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Pollution Haven Hypothesis Revisited: FDI and Environmental Regulation

Abstract: In an era of global economic liberalization, the proliferation of capital flows is commonplace. While the decline in protectionism brings bountiful benefits, there are costs that must be considered. One such cost is the degradation of environmental quality. This analysis investigates the potential relationship between the flow of Foreign Direct Investment, from the US to 89 countries between 1982 and 1999, and environmental regulation. The results depict an insignificant relationship such that there is insufficient evidence to support the claim that rising FDI flows are driven by weak environmental regulation. Hence, the analysis levels doubts on the credibility of the pollution haven hypothesis with respect to the flow of FDI.

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Introduction

Leading up to and ever since the Seattle Round of the World Trade Organization in 1999, there has been strong opposition against the proliferation of free trade (Shah, 2001). Among the antagonists, environmental protection groups have cited important issues regarding a potential 'race to the bottom' of environmental regulations engendered by trade. There is rising concern that countries, hoping to follow an export-led growth model, will be forced to substantially reduce environmental regulation in order to reduce production costs in light of declining protectionism engendered by organizations such as the WTO.

A similar concern among academics is formally known as the pollution haven hypothesis. Ederington (2007) explains the pollution haven hypothesis as a prediction of firms moving from nations implementing strict environmental regulation to nations with weak or no environmental regulation, pollution havens. Firms are expected to make this relocation decision in order to exploit lower costs of production engendered by lower pollution abatement costs. The above argument also implies that nations with more pressing issues such as poverty and internal stability will prefer to trade environmental quality for higher government revenues and GDP, and that developing or low income nations are most likely to make this trade-off.

When making location decisions, firms do not consider just pollution abatement costs. Larger factors may be at play in such decisions, some of which include the availability of raw material, size of market, and distance between producer and consumer. The importance of these other variables makes it unlikely for firms to move solely based on costs of pollution abatement and this is part of the reason for a lack of scholarly consensus regarding the pollution haven hypothesis. Consideration of these gaps in literature and dearth of concrete evidence, presented in the literature review, is encouragement for my research interest in the investigation of a potential relationship between Foreign Direct Investment (FDI) and a 'race to the bottom' of environmental regulations. Thus, the purpose of this analysis is to consider whether FDI flows follow weak environmental regulation regimes in order to exploit lower pollution abatement costs in pollution havens.

FDI is the flow of investment from a firm in a foreign country in order to incorporate a wholly owned subsidiary, acquire a related enterprise, or some other form of cooperative business effort, to expand into the host country's market (OECD Factbook, 2013). While firms consider a vast array of variables before initiating FDI, Gao (2009) finds most of these variables to be similar to those considered in the re-location of firms to foreign nations and those that determine trade flows, such as the size of target market, availability of resources, profitability of enterprise in host country, transportation costs, etc. The advantage of considering FDI rather than firm location when studying this relationship is that the cost of relocation has no bearing on FDI, as there is negligible physical relocation involved. Thus, we might expect pollution abatement costs to constitute a larger share in FDI decision-making processes such that FDI flows in the current year might follow weak environmental regulation from the previous year.

In my literature review, I establish the theoretical framework required for the investigation of a potential relationship between FDI flows and environmental regulation. My conjecture is that a decrease in environmental regulation leads to a rise in FDI, while controlling for all other predictors of FDI flows. I use the third section of this analysis to detail my model of choice, the Gravity Model with augmented control variables, and its theoretical backing, data employed and my regression equations. In section four, I present key results across a variety of estimation techniques and using random effects I find a positive but insignificant relationship between environmental regulation and FDI. Section five is dedicated to a discussion of choices made in this analysis, their implications and problems tackled. Finally, in section six, I draw important conclusions from the result of an insignificant effect of environmental regulation on FDI, highlight limitations of my analysis and also propose directions of further research.

