable in sign and significance. When they are not used, we add in regressions GDPs per capita of both partners to mainly capture the productivity differential. These controls are widely used in the literature, especially in international economics. [24]

All data sources are reported in Table (8) in Appendix A. Before presenting the results of this paper, we have reported descriptive statistics of all explanatory variables.

Table 1: Descriptive statistics of explanatory variables

	Obs	Mean	Std deviation	Min	Max
Bilateral Market Access $ln(\phi_{NS}^{kt})$	22226	-9.136	3.415	-34.571	5.371
Environmental expenditures (share GDP) $ln(E_{NS}^{kt})$	39463	4.893	2.345	-1.966	10.248
Persistent Organic Pollutants E_N^t	63526	18.307	4.852	0	21
Persistent Organic Pollutants E_S^t	63526	15.097	7.932	0	21
EPI: *de facto* standards E_N^t	63526	62.842	5.401	48.256	70.374
EPI: *de facto* standardsE_S^t	60969	57.427	10.195	32.543	77.993
Environmental regulation gap ζ_{NS}^t	60961	5.43	11.38	-29.09	37.48
Environmental regulation gap in log $ln(\zeta_{NS}^t)$	40909	1.98	1.15	-5.03	3.62
1971 Persistent Organic Polluants E_S^{1971}	63526	2.328	4.128	0	18
Corruption index c_S^t	63526	-0.897	1.415	-3.330	2.157

4.3 Econometric strategy: which count data model?

Concerning the choice of the econometric specification and looking at the number of firms, we have used regression models for count data. Figure (2) illustrates the distribution of the number of European affiliates towards foreign markets for the period 2007-2010. This histogram clearly displays a high proportion of zero which justifies the use of derived Poisson models. Actually a basic Poisson model underestimates the probability of zero counts. This *excess of zero* is a significant and relatively common issue, which needs specific econometric processing, i.e. zero-inflated and hurdle models.

Both models deal with the high occurrence of zeros in observed data but present one important distinction in the interpretation of zero counts. More specifically, both models assume that the zeros and the positive values do not stem from the same data-generating process,

[24] See for instance Fieler (2011).

which allows dealing with the excess of zeros. But, in the case of the hurdle model, the process for zeros is not constrained to be the same: a Bernoulli probability governs the binary outcome of zero/nonzero value and then positive realizations are governed by a truncated-at-zero model (Poisson or Negative Binomial). Conversely, with zero-inflated models the first-step is constrained. The response variable is modeled as a mixture of a Bernoulli and Poisson (or Negative Binomial) distribution. Positive values are determined similarly. In our case study, we have chosen zero-inflated models as our core strategy because we suspect that zero counts have both origins.

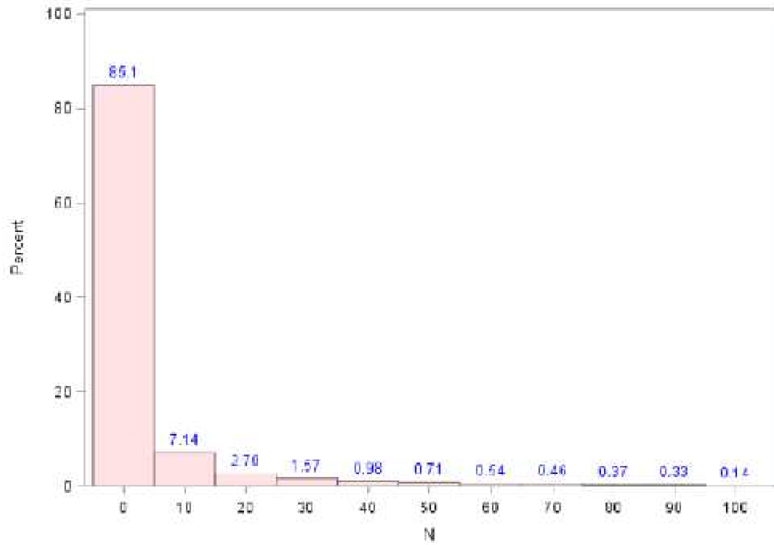
Another distinctive feature of count data is *overdispersion* observed when variance is clearly higher than the mean value. To check the presence of overdispersion, we have first taken a look at Figure (2), which illustrates intrinsic heteroskedasticity, with variance increasing with the mean value. To confirm this, we have reported summary statistics in Table (2):

Table 2: Summary statistics

	Obs	Mean	Std deviation	Min	Max
Nb of European affiliates	9584	39.974	175.359	0	4217

The mean number of European affiliates is obviously lower than the variance, which enable us to consider the data as clearly over-dispersed. Following this statement, the econometric treatment needs to be adjusted by replacing the Poisson distribution by the Negative binomial distribution, a better fits for over-dispersed data. This concern leads us to choose a zero-inflated negative binomial model as the core of our econometric strategy and will be compared with other count data models. Overdispersion tests, such as the likelihood-ratio test are reported for each regression, adding weight to the idea of Poisson distribution not being appropriate.

Figure 2: Distribution of the number of affiliates from Europe, 2007-2010



The zero-inflated negative binomial regression model is defined formally

$$P\left[s_{NS}=0\right]=\varpi_{NS}+\left(1-\varpi_{NS}\right)\left(\frac{\alpha^{-1}}{\alpha^{-1}+\nu_{NS}}\right)^{\alpha^{-1}}$$

$$P\left[s_{NS}\right]=1-\varpi_{NS}\frac{\Gamma\left(s_{NS}+\alpha^{-1}\right)}{s_{NS}!\Gamma\alpha^{-1}}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\nu_{NS}}\right)^{\alpha^{-1}}\left(\frac{\nu_{NS}}{\alpha^{-1}+\nu_{NS}}\right)^{s_{NS}}$$

in which s_{NS} is our simplified dependent variable, the number of European affiliates,ν_{NS} is the conditional mean which is an exponential function of the independent variables , Γ is the Gamma function,[25] α is a dispersion parameter which incorporates unobserved or intrinsic heterogeneity into the conditional mean, such that overdispersion can be taken care.[26] ϖ_{NS} is the proportion of observations with strictly zero counts ($0<\varpi_{NS}<1$), which is determined by a logit model. Thus, if $\varpi_{NS}=0$ the model is reduced to the Negative Binomial model.