Literature Review

As stated above, firm relocation is a complex decision making process wherein pollution abatement costs are rarely expected to be a priority. Firms are more likely to prioritize the availability of raw material, transport costs, quality of infrastructure, etc. in their location decisions. Thus, the pollution haven hypothesis, considered from the conventional firm relocation perspective, has limited theoretical standing. Copeland and Taylor (2004) shed light on the potential relationship between international trade, economic growth and the environment via a general equilibrium model. Their analysis focuses on channels through which trade affects environmental quality, of which the ones pertinent to this analysis are the pollution haven effect and the pollution haven hypothesis. According to Copeland and Taylor (2004), the pollution haven effect is a phenomenon wherein a rise in pollution regulation has an effect on firm location decisions and trade flows which can be affected by factors other than environmental regulation alone. The pollution haven hypothesis, on the other hand, attributes the entirety of this location decision to environmental regulations. However, trade theory suggests that several crucial factors affect trade, to a greater extent than environmental regulation, such that the pollution haven hypothesis has a weak theoretical basis. Furthermore, they argue that there is little empirical support in favor of this hypothesis. Even the sparse evidence that exists is not credible due to a variety of problems with data and estimation techniques. A majority of these problems stem from an inherent complexity in establishing causal relationships, addressed below, between environmental regulation, trade and international capital flows.

Levinson and Taylor (2008) address the difficulty of empirics associated with the study of the pollution haven hypothesis. Using panel-data with a partial equilibrium model for a firm-level analysis, they face an endogeneity problem. Endogeneity is a statistical problem wherein the independent variable may be correlated with the error term leading to biased estimates. Endogeneity is a common result of a causality loop between the dependent and independent variable and Levinson and Taylor (2008) expect this in the case of the pollution haven hypothesis. Hypothetically, a nation might become a pollution haven due to already existent weak environmental regulation combined with globalization such that pollution intensive industries may set-up in pollution havens and begin exporting polluting goods. Conversely, a developing nation might purposely reduce strictness of environmental regulation in order to attract capital intensive, polluting, industries in order to hasten the process of economic development. Thus, the potential problem of endogeneity is a critical issue when a causal argument is being made. Quiroga et al (2007) is another analysis that investigates the extent to which weaker environmental regulation leads to a comparative advantage in trade and faces an endogeneity problem. They hypothesize that weaker regulation implies lower production costs in heavy-polluting sectors but nations might choose to reduce environmental regulation to boost exports by engendering a comparative advantage via reduced production costs. This is expected for most developing nations that are desperate to establish an industrial base such that they might pursue economic policy detrimental to the environment so as to attract pollution-intensive firms that can then export the polluting goods to the global market.

Furthermore, as Taylor (2005) suggests, it is not sufficient to simply depict that firms move to pollution havens. Firms may also move to an apparent pollution haven to take advantage of lower labor costs, which, among other things, is a regular characteristic of developing nations, which are most commonly considered pollution havens. As international trade agreements provide firms with avenues to exploit lower costs and an opportunity to outsource to nations that enjoy comparative advantage, there is potential for a relationship between weaker environmental regulation and trade. Thus, Taylor (2005) argues that studies focused on the investigation of this relationship must explore the possibility that international trade agreements cause pollution havens, which, given the problem of endogeneity, is a daunting task. Not to mention the additional difficulty associated with creating a nation-wide variable for environmental quality.

Kuik and Gerlagh (2003) examine the potential effect of trade liberalization on carbon leakage: a rise in carbon dioxide emissions in one nation as a result of increased regulation of carbon dioxide emissions in another. Their central argument is that when economically liberalized nations attempt to increase regulation of carbon dioxide emissions, energy-intensive, high carbon dioxide emitting production relocates internationally (in nation with weaker regulation) thereby manifesting increased emissions in another nation. Hence, Kuik and Gerlagh (2003) argue that economic liberalization may undermine a nation's individual ability to regulate the environment. To test their hypothesis, Kuik and Gerlagh (2003) employ a business as usual model wherein there is no regulation of carbon emissions and no economic liberalization. This is compared to the realistic scenario of carbon-reduction policies, in line with the Kyoto Protocol, and economic liberalization as a result of the Uruguay round of GATT. This statistical analysis finds import tariff reductions to increase the overall rate of carbon linkage such that international economic integration undermines the individual ability of a nation to regulate the environment.