This model is estimated by a Maximum Likelihood method and is consistent in the presence of heteroskedasticity. This estimator is also especially efficient in large samples (Cameron and Trivedi, 1986; King, 1988). As a more effective control for heteroskedasticity, robust standard errors have been computed and confronted with bootstrapped standard errors to check the sensitivity of our results.

[25]Not to be confused with the parameter Γ in the theoretical part of this paper.

[26]The larger α is, the larger the degree of overdispersion. This dispersion parameter allows the conditional variance to exceed the conditional mean. As explained further, a likelihood-ratio test of α is performed to test whether a Negative Binomial distribution is prefered to a Poisson distribution (Cameron and Trivedi, 1986).

4.4 Baseline specification

Before presenting the regressions results, we present in details the core model specification. As suggested by the theoretical expression (12), our empirical analysis involves the three pillars highlighted until now i.e. globalization, environmental regulation and corruption and their interaction effects which were the heart and soul of the theoretical work. In more details, the dependent variable is the number of affiliates s_{NS}^{kt} from N, a European state, to S, a destination country, in the industry k at time t. The condition mean of s_{NS}^{kt}, denoted ν_{NS}^{kt} is an exponential function of three vectors of independent variables, two vectors of dummies and a constant, as following

$$\nu_{NS}^{kt} = exp\left(A + \Phi + \xi + \Omega + \lambda_t + \lambda_k\right), \tag{16}$$

in which A is the constant, Φ refers to the first theoretical pillar related to globalization effects, ξ is the second one related to environmental standards in both countries, Ω refers to corruption effects and λ_t and λ_k are time and sector specific dummies, which control for specific temporal shocks and for sector-based characteristics. In our baseline specification, partners fixed effects and pair dummies are not included in the set of regressors mainly because of multicollinearity issues, which implies a massive dummies elimination. This choice is mainly justified because these dummies may interfere in what we aim to capture since most of our variables of interest displays small variations over time. But, to control for the quite essential effect of labor cost differential between origin and destination, we add the logs of GDPs per capita in most regressions. Also, additional robustness checks including country fixed effects are reported in Appendix C and most of the results hold.

Focusing on globalization effects, the vector Φ is given by

$$\Phi = a_1 ln\phi_{NS}^{kt} + a_2 ln(\phi_{NS}^{kt}\zeta_{NS}^{t})$$

in which ϕ_{NS}^{kt}, the market access to an European country, is expected to positively affect the relocation of firms in the partner country. [27] The interaction term between bilateral market access ϕ_{NS}^{kt} and the environmental gap ζ_{NS}^{t} is introduced in the light of Figure (3.2.2) and Proposition 3.[28] These theoretical elements suggest to be cautious on the expected empirical results. The interactive effect of regulation and openness on the foreign location of affiliates, captured by a_2, can be positive or negative depending on the level of trade costs and on the level of environmental costs. Robustness checks will be performed by

[27]In other words, the estimated coefficient a_1 is expected to be positive.

[28]This environmental gap is defined as the difference of environmental standards between a country N and S, namely built as a bilateral variable$\zeta_{NS}^{t} = E_N^t - E_S^t$.

using alternative measures of market access, notably by distinguishing the domestic from the foreign component part.

Now the vector ξ takes into account environmental regulation at the industry level for European countries in addition to environmental standards of each country of origin and destination:

$$\xi = a_3 ln(E_N^{kt}) + a_4 ln(E_N^t) + a_5 ln(E_S^t).$$

These variables are introduced to determine whether it is regulation in Europe that is a push factor to relocate activities in N or whether less stringent regulation in S is a pull factor, or both. A comparison of the estimated coefficients a_4 and a_5 allows analyzing the relative sensitivity of relocation to environmental norms. We expect a positive sign for E_N^{tk} and E_N^t, and a negative one for E_S^t to find evidence of the PHH (Proposition 1). To confirm it, instead of country-level variables, we alternatively use the differential of environmental standards, ζ_{NS}^t, previously introduced in the interaction term with market access. The idea is to use both levels and difference variables to check our main assumptions. Furthermore, *de facto* standards, measured by the overall EPI, will be used to check the robustness of the estimated coefficients to other measures of environmental regulation.

Finally estimation of (16) takes into account corruption and its interactive effect with the environmental gap with the vector

$$\Omega = a_7 c_S^t + a_8(\zeta_{NS}^t c_S^t)$$

in which c_S^t is a measure of bad governance. Following the literature on FDI and our theoretical prediction regarding the direct cost of corruption (Proposition 1) we expect a negative sign. To answer to our question "does pollution haven are also corruption paradise?" we also interact the existence of an environmental regulation gap with corruption levels. Following our theoretical results, we expect a negative coefficient for corruption but a positive effect of its interactive effect with the environmental gap. An extra set of regressions will be performed to produce refined results about the interactive effect of corruption, notably by separating countries in different groups.

These regressions are also performed by replacing the number of affiliates with the recorded turnover. This alternative dependent variable is denoted T_{NS}^{kt} and provides very similar results as shown in the next section.

5 Results

Our empirical analysis is carried out in several steps. We first proceed to the estimation of our baseline specification, involving the main theoretical determinants highlighted by the theory. The main strategy has been described in the last section and the next one is dedicated to a discussion of the results. Next, in a second step we proceed to a deeper analysis of the corruption effects, precisely, the interactive effects of corruption and environmental regulation, thanks to a two-step procedure of estimation, which is the subject of a second sub-section. Finally, a last sub-section is devoted to a robustness analysis through some Placebo tests and through a sector-based decomposition of the data. The additional robustness checks are relegated to the annexes. Then, for leading to further political implications, we will use our benchmark results in order to simulate some policy scenarios. This is the aim of the last section of the paper.