While the above literature examines the relationship between economic liberalization and environmental regulation in the direction of the pollution haven hypothesis, some scholarly evidence suggests a relationship contrary to it. Antweiler et al (2001), when considering trade data against sulfur dioxide emissions, find freer trade to result in the transfer of these emissions from developing to developed countries, such that developing countries were observed to have reduced emissions whereas emissions in developed nations grew. They explain this observation by arguing that trade may have both positive and negative effects on pollution. As trade increases income, it increases the demand for a pollution free environment, thereby reducing emissions. But, trade also leads to capital accumulation in developed nations, which favors the production of pollution intensive goods. Therefore, Antweiler et al (2001) argue that pollution effect of growth depends on the process of growth such that growth through capital accumulation would likely lead to greater pollution than other forms of growth. Ederington (2007) reports similar findings with respect to the pollution content of US exports from 1972-1994 in that they find exports to have become more polluting relative to US imports, which conflicts with pollution haven predictions, but is in line with the increase in capital stock in the US, thereby in harmony with the findings of Antweiler et al (2001).

Frankel and Rose (2005) is another analysis that attempts to sort out the causality between trade flows and environmental quality. The causality loop causes an endogeneity problem such that trade and SO_2 emissions might be inversely correlated as predicted by the Porter Hypothesis: increased environmental regulation stimulates productivity by engaging new technology and creates new jobs such that income rises in the economy and a higher income may lead to higher imports. In this scenario, reduced SO_2 emissions may lead to higher trade. Another reasonable explanation is that trade tends to increase incomes as nations specialize in goods and services in which they enjoy a comparative advantage. This higher income may engender a rise in environmental regulation. Having established the endogeneity problem, Frankel and Rose (2005) employ exogenous geographic determinants of trade, such as GDP and distance between trading nations, as instrumental variables to test the effect of trade on country's air pollution and find little evidence to suggest that trade harms the environment. Furthermore, in some cases (SO_2), they report a positive impact of trade on the environment. Zeng and Eastin (2007) also hypothesize relationships between economic integration and environmental quality contrary to pollution haven predictions. They justify their hypothesis by arguing that increased investment and trade facilitates an exchange of regulatory expertise and environmentally safe technologies thereby improving environmental quality. On testing their hypothesis against evidence from China during 1996-2004, they find greater trade and investment flows to decrease SO_2 emissions. Their results are qualified by the understanding that the impact of investment and trade on environmental quality varies depending on the structure of industry in the source and recipient nation. As many analyses report weak results at the country-level, industrial structure could potentially be the missing dimension.

The above review of previous studies that have investigated the pollution haven hypothesis, or similar predictions, reveals little evidence in its favor (at the country-level) while Levinson and Taylor (2008) do find evidence with sector-level data. It is important to note that a majority of these analyses report that a lack of evidence does not necessarily mean that trade is not leading to a decline in environmental quality. Copeland and Taylor (2004) argue that an absence of statistical evidence in these studies is often a symptom of econometric problems and not evidence that environmental regulations are irrelevant in decisions regarding trade and investment flows, an argument of interest for my study given the econometric problems I tackle in my estimations section. Hence, even though the traditional pollution haven hypothesis has existed for decades, there is little evidence in support of it.

Additionally, it is well known that the cost of movement of physical capital is far greater than that of financial capital such that a study of FDI might better reveal the relationship of interest. Thus, the above lack of evidence and the general expectation that pollution abatement costs may be more seriously considered in FDI decisions are motivations for my study of the relationship between FDI and environmental regulation.

Mabey and Mcnally (1999) draw attention to a substantial decline of control on international capital movements, specifically in developing economies, which began in 1990 largely due to the resolution of the Cold War and reunion of East and West Germany. They find part of this decline to have triggered a rise in FDI flows into developing economies, with a large chunk of these flows concentrated in “environmentally sensitive sectors" (Mabey and Mcnally, 1999, p.4). Mabey and Mcnally (1999) hint at a correlation between FDI and environmental quality when they state that the same decade that has seen a sizable rise in FDI has also seen the most damage, at the fastest rate, to the environment. It is important to note that despite several analyses leveling doubt on the conventional pollution haven hypothesis, few make the claim that there is no relationship between international economic integration and environmental degradation. Thus, qualitative evidence presented by Mabey and Mcnally (1999) is justification for my analysis of the pollution haven hypothesis via FDI.