5.1 Baseline results

As explained in the previous section, Equation (16) is estimated using the zero-inflated negative binomial (ZINB) estimator in all regressions on the basis of a Logit inflation model and Maximum Likelihood methods.[29] Coefficient significance is analyzed through robust and bootstrapped standard errors.[30] To examine the global model significance, pseudo-R^2, Wald, likelihood-ratio and Vuong tests are reported for each estimation in the last line of Table (3). Overall, the econometric model fits the data well. The computed pseudo-R^2 is always higher than 0.6 even if countries fixed effects are not introduced. Concerning the estimator, the choice of ZINB instead of ZIP (Zero-Inflated Poisson) estimator is confirmed by the overdispersion test which consists in testing the null hypothesis of equidispersion. This empirical test is conducted on the basis of the Chi-squared statistic. For each regression the dispersion parameter *alpha* is between confidence intervals and rejects the null hypothesis. Furthermore, ZINB is also preferred to a negative binomial estimator following likelihood-ratio and Vuong closeness tests. The latter is a derived test from the likelihood-ratio family but is based on the Kullback-Leibler Information Criterion in order to measure a model's veracity (Vuong, 1989). Both tests conclude that a two-step procedure better fits our data than a single-step procedure, which is coherent with the first graphical reading. These

[29] A probit inflation model has also been used and final results are not affected. Coefficients available upon request

[30] Robust standard errors are reported but when fixed-effects are used, bootstrapped standard errors are also computed. Results remain unchanged and bootstraped standard errors are slighly lower than the robust ones.

successive goodness-of-fit statistics lead us to consider that our estimations are reliable and allow us to comment upon each estimated parameter in the light of our economic model.

Table 3: Baseline results

	(1)	(2)	(3)	(4)	(5)	(6)
			s_{NS}^{kt}			T_{NS}^{kt}
Bilateral Market Access $ln(\phi_{NS}^{kt})$	0.147	0.145	0.146	0.044	0.044	0.104
	0.010^a	0.011^a	0.011^a	0.011^a	0.011^a	0.014^a
Market Access*env gap $ln\left(\phi_{NS}^{kt}\zeta_{NS}^{t}\right)$				0.103	0.103	0.134
with $\zeta_{NS}^t = E_N^t - E_S^t$				0.011^a	0.011^a	0.040^a
Environmental regulation						
Env expenditures $ln(E_N^{kt})$	0.410	0.426	0.424	0.424	0.424	0.482
at the industry-level	0.013^a	0.014^a	0.014^a	0.014^a	0.014^a	0.026^a
Home env regulation E_N^t	5.131					
at the country-level	0.427^a					
Host env regulation E_S^t	-0.390					
at the country-level	0.143^a					
Env regulation gap $log(\zeta_{NS}^t)$		0.113	0.102	0.102	0.102	0.076
		0.023^a	0.023^a	0.023^a	0.023^a	0.039^b
Corruption effects						
Corruption index c_S^t	-0.233	-0.297	-0.155	-0.155	-0.221	-0.168
	0.020^a	0.019^a	0.028^a	0.028^a	0.034^a	0.064^a
$\zeta_{NS}^t * c_S^t$					0.063	-0.001
					0.024^a	0.004
Origin productivity			0.227	0.227	0.222	0.914
			0.040^a	0.040^a	0.032^a	0.062^a
Destination productivity			0.150	0.150	0.154	0.336
			0.026^a	0.026^a	0.022^a	0.043^a
Inflation model	Logit	Logit	Logit	Logit	Logit	Logit
Time Effects	yes	yes	yes	yes	yes	yes
Countries (cty) / Industry (ind) FE	no	no	ind	ind	ind	ind
Pseudo-R^2	0.62	0.63	0.67	0.67	0.70	0.72
Log Likelihood	-24543.33	-19389.98	-19328.89	-19328.89	-19325.42	-35173.74
Wald Chi-2	1857.56[1]	1522.68[1]	1624.79[1]	1624.79[1]	1656.00[1]	1173.81[a]
Likelihood-ratio test	4.9e+05[1]	3.7e+05[1]	3.7e+05[1]	3.7e+05[1]	3.7e+05[1]	2.07e+07[1]
Vuong test	95.20[1]	81.32[1]	76.02[1]	76.02[1]	75.00[1]	18.44[1]
Overdispersion test (alpha)	1.185[1]	1.173[1]	1.151[1]	1.151[1]	1.150[1]	2.651[1]
Zero observations	11542	7943	7902	7902	7902	7902
Observations	16546	11915	11869	11869	11869	11869

[abc]denote significance at the 1, 5 and 10% level respectively; [1]denotes the rejection of Null hypothesis at the 1% level. Robust standard errors are reported in parenthesis. They have also been confronted with bootstrapped standard errors which allows confirming that coefficients' significance is not affected.

In column 1 and 2 of Table 3, we estimate Equation (16) without the two interaction effects of the model (without the terms $\phi^{kt}_{NS}\zeta^{t}_{NS}$ and $\zeta^{t}_{NS}c^{t}_{S}$) and without sector dummies. The main difference between these two columns concerns the measure of environmental standards: in column 2, we replace the levels of POPs regulation in each country by a bilateral variable measuring the difference between origin and destination levels.[31] Now, turning to the results, the estimated parameters show that a good market access between N (Europe) and S is a good incentive to relocate activities in S since the coefficient of the bilateral market access is positive and highly significant.[32] If the bilateral market access doubles, it implies an increase of around 15% of the number of relocated firms.

Concerning environmental standards, they explain a significant part of European location choices. As expected, an higher level of norms in Europe, at country and sector levels, fosters the relocation of firms just as a lower level of norms in the destination country. Comparing the two coefficients of environmental norms leads us to conclude that European location choices are more *sensitive* to the norm in the origin country than to the norm at the destination. Actually, elasticities are equal to respectively 5.13% and 0.39% of variation following a 1% increase in environmental regulation. Moreover, a stronger gap between these environmental norms represents an opportunity to relocate, as shown in column 2, with an elasticity around 0.13%. All these coefficients are significantly different from zero confirming the PHH. The first two columns also report the coefficient for corruption which is negative and highly significant. This last result matches with our expectations, corruption is a cost, a dispersive force which leads European firms to stay located in their origin country.

Column 3 shows the results of the regression in which we add the GDPs per capita of each country to control for differences in productivity. We also add sector dummies to control for sector-based heterogeneity. The other coefficients are not affected in size and significance.