It is important to note, early in the analysis of FDI and environmental regulation that the problem of reverse causation is not limited to study of the pollution haven hypothesis through trade. Cole et al (2006) explicitly consider the reverse causation (opposite of my analysis), hypothesizing that recipients and originators of FDI jointly campaign for favorable environmental regulation and the outcome of this lobbying depends on the "local government's degree of corruptibility" (Cole et al, 2006, p.1). Testing this hypothesis through a political economy model with imperfect competition, Cole et al (2006) find evidence to suggest that a low degree of corruptibility implies a small, negative effect of FDI on environmental regulation but a high degree of corruption implies a strong, deregulatory effect of FDI on the environment of the recipient. As this analysis reports evidence for a causal direction opposite to my expectations, there arises a potential endogeneity problem, which is duly noted and influences the construction of my environmental regulation variable, detailed in the methodology section. Endogeneity is an important concern as the purpose of my research is to investigate the expected causal relationship that weak environmental regulation drives higher FDI inflows.

Kheder (2005) is a sector level analysis of the relationship between FDI and environmental regulation. Nonetheless, the estimates from her analysis are relevant to the discussion due to limited scholarly precedent of the investigation of the relationship of interest. Kheder (2005) finds the coefficient estimates of recipient nation's GDP to be significant at the 1% level only for Chemicals sector. These estimates for the transport and food sectors are significant at the 10% level and insignificant in the primary, machinery and electronic products sectors. On average, a 1 US dollar increase in GDP of recipient nation explains a 3% increase in FDI. Kheder (2005) uses CO_2 as a quantitative measure of environmental regulation and reports significant (at 10% level) estimates only for chemical industries but the sign here is negative. Kheder (2005) is unable to offer a tenable explanation for the mismatch between theoretical expectations and reported estimates of CO_2. Kheder (2005) also observes a negative relationship between population density and FDI for every sector but machinery. This observation can be explained by the fact that population density might be capturing more than just agglomeration economies and market size. While agglomeration economies are significantly beneficial in some sectors, they may be detrimental in other sectors specifically with respect to pressure on infrastructure and scarcity of investment in other areas. Therefore, at the country level, it cannot be said with certainty that the population density of the recipient nation must have a positive relationship with FDI inflows, an important consideration in the discussion of control variables in my analysis, presented below.

Methodology

I devote this section to the discussion of my decisions regarding the use of data, inclusion and construction of variables, and model employed. Additionally, I also present expected relationships between the independent variables and FDI.

I Data

A list of all variables and their sources can be found in Table 1. The data employed is country-level panel data from 1980-1999. I chose this time period based on legislation regulating SO_2 emissions in the US. SO_2 emissions are selected based on a wide array of considerations to establish which I must first present the construction of my environmental regulation variable. Following from Quiroga et al (2007), I employ an output oriented environmental regulation variable, as the consideration of both form and enforcement of the regulation are crucial. An output-oriented variable is pertinent as it effectively captures stringency and regulatory efficiency while an input-oriented variable simply considers the efforts in environmental protection such as legislation. The construction of an output-oriented variable requires the identification of indicators that will be suitable for my data set. Thus, in selecting an indicator, I attempt to conform to the conditions laid out by Quiroga et al (2007) in that the emission must be from a process of production, must be regulated due to potential harmful impacts, be widely recognized and have universal abatement processes, and most importantly must have abundant data. A pollutant that reasonably fits this bill is Sulfur Dioxide.

Sulfur Dioxide (SO_2) is a common pollutant from anthropogenic practices and is the major cause of acidification of ecologies as it forms sulfuric acid when introduced to moisture. Coal, a major energy resource employed in the generation of electricity, is the foremost contributor of global sulfur dioxide emissions due to its natural sulfur content that is oxidized when coal is burned. Yet another source is the combustion of crude oil, a resource that modern industry is hinged on. Thus, sulfur dioxide emissions are not endemic to a specific set of nations and are expected to be global contributors to environmental degradation due to widespread use of fuels that generate them. These emissions can be reduced through various abatement processes that involve methods like desulfurizing, scrubbing or changing fuel sources based on sulfur content. These methods are costly enough to cause a considerable hike in production costs. Thus, the level of national SO_2 emissions is determined by the quantity of coal and oil consumed, sulfur composition of these fuels, and the application of abatement methods. Following from the above argument, I construct my environmental stringency variable by calculating the ratio of sulfur dioxide emissions to the share of coal and oil in a nations energy production, in line with Quiroga et al (2007). Stern (2005) provides the sulfur dioxide emissions data that I compiled with share of coal and oil in a nations energy production (EIA).