Now interaction terms are introduced in order to check their effects on the set of coefficients and to match with the theory. Columns 4 and 5 report the estimated coefficients with the terms $\phi^{kt}_{NS}\zeta^{t}_{NS}$ and $c^{t}_{S}\zeta^{t}_{NS}$, matching with the complete specification described in Equation (18). These two estimations allow studying the interactive effect of the environmental regulation gap with market access and bad governance. A higher gap in environmental standards leads to more relocation in countries that benefit to a good European market access. Making the parallel with Figure 3.2.2, the positive sign indicates that our framework may be located in the decreasing part of the bell-shaped curve. This result illustrates the PHH in a globalized context (i.e. conditioned by trade openness). If the direct effect of corruption is clearly

[31] When this differential is used, the logarithmic transformation implies the elimination of all observations for which the differential is not strictly positive. This restriction means that for followed colums, the subsample only concerns the pairs of countries which are under the PHH.

[32] This result will be robust to the use of alternative measures of market access as shown in Appendix C.

negative, it is important to assess its conditional effect with the environmental gap. The positive coefficient suggests the complementarity of the two determinants, countries with bad governance are more attractive than others when they offer a differential in the regulation of pollutants. Quantitatively, the coefficient implies that, in case of an higher differential in environmental standards, corrupted countries attracts around 6.3% more firms than other countries. In that case the applied regulation gap may be stronger than the official one.

An important test of our result consists in replacing the dependent variable, namely the number of affiliates, by the associated turnover recorded in the same database. Column 6 reports the parameter estimates of this last regression.

The explanatory power of corruption leads us to conduct a deeper analysis of corruption effects in order to refine our conclusions and discuss the potential indirect effect of corruption on the relocation of European affiliates. The next sub-section is devoted to this analysis, focusing on the role of bad governance.

5.2 The role of corruption

5.2.1 Complementary results based on interaction effects

As discussed previously, bad governance within the framework of PHH is certainly attractive but only for intermediate levels of corruption. Actually, it is likely that countries with the worst institutions are not attractive even if they supply very low levels of environmental regulation. We thus re-estimate the previous model three times by considering different thresholds of corruption. In concrete terms, we define a dummy variable which takes the value 1 for a specific level of corruption. This dummy variable is denoted $corrupt_S$ and its interaction with the gap ζ_{NS} is introduced in the regressions.

Destination countries are split into three groups, following the degree of corruption.[33] All other independent variables previously used are also included in the regression but in reason of identical results we only report the interaction term in Table (4). Column 1 and 3 reveal that the environmental regulation gap is not attractive at the extreme of the spectrum of governance. In short the PHH is neither verified in countries with good governance nor in country with very bad governance. This certainly explains why many studies have considered the PHH as a myth. But the myth turns out to be true for an intermediate level of governance. Indeed for moderately bad governance the negative effect is significantly positive.

[33] Each group is determined based on a threshold on the corruption index. If it is less than -1, the country is considered very corrupt (denoted *bad*), between -1 and 0 as moderately corrupt, and if not as uncorrupted (denoted *good*).

Table 4: Interaction effects

Dep variable	s_{NS}^t			T_{NS}^t		
Country group	Bad	Moderately bad	Good	Bad	Moderately bad	Good
$\delta_{NS} corrupt_S$	-1.342	0.110	-0.012	-1.803	0.590	0.534
RSE	0.124^a	0.008^a	0.100	0.167^a	0.161^a	0.146^a

Results go in the same direction for turnovers with the additional interesting result that good governance is now significantly attractive which is a well known fact in the literature on tax havens (Dharmapala and Hines, 2009).

5.2.2 Environmental regulation and corruption, a two-step procedure

The previous step emphasizes that corruption has a negative effect on the whole sample but can be positive for firms attracted by the environmental regulation gap in countries with a moderately bad level of governance. This means that in this group of countries, environmental regulation can be endogenously influenced by corruption. Here, the aim is to take into account this potential endogeneity bias and to assess the indirect effect of bad governance on location choices.

Thus this second empirical strategy takes up a two-step procedure through an instrumentation strategy. Resolution of the identification problem requires to find suitable instruments for environmental regulation. The first step consists in decomposing and estimating the environmental regulation in all partners with "moderately bad governance" where firms relocate a part of their activities, with an instrument for environmental regulation and with the indirect effect of corruption on standards:

$$E_S^t = \varphi E_S^{1971} + \varrho c_S^t + \iota_S^t. \tag{17}$$

where as previously c_S^t is the measure of corruption while E_S^{1971} is the historical level of the norm and ι_S^t an error term. We have chosen to use the level of POPs regulation in 1971 (and alternative periods as robustness checks) as an instrument considering that this past levels of regulation, preceding the 1973-74 oil crisis, is a good proxy of green vanguard activism preceding and explaining the future political mobilization and the current environmental laws.[34] For instance in India, the Dasholi Gram Swarajya Sangh was founded in 1964 and next gives birth to the Chipko movement in 1974 (a movement with Gandhian method consisting to tie activists up to trees against deforestation). The activism of that period

[34]The role of vanguard is of a particular importance to explain political change (e.g. Bueno de Mesquita, 2010)

was crucial to fight against the Bhopal gas tragedy a decade later, one of the worst gas leak incident in India and in the world.

This condition to obtain a relevant instrument is verified if φ is significantly different from zero. The second econometric condition requires that this variable has no effect on the number of established firms forty years later. One more time the year 1971 appears useful, for instance in China the "open door" policy has started with the creation of Special Economic Zones only in 1978. Even after that year, openness has been gradual, the major turning point with strong investment in infrastructures, tax holidays to attract FDI and a fully export-oriented economy is dating back to the 90s. In short, the exogeneity/exclusion condition which consists in assuming that $cov(E_S^{1971}; \varepsilon_{NS}^{kt}) = 0$ is well verified.[35]

The introduction of c_S^t in this first step, is our technical trick to worm the indirect effect of corruption out of the environmental standard when building the predicted value of this last variable. Indeed the predicted value that we consider is only $\widehat{\varphi} E_S^{1971}$. The data built from $\widehat{\varrho} c_{st}$ can thus be used to isolate and directly measure the positive effect of corruption to buy environmental law in soft kleptocracy interested to attract dirty firms. More precisely we estimate the following second step to explain relocation in moderately bad governance environment. The new conditional mean ν_{NS}^{kt} is expressed as following

$$\nu_{NS}^{kt} = exp(a_1(\widehat{\varphi} E_S^{1971}) + a_2(\widehat{\varrho} c_{st}) + X_{NS}^{tk} + \lambda_t + \lambda_k), \tag{18}$$

where a_1 and a_2 are coefficients that we aim to estimate and where X_{NS}^{tk} takes into account variables already used in the previous estimation and nominally reported in Table (5). Because fixed effects are used in prior regressions (in particular for the market access), we have computed bootstrapped standard errors in order to obtain unbiased confidence intervals.