Additionally, qualitative evidence points to a potential relationship between international capital flows and rising SO_2 emissions. Global FDI outflows rose from $621 billion in 2001 (IMF, 2003) to $1200 billion in 2006 (UNCTAD, 2006). Over these 5 years, SO_2 emissions rose substantially in developing nations as was seen in the case of China with SO_2 emissions rising from 21,393 Gg in 2000 to 32,673 Gg in 2005. Proliferation of these emissions is a cause for concern as acidification of ecologies leads to destruction of agricultural crops and biodiversity. Additionally, higher levels of SO_2 emissions are harmful for humans as they lead to respiratory and heart diseases (MMA).

Moving back to the issue of data selection, I chose to use panel data from 1980-1999 based on Swift's (2001) report that the US passed the first piece of legislation to regulate SO_2 emissions, the Clean Air Act, in 1970. While this legislation enjoyed limited success, concerns regarding acid rain were reflected in numerous bills proposed by congress through the 1980s. According to Swift (2001), in 1990 the Bush Administration successfully developed legislation that capped SO_2 emissions at 8.95 million tons per year for electricity production. While electricity production cannot be relocated, the US regulation of SO_2 serves as a proxy for its stringency with respect to environmental regulation.

The dependent variable is FDI flows from the US to 89 recipient nations from 1980-1999 and is sourced from the US BEA. FDI flows also played an important role in my selection of data. As the US was intensively involved in the Cold War, a lot of its foreign investments rose substantially after the collapse of the USSR, beginning in 1990. In order to get a healthy sample to depict this trend, I identified a 19-year window around the collapse of the Soviet Union, which also overlapped with my selection of SO_2 emission data.

There is also a strategic reason for my choice of panel over cross-section data. Levinson and Taylor (2008) find estimation techniques to be evenly divided between researchers investigating the pollution haven hypothesis such that some employ firm-level data while others consider country-level data. Common denominators between these studies are that they employ cross-sectional data and find little evidence, as cross-sectional data limits the ability of scholars to control for confounding variables correlated with environmental regulation and trade flows, as dissipation over time or past effect is not available. For example, control variables that explain firm relocation or even FDI (GDP of recipient nation, Inflation, etc.) are likely to vary over time and this variation is not captured in cross-section data. Levinson and Taylor (2008) highlight a dearth of studies employing panel data and report small but significant statistical evidence in favor of the pollution haven hypothesis for those that do use panel data. Thus, in order to avoid bias from confounding variables, I employ panel data. Additionally, I selected country-level data rather than sector-level data for a couple of reasons. Firstly, country-level data provides a macroeconomic view of FDI flows and allows consideration of the effect of environmental regulation on FDI through national policies. Secondly, as several studies using country-level data found little or no evidence for the pollution haven hypothesis from the firm relocation perspective, I wanted to consider FDI at the same level and evaluate whether the reason for lack of evidence at the country-level was due to the consideration of the pollution haven hypothesis from the conventional firm relocation perspective.

II Model

As stated above, FDI is the dependent variable in my analysis and environmental stringency is the key independent variable. In order to test the potential of a causal relationship between FDI and nation specific environmental stringency, the FDI variable must depict flows for specific country pairs over each year. The original data available on FDI, from the US BEA, is an aggregate variable with built-in depreciation. Therefore, the data provides aggregate outward stock of FDI from the US to recipient nations for all available years. In order to develop a flow variable, the FDI stock is first differenced.