Table 5 reports the results for the two steps of estimations.

[35]We also used more recent data, namely the level of POPs regulation in 1975, 1985 and 1995 in the instrumentation strategy. Results are very similar.

Table 5: The Pollution Haven Hypothesis and the role of corruption

	(1)	(2)	(3)	(4)
Dependent variable		s^t_{NS}		T^t_{NS}
Destination group	*Baseline*	IV	IV	IV
Bilateral Market Access ϕ^{kt}_{NS}	0.147	0.107	0.098	0.110
	0.010^a	0.028^a	0.029^a	0.012^a
Environmental expenditures E^{kt}_N	0.410	0.568	0.601	0.449
at the industry-level	0.013^a	0.038^a	0.037^a	0.028^a
Home environmental regulation E^t_N	5.131	0.066	0.049	0.031
at the country-level	0.427^a	0.021^a	0.019^a	0.014^b
Host environmental regulation E^t_S	-0.390			
at the country-level	0.143^a			
Predicted Host env regulation $\widehat{\varphi} E^{t-1}_S$		-0.137	-0.265	-0.022
at the country-level		0.028^a	0.044^a	0.027
Direct effect of corruption (c^t_S)	-0.233	-2.303		
	0.020^a	0.496^a		
Indirect effect of corruption ($\widehat{\varrho} c^t_S$)			0.282	0.080
			0.060^a	0.007^a
First-step coefficients				
IV past regulation E^{t-1}_S	0.334	0.334	0.334	0.334
using POPs regulation in 1971	0.020^a	0.020^a	0.020^a	0.012^a
Corruption index c^t_S	-4.337	-4.337	-4.337	-4.337
	0.055^a	0.055^a	0.055^a	0.055^a
First-step coefficient of determination	0.45	0.45	0.45	0.45
Overidentification test p-value	0.51	0.51	0.51	0.65
First-step Fisher coefficient	4233.22^a	4233.22^a	4233.22^a	4233.22^a
First-step Root MSE	7.40	7.40	7.40	7.40
Log Likelihood	1719.01^1	1688.65^1	1674.32^1	1306.97^a
Wald Chi-2	$8.3e{+}05^1$	$8.2e{+}05^1$	$7.2e{+}05^1$	$7.6e{+}07^1$
Observations	11869	11869	11869	11869

a, b and c denote significance at the 1, 5 and 10% level respectively

Bootstrapped standard errors are reported in parenthesis

From the first-step, the good performance of the instrumentation strategy is clear. The coefficient of determination for the first-step is strong, reaching 0.45, and the estimated coefficient of our instrumental variable is highly significant, enabling us to reject the null hypothesis of weakness of the instrument. The level of POPs regulation in 1971 positively explains current regulation. Still from this first-step, corruption costs significantly reduce the level of regulation, which is in keeping with one of the main assumptions of the theoretical framework, namely that corruption is viewed as a means to bring down environmental standards.

Turning to the second step, the most interesting result concerns the impact of corruption, which (as previously) is always negative when taking into account direct measure c_S^t (see Column 1 and 2), but becomes positive when considering the indirect effect of bad governance on green regulation $\widehat{\varrho} c_S^t$ (see Column 3 and 4). Thus the result obtained in the previous section using interaction terms, is here confirmed for the second time with a very different method: bad governance, in this group of countries, is attractive from its impact on environmental regulation.

Another interesting result is that the predicted value of environmental regulation, $\widehat{\varphi} E_S^{t-1}$, has a stronger negative impact (see column 2 and 3) than the original data E_S^t (see column 1). The coefficient of the environmental gap increases from 0.051 to 0.292 between column 1 and 2. Thus a naïve regression not taking into account the endogeneity bias tends to underestimate the PHH.

5.3 Placebo tests for the PHH

To check the robustness of our conclusions and the validity of the PHH, we first proceed to a sector decomposition. We build a placebo test by considering two groups. A reference group is defined as the most highly polluting industries, based on nitrous oxide, and a control group defined by less polluting industries.[36] This classification is very similar when sulfur dioxide or CO2 emissions are used as criteria. We regress Equation (18) for the reference group and then we re-estimate our baseline model by introducing less-polluting firms (Placebo group) into the analysis. If the impact of their introduction is not significant, baseline results are confirmed. Table (6) reports these results for the reference group in Column 1 and for the whole sample in Column 2. Lastly the model is re-estimated by considering only the control group (Column 3), by considering only chemicals firms (Column 4), which are usually considered as polluting firms (e.g. Millimet and Roy, 2013) and lastly by focusing on transport equipment which are produced without generating too much pollution. This last group can furthermore be interesting because related to economic growth and thus allows analyzing if our variables of environment incorrectly capture other things (linked to steps of development) that are not our primer interest.

Controlling for the placebo group (Column 1) does not qualitatively affect our estimates for the original treatment (Column 2, which is identical to Column 3 in the previous Table 5).

[36]Polluting industries are: coking, extractive industry, energy, chemical industry, metallurgy, food-processing industry, rubber industry.

Less polluting industries are: manufacture, textile and apparel, transport and equipment industry, wood industry, communication and computing.

Indeed comparisons of results show that all variables have the same sign when analysing polluting firms only. Results display in the previous section which use the whole sample are thus actually well driven by polluting firms.

Now, by looking more precisely at coefficients for less polluting industries only (Column 3), one can first observe similitude, the market access and regulation at home are still significant. But the most striking differences concern the impact of the environmental norm in the destination country and the regulation environmental that are no longer significant. In a similar way the indirect effect of corruption is not significant. Comparison of chemical and transport equipment confirms these results, bad governance and laxer environmental norms are only attractive in the chemical sector. To conclude, while the previous section have shown that some countries applying laxer environmental attract firms, this section shows that these firms are dirty firms.