In the process of intuitively selecting a model, I attempted to establish a list of independent variables that would serve as predictors of FDI flows. Firstly, GDP of the US is expected to be a very strong predictor of FDI flows given that the ability of American firms to invest abroad largely depends on the value of their product and thereby the revenue that they generate. A rise in GDP essentially means a rise in the value of the domestic product such that incomes rise and firms seek investment opportunities abroad. The GDP of the recipient nation is also expected to have an important relationship with FDI inflow. A nation generating a high GDP shows signs of potentially profitable enterprise in its domestic economy. Additionally, the GDP of a nation can be considered as a proxy for market size given that GDP and income are highly correlated. Thus, a higher GDP in the recipient nation would encourage greater FDI flow from the US.

Another important influence on FDI flows is information cost. This cost is expected to embody the process of communication, relay of market-sensitive information and the cost of transition of capital through international markets. A good proxy for this, according to Subasat and Bellos (2013) is the distance between the two nations. Though I previously asserted that distance might be a lesser important factor in FDI decisions compared to complete firm relocation, it does not mean that the distance between the two nations has no bearing on FDI flows. Subasat and Bellos (2013), in their survey of previous literature, find the distance between two nations to be a sound predictor of FDI flows between them. Their observation can be rationalized by arguing that distance serves as a proxy for information costs as greater the distance between the two nations, greater the time difference such that their respective capital markets take longer to relay information thereby increasing the cost of capital flows. Therefore, I expect a negative relationship between FDI and distance between the two nations. An important aspect to note about FDI flow and GDP of the recipient nation is that they vary significantly such that FDI ranges from 0 to very high values and GDP also has a similarly large range. In order to control for this large degree of variation, and to linearize the relationship between FDI and GDP, I use a double log form, which results in the basic specification below.

$lFDI_{usjt} = \alpha_0 + \beta_1\ lgdp\_us_t + \beta_2 lgdp\_r_{jt} + \beta_3 ldist\_cap$

The above specification is the double-log or log-linearized form of the Gravity Model. Subasat and Bellos (2013), and a host of studies they consider, find the Gravity Model to be a good predictor of FDI flows. Additionally, Gao (2009) tests the applicability of the Gravity Model to FDI flows. As the Gravity Model allows for data using country pairs over a number of years, it works well with panel data. Gao (2009) highlights that the Gravity Model is an excellent predictor of trade flows, validated by a host of analyses that employ this model. He also stresses the high likelihood of a complementarity between FDI and trade such that a nation that is profitable for capital inflows may well be an attractive export market. Thus, Gao (2009) expects that unless there are considerable information asymmetries, FDI and trade will follow a similar pattern. On running a simple OLS, Gao (2009) finds GDP of both nations and distance between the nations to be significant predictors of FDI with relationships in the expected directions.

The environmental stringency variable (ENV) represents the strictness of environmental regulation in the recipient country. The variable is a ratio of SO_2 emissions to the share of coal and oil in total energy production in the recipient nation. If the environmental stringency variable has a high value (ratio is high) it implies that between energy production and consumption, the checks and balances placed on SO_2 emissions are weak and a low ratio implies that regulation is strong. Therefore, the environmental stringency variable is expected to have a positive correlation with the FDI variable if the pollution haven hypothesis holds. I also consider control variables to account for FDI flows between the US and recipient nations. Population density (POP) is included to serve as a proxy for market size and agglomeration economies in the recipient country. Population density is expected to have a positive correlation with FDI flows, as more firms are willing to invest in nations that have a larger market size, i.e. greater population density in this case. Capital-labor ratio (KL) and the square of this ratio (KL_sq) are included to represent the nature of factor endowments in the recipient nation. A high capital-labor ratio implies more capital per worker, whereas a low capital-labor ratio depicts a scarcity of capital. It is reasonable to expect a positive relationship between capital-labor ratio and FDI as nations with similar industrial structure tend to exchange greater capital flows. The square of capital-labor ratio is included to encapsulate the diminishing effect of capital at the margin and is also expected to have a positive correlation with FDI. Official (comlang_off) and ethnic (comlang_ethno) common language dummy variables are included to account for the reduction in negotiation, information and communication costs due to the presence of either an ethnic or official common language. These dummy variables are expected to have a positive effect on FDI. Inflation is included to serve as a measure of macroeconomic stability. A high level of inflation implies macroeconomic instability, which is expected to have a negative effect on FDI. Additionally, FDI is expected to flow from nations with high GDP per capita to nations with low GDP per capita due to a higher return on capital in low-income nations such that the difference in GDP per capita (gdpcap_diff) between the two nations is expected to have a positive correlation with FDI. Finally, the corporate tax rate (TAX) is expected to have a negative correlation with FDI, as firms would prefer to invest in companies that face lower rates of taxation.