Table 6: Placebo Test, a sector-based decomposition

	(1)	(2)	(3)	(4)	(5)
Dependent variable		s_{NS}^{kt}			
Sectors	*More polluting*	*All*	*Less polluting*	*Chemicals*	*Transport equ.*
Bilateral Market Access ϕ_{NS}^{kt}	0.207	0.098	0.109	0.354	0.109
	0.023^a	0.029^a	0.036^a	0.026^a	0.036^a
Environmental expenditures E_N^{kt}	0.309	0.601	0.658	0.350	0.648
at the industry-level	0.043^a	0.037^a	0.083^a	0.041^a	0.081^a
Home environmental regulation E_N^t	0.138	0.049	0.125	0.138	0.098
at the country-level	0.019^a	0.019^a	0.043^a	0.019^a	0.026^a
Predicted Host env regulation $\widehat{\varphi} E_S^{t-1}$	-0.148	-0.265	0.010	-0.275	0.009
at the country-level	0.037^a	0.044^a	0.012	0.022^a	0.012
Indirect effect of corruption $(\widehat{\varrho} c_S^t)$	0.260	0.282	0.115	0.243	0.116
	0.057^a	0.060^a	0.109	0.046^a	0.109
Inflation model	Logit	Logit	Logit	Logit	Logit
Time Effects	yes	yes	yes	yes	yes
Pseudo-R^2	0.62	0.77	0.59	0.57	0.59
Log Likelihood	312.01[1]	688.65[1]	276.34[1]	123.12[1]	157.24[1]
Wald Chi-2	3.3e+04[1]	8.2e+04[1]	4.2e+04[1]	2.2e+04[1]	2.3e+04[1]
Observations	2607	5643	3036	566	548

[abc] denote significance at the 1, 5 and 10% level respectively;

[1] denotes the rejection of Null hypothesis at the 1% level

Robust standard errors are reported in parenthesis. They have also been confronted with bootstrapped SE which allows confirming that coefficients ' significance is not affected.

More Polluting sectors: extractive industries, food-processing, manufactures of wood, petroleum, chemicals, rubber products, coke products.

Less Polluting sectors: textile and apparel, metal products, manufacture of machinery and equipment, office and transport equipment.

We proceed to further robustness checks which are reported in Appendix C. These tests consist in using alternative measures of market access, other environmental regulations variables (de jure/ de facto). Most of the results are unchanged, even when country fixed effects are introduced.

6 But just how important are environmental and trade policies for the PHH?

Our results are statistically significant, but do they also matter economically? On the basis of previous parameters estimates, it may be interesting to shock the data in order to quantify how more stringent environmental regulations in partners countries affect relocation choices. Based on results obtained by estimating equation (16) reported in Table (5, Column 3), we first simulate the impact of an effective policy of environmental harmonization at the European scale. We enforce all European countries with a laxer environmental regulation E_S^t to raise this regulation at the level of the partners E_N^t. In short, we cancel the environmental regulation gap in Europe. The predicted number of relocated firms after this shock is far from being negligible. The numbers of firms that are interested to relocate their activities in these countries after harmonization decreases by 15%. Taming the PHH in Europe can thus be economically important.

Now we turn to a second scenario. We have emphasize during all the text that the market access is an important determinant of relocation, then we aim here to study how negotiation on trade between Europe and its partners can be useful to negotiate on environmental regulations. We present here our result along a scenario of a carbon tax, i.e we aim to assess the reduction in the market access required to compensate the regulation environmental gap. This is typically a policy of "environmental regulations for trade", however it must be clear that the way to compute this policy is strictly equivalent in our framework to a policy of "trade for environmental regulations", where for instance preferential agreements can be enforced with countries accepting to abandon their laxer environmental policy. We select key partners namely, the Maghreb region (Tunisia and Morocco for which the data is available) and China which attract a significant number of European affiliates. Given the current level of relocation, a carbon tax reducing the European market by 13% for firms operating in the Maghreb erases the advantage of the environmental regulation gap. This protection needs to be much more higher for China, implying a reduction of 37% of the European market access from this country. Not analyzed here, such a high level of tax could imply substantial loss for European consumers.

7 Conclusion

The world is not flat, however countries with heterogeneous institutions have rarely been so integrated. How polluting firms evolves in this political and economical environment? Do pollution havens exist, and if yes, are they also corruption paradises? To tackle these issues, the current analysis has proposed a theoretical model and an empirical analysis of the PHH regarding the locations of European affiliates over the period 2007-2009. Evidence of a positive influence of trade openness magnified by environmental regulation gap on the flight of polluting firms towards pollution haven have been found. In the current context of globalization, some countries, especially developing and emerging countries with an intermediate level of bad governance attract dirty firms. Pollution Haven and Corruption Paradise are not a theoretical curiosity, they are attractive for some European firms. The European Union and its large market has the potential to bring some improvements however only coordination policies at the world level regarding environmental standards, trade integration and governance can really change the current situation. Due to the failures of past global collective actions on these subjects, the future looks less bright with validations of the PHH than without.

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Appendix

Appendix A: Data

Some figures on Foreign Affiliates Statistics (o-FATS) To complete the descriptive statistics of sub-section (4.2), we report in Table (7) some figures concerning E.U. countries which record more than 1000 affiliates located abroad. Three main variables are reported, the number of firms, the associated turnover and employment.

Table 7: 2008 data, total of non-EU affiliates, total economic activity

	Nb of firms (x1000)	Turnover (bn €)	Employment (x1000)
Germany	11.3	682	2309
France	10.3	443	1785
Italy	7.8	142	739
Netherlands	6.1	295	666
Sweden	4.2	88	658
Denmark	2.9	n.a.	250
Finland	1.5	67	214
Slovenia	1.5	3	47
Belgium	1.2	19	110
Austria	1.0	35	153

Germany is the biggest contributor in all variables and almost all destinations. U.S. affiliates are very important for Germany (41%), but also for the Netherlands, Italy, Sweden, Finland and Belgium. Italy is particularly present in Africa, Netherlands in South-East Asia. 21% of turnover for the Netherlands is recorded by affiliates resident in offshore financial centers.

Data sources In table (8) are reported the different data sources used in our empirical analysis. The first-step (first raws) refers to the construction of the market access, following the Redding and Venables strategy, which is detailed in Appendix B. Other variables are included in the set of regressors involved in the estimation of Equation (18)

Table 8: Data sources

First-step	Construction of market access	Source
Bilateral trade	Imports and Exports at the 2-digit SITC rev2	UN Comtrade database
Gravity variables	Distances, contiguity, borders, language from	Geodist and Gravity (CEPII)
GDP	in current dollars	WDI database
Second-step	Outsourcing equation	
Nb of firms	Firms relocated from European countries at the industry level Nace rev1 and rev2	FATS (Eurostat)
Environment regulation	Env expenditures by industry (Nace rev 1)	Eurostat
	Env taxes as share of total taxes	Eurostat
Env Performance Index	Global index of env performance	EPI 2013
POPs regulation	Global notation	UNEP-Chemicals
Corruption costs	Kauffman, Mastruzzi Kraay index	ITU-ITC

Governance classment In sub-section 5.2.2 countries are splitted in three groups, ordered by their corruption score, with bad, moderately bad and good governance. We present here the list of each group of countries (sorted by score order)

- Bad governance (score <-1): Somalia, Myanmar, Afghanistan, Equatorial Guinea, Turkmenistan, Angola, Irak, Congo (Democratic rep.), Korea (Dem.'s people rep.), Papua New Guinea, Chad, Zimbabwe, Uzbekistan, Kyrgyzstan, Congo, Sudan, Venezuela, Libya, Jamaica, Haiti, Cambodia, Tajikistan, Azerbaijan, Russia, Laos, Guinea-Bissau, Côte d'Ivoire, Pakistan, Burundi, Kenya, Yemen, Guinea, Togo, Ukraine, East Timor.
- Moderately Bad Governance (score between -1 and 0.5): Bangladesh, Nigeria, Syria, Sierra Leone, Gabon, Cameroon, Ecuador, Central African Rep., Kazakhstan, Honduras, Uganda, Paraguay, Indonesia, Lebanon, Philippines, Comoros, Iran, Mongolia, Tonga, Dominican Rep., Nicaragua, Ethiopia, Benin, Maldives, Moldova, Nepal, Bolivia, Belarus, Niger, Fiji, Mauritania, Cook islands, Niue, Armenia, Gambia, Guyana, Algeria, Senegal, Zambia, China, Guatemala, Liberia, Argentina, India, Albania, Tanzania, Vietnam, Jamaica, Egypt, Eritrea, Mozambique, Sri Lanka, Sao Tome, Malawi, Nauru, Palau, Burkina Faso, Bosnia, Suriname, Mexico, Peru, Thailand, Morocco, Panama, Colombia, Djibouti, Romania, Serbia, Georgia, Bulgaria, Trinidad, Madagascar, El Salvador, Swaziland, Tuvalu, Kiribati, Brazil, Tunisia, Croatia, Belize, Malaysia, Italy, Greece, Ghana, Saudi Arabia, Turkey, South Africa, Samoa, Rwanda, Latvia, Macau, Lithuania, Lesotho, Jordan, Namibia, Bahrain, Slovakia, Seychelles, Kuwait, Grenada, Vanuatu, Hungary, Oman, Czech republic, Poland, Cuba.
- Good governance (score >0.5): Korea, Taiwan, Mauritius, Costa Rica, Israel, Dominica, Cape Verde, Bhutan, Guam, Netherlands Antilles, Virgin Islands, Botswana,

Malta, Estonia, Brunei, Cyprus, United Arab Emirates, Spain, Slovenia, Portugal, Saint Kitts and Nevis, Saint Vincent, Aruba, Cayman Islands, Greenland, Uruguay, Saint Lucia, United States of America, Barbados, Anguilla, Antigua and Barbuda, Bermuda, Japan, Bahamas, Chile, France, Belgium, United Kingdom, Qatar, Germany, Liechtenstein, Ireland, Austria, Hong kong, Norway, Luxembourg, Australia, Switzerland, Canada, Iceland, Netherlands, Singapore, Finland, Sweden, New Zealand, Denmark.

Appendix B

Market access following Redding and Venables (2004)

Concerning explanatory variables, let us start the description with the indicator of trade integration. We have used an indirect measure taken from a gravity equation. Direct measures such as tariffs are indeed not relevant since the FATS database includes activities (e.g. services) for which tariffs represent only a small fraction of trade costs.

Based on Redding and Venables (2004), our empirical investigation is a twofold procedure which consists in estimating a gravity equation with fixed effects and in using their estimation to build price indexes. The gravity equation is estimated using a PPML estimator[37] and country-level fixed effects to control for invariant importer-specific and exporter-specific characteristics. This equation is estimated in cross-section, for each industry and each year reported in our sample. The assumptions layered in the gravity equation of Anderson and van Wincoop (2003) are only relevant in the case of a cross-section data set. [38] Thus, we need to estimate this equation in cross-section in order to obtain time-varying market access through different coefficient estimates.

$$X_{ij} = \lambda \ln \tau_{ij} + a_i \ln FX_i + a_j \ln FM_j + e_{ij}, \tag{19}$$

where FX_i and FM_j are fixed effects to control for a country's market and supply capacity. Note that we use the indices i and j instead of N and S because we use trade data for all trading partners and not only countries recorded in the FATS database. Now, a bilateral

[37]Following the work of Silva and Tenreyro (2006), the use of pseudo-maximum likelihood estimators (Poisson and derivative econometric models) is justified for treating heteroskedasticity and dealing with the presence of zero trade values.