Therefore, the augmented Gravity Model specification is as follows:

$lFDI_{usjt} = \alpha_0 + \beta_1\ lgdp\_us_t + \beta_2 lgdp\_r_{jt} + \beta_3 ldist\_cap + \beta_4 lPOP_{jt} + \beta_5 lKL_{jt-1} + \beta_6 lKL\_sq_{jt-1} + \beta_7 comlang\_off + \beta_8 comlang\_ethno + \beta_9\ lInflation_{jt} + \beta_{10} lENV_{jt-1} + \beta_{11} lgdpcap\_diff_{usjt} + \beta_{12} Tax_{jt} + \Sigma_{ijt}$ (1)

The capital-labor ratio variables are lagged by one year to capture the influence of capital stock in the previous year on the FDI in the current year. The environmental stringency variable is time lagged (by one year) to avoid an endogeneity problem. Time-lagging allows me to isolate the effect of environmental stringency in year 't-1' on FDI in year 't' as firms are expected to make FDI decisions in the current year based on pollution abatement costs in the previous year and my research question is whether FDI follows weak environmental regulation. This also allows exclusion of the influence of FDI in year 't' on regulation in year 't' as nations are expected to decrease environmental regulation to invite FDI in year 't+1' if they are unsatisfied with FDI in year 't'.

Subasat and Bellos (2013) include several additional control variables, in predicting FDI, that serve as proxies for the quality of business environment, ease of doing business and quality of public governance. The sourcing of this data requires funds beyond the means available to this analysis. The exclusion of these variables has important implications with respect to the reliability and significance of coefficient estimates.

Estimations

I begin my analysis of the data with a basic Ordinary Least Squares (OLS) estimation and find violations of classical assumptions: multicollinearity, heteroskedasticity and serial correlation. While multicollinearity is corrected for by dropping capital-labor ratio (KL), heteroskedasticity is dealt with by the use of heteroskedasticity-consistent standard errors. Serial correlation requires the use of Generalized Least Squares. Fixed effects is employed to control for potential omitted variable bias but it does not allow for time-invariance in independent variables and hence, the estimates from Random effects are preferred.

I OLS

Detailed estimates of the robust OLS regression can be found in Table 2.

An ordinary least squares regression of specification (1) presents a problem, as the sample size is too small if all variables are included. The culprit is found to be the corporate tax rate and once dropped, the sample size rises from 30 to 312 observations. The latter specification is preferred while keeping in mind that it may suffer from omitted variable bias. Thus, the new specification is:

$$lFDI_{usjt} = \alpha_0 + \beta_1\ lgdp\_us_t + \beta_2 lgdp\_r_{jt} + \beta_3 ldist\_cap + \beta_4 lPOP_{jt} + \beta_5 lKL_{jt-1} + \beta_6 lKL\_sq_{jt-1} + \beta_7 comlang\_off + \beta_8 comlang\_ethno + \beta_9\ lInflation_{jt} + \beta_{10} lENV_{jt-1} + \beta_{11} lgdpcap\_diff_{usjt} + \Sigma_{ijt} \quad (2)$$

As both capital-labor ratio and its square are included, I suspect the possibility of multicollinearity and test for it using Variance Inflation Factors (VIF). The test reveals a mean VIF of 313.24, way above the threshold value of 5. Capital-labor ratio and its square have VIFs of 1735.21 and 1693.31 respectively. Upon dropping the basic ratio, the mean VIF drops to 1.90. Multicollinearity is problematic in this case as two of my independent variables are highly correlated (one being the square of the other) thereby making the coefficients on individual predictors unreliable and also increasing the standard errors. Dropping the capital-labor ratio yields results with lower standard errors implying more reliable tests of significance.