[38]Indeed, the particular normalization of Anderson and van Wincoop ($\Omega_i = \lambda P_i$, where $\lambda = 1$) is incorrect for panel data applications, as Baldwin and Taglioni (2007) have explained and proved with a simple application with three countries and a time dimension.

expression of the market access is following

$$\widehat{\phi_{ij}} = \underbrace{\left[(\exp(FM_i))^{\widehat{a_i}}\,\tau_{ii}^{\widehat{\lambda}}\right]}_{Domestic} + \underbrace{\left[(\exp(FM_j))^{\widehat{a_j}}\,\tau_{ij}^{\widehat{\lambda}}\right]}_{Foreign} \tag{20}$$

in which $\widehat{a_i}$, $\widehat{a_j}$, $\widehat{\lambda}$ are the parameter estimates of the PPML regression *for each cross section.* It appears from Equation (20) that domestic and foreign market access can be distinguished. In this equation, bilateral trade costs τ_{ij} take the following common specification

$$\tau_{ij} = dist_{ij} \exp[Z_{ij}]. \tag{21}$$

where Z_{ij} is a vector of dummies characterizing bilateral trade barriers, such as contiguity. Turning to internal trade costs τ_{ii}, we follow Redding and Venables (2004) by expressing internal trade costs as a function of internal distances, computed for a circular country, as it follows:

$$\tau_{ii}^{1-\sigma} = dist_{ii}^{\frac{1}{2}\widehat{\lambda}}$$
$$dist_{ii} = 0.66\left(\frac{area_i}{\pi}\right),$$

where $area_i$ is the surface in km².

Appendix C

Robustness checks on market access

The following table reports the coefficients estimates of alternative measures of market access, especially, the aggregated measure on all trade partners. In the same vein of our prefered measure of market access, we use the predicted values of a gravity equation to build an aggregated index of market access which is given by:

$$\widehat{\phi_i} = \underbrace{\left[(\exp(FM_i))^{\widehat{a_i}}\,\tau_{ii}^{\widehat{\lambda}}\right]}_{Domestic} + \underbrace{\sum_{j\neq i}\left[(\exp(FM_j))^{\widehat{a_j}}\,\tau_{ij}^{\widehat{\lambda}}\right]}_{Foreign}. \tag{22}$$

We first regress the number of firms by $\widehat{\phi_N}$ and $\widehat{\phi_S}$ and then we use the two component parts (domestic/foreign). The two regressions include the same set of regressors than in Column 5 of Table (3). All coefficients are positive and significant, confirming the fostering impact of market access.

Table 9: The role of market access: robustness checks

Alternative measures of market access	Coefficient	RSE	Coefficient	RSE
Origin multilateral market access	0.107	0.028[a]		
Destination multilateral market access	0.099	0.025[a]		
Origin domestic multilateral market access			0.088	0.018[a]
Origin foreign multilateral market access			0.115	0.029[a]
Destination domestic multilateral market access			0.124	0.026[a]
Destination foreign multilateral market access			0.101	0.027[a]

Robustness checks on environmental regulation (de jure/de facto) and countries fixed effects

As explained in Sub-section (4.2), our preferred proxy of environmental standards is POPs regulation (from the Yale database), which is a *de jure* variable. This choice has been justified, mainly because we prefer a more restrictive measure. A significant sign would be even stronger, knowing that developing countries do not systematically apply these standards. But for the sake of empirical verification, we compare the results using a *de facto* measure captured by the overall performance index. One advantage of this measure is its time variability which allows the use of country-specific fixed effects. Columns 1 and 2 of Table (10) resume our benchmark estimations with levels and difference of standards, columns 3 and 4 report the parameter estimates once environmental standards are replaced by the overall EPI and finally the last two columns check the robustness of our results by introducing countries fixed effects and thus capturing the sample heterogeneity.

Table 10: Environmental standards, de jure or de facto regulation

	(1)	(2)	(3)	(4)	(5)	(6)
	DE JURE		*DE FACTO*		COUNTRIES FE	
Bilateral Market Access $ln(\phi_{NS}^{kt})$	0.145	0.146	0.145	0.146	0.103	0.103
	0.011^a	0.011^a	0.011^a	0.011^a	0.011^a	0.011^a
Environmental regulation						
Env expenditures $ln(E_N^{kt})$	0.416	0.424	0.416	0.424	0.416	0.424
at the industry-level	0.014^a	0.014^a	0.014^a	0.014^a	0.014^a	0.014^a
Home env regulation E_N^t	5.131		0.792		0.127	
at the country-level	0.427^a		0.027^a		0.017^a	
Host env regulation E_S^t	-0.390		-0.410		-0.099	
at the country-level	0.143^a		0.013^a		0.013^a	
Env regulation gap $log(\zeta_{NS}^t)$		0.102		0.108		0.093
		0.023^a		0.026^a		0.016^a
Corruption effects						
Corruption index c_S^t	-0.221	-0.221	-0.221	-0.221	-0.101	-0.101
	0.034^a	0.034^a	0.034^a	0.034^a	0.004^a	0.004^a
$\zeta_{NS}^t * c_S^t$	0.063	0.067	0.057	0.060	0.009	0.009
	0.024^a	0.024^a	0.016^a	0.024^a	0.006^a	0.006^a
Origin productivity	0.227	0.227	0.227	0.227		
	0.040^a	0.040^a	0.040^a	0.040^a		
Destination productivity	0.150	0.150	0.150	0.150		
	0.026^a	0.026^a	0.026^a	0.026^a		
Inflation model	Logit	Logit	Logit	Logit	Logit	Logit
Time Effects	yes	yes	yes	yes	yes	yes
Countries (cty) / Industry (ind) FE	ind	ind	ind	ind	ind	ind
Pseudo-R^2	0.67	0.70	0.67	0.70	0.67	0.70
Log Likelihood	-19328.89	-19325.42	-19328.89	-19325.42	-19328.89	-19325.42
Wald Chi-2	1624.79[1]	1656.00[1]	1624.79[1]	1656.00[1]	1624.79[1]	1656.00[1]
Likelihood-ratio test	3.7e+05[1]	3.7e+05[1]	3.7e+05[1]	3.7e+05[1]	3.7e+05[1]	3.7e+05[1]
Vuong test	76.02[1]	75.00[1]	76.02[1]	75.00[1]	76.02[1]	75.00[1]
Overdispersion test (alpha)	1.151[1]	1.150[1]	1.151[1]	1.150[1]	1.151[1]	1.150[1]
Zero observations	7902	7902	7902	7902	7902	7902
Observations	11869	11869	11869	11869	11869	11869

[abc]denote significance at the 1, 5 and 10% level respectively;

Robust standard errors are reported in parenthesis. They have also been confronted with bootstrapped SE which allows confirming that coefficients' significance is not affected.

It appears that our prior conclusions are quit confirmed by these two tests. All coefficients are always highly significant and of similar sign. As expected, we are seeing a slight decrease in amplitude following the introduction of fixed effects.