The Breusch-Pagan test reveals the problem of heteroskedasticity and I correct for it by the use of heteroskedasticity-consistent standard errors. Estimates with robust standard errors, and without the basic capital-labor ratio, have an R-squared of 0.2579 such that the model explains 25.79% of the flows of FDI from the US to recipient nations during the years 1980-1999. Most importantly, the environmental stringency variable has a positive sign, in the expected direction, but is insignificant at the 10% level. A 1% higher ratio of SO_2 emissions to the share of coal and oil in total energy production explains a 0.08% rise in FDI. GDP of the recipient nation and inflation yield coefficient estimates significant at the 5% level such that a 1% increase in GDP of the recipient nation explains a 0.81% rise in FDI from the US to that nation, all else equal. Additionally, a 1% rise in inflation explains a fall in FDI by 0.27%. These estimates meet expectations. All other estimates are insignificant at the 10 % level. Keeping the insignificance of these results in mind, I find that a 1% rise in US GDP explains a 0.55% rise in FDI. Distance between the capitals of the two nations defies expectations such that it has a positive sign but the estimates are insignificant. Population density has a negative sign, against expectations, also insignificant at the 10% level.

A test for first-order auto correlation reveals serial correlation to be a problem. As Generalized Least Squares corrects for serial correlation in panel data, its estimates are discussed below.

II Generalized Least Squares (GLS)

Refer to table 3 for detailed estimates.

The GLS regression technique corrects for auto-correlation in panel data. The estimates from this regression reveal that the coefficient of the environmental stringency variable is insignificant at the 10% level but a 1% rise in the ratio of SO_2 emissions to the share of coal and oil in total energy production of the recipient nation explains a 0.08% rise in FDI. A positive and significant relationship (at 1% level) between recipient nation's GDP and FDI is observed such that a 1% rise in GDP of the recipient country predicts a rise in flow of FDI by 0.74%. Inflation is significant at the 5% level such that a 1% rise in inflation explains a 0.27% decline in FDI flow. Official common language is significant at the 10% level such that recipient nations with English as their official language are likely to receive 0.78% higher FDI. All other variables are insignificant at the 10% level. Distance between capitals of the two nations has a positive sign but is insignificant and the coefficient estimate is almost negligible in size (0.02%). Square of capital-labor ratio has a positive sign (as expected) such that 1% rise in capital-labor ratio explains a 0.07% rise in FDI but this result is also insignificant. Difference between per capita GDP is insignificant yet the relationship is in the expected direction such that a 1% greater difference in GDP per capita between the US and recipient nation explains a rise of 0.28% in FDI flows from the US to the recipient nation. Population density is insignificant at the 10% level. That is weak enough for the negative sign on the variable, contrary to expectations, to not have much meaning.

III Fixed and Random Effects

The fixed effects estimation carries a major advantage such that it avoids bias due to omitted variables that don't change over time. Such time invariant omitted variables are referred to as unobserved heterogeneity or the fixed effect. By avoiding this bias, fixed effects produces reliable estimates (Studenmund, 2001). This estimation technique is apposite given the known (corporate tax rate, quality of governance, and easy of doing business) and unknown omitted variables. Though we do not expect time-invariance for our known omitted variables, it is not impossible for nations to have a steady corporate tax rate over a number of years. A potential problem with fixed effects is that it removes all independent variables that remain unchanged over-time. In this case, ldistcap is that time invariant independent variable. The variable ldistcap measures the natural log of the distance between Washington, D.C. and the capital of the recipient nation. As this variable is time invariant, it is dropped from the fixed effects estimation. This makes fixed estimates unreliable, as the distance between capitals of nations is a crucial predictor of FDI.

An alternative technique is the random effects estimation detailed estimates of which can be found in Table 4. The random effects estimation avoids the above issue by assuming that the time-invariant differences between individual samples are random rather than fixed. Therefore, the random effects model allows more degrees of freedom while also allowing for the observation of the relationship between the dependent and time-invariant independent variable (ldistcap in my case).

The random effects estimation reveals relationships similar to those observed with basic GLS estimates. The environmental stringency variable is insignificant at the 10% level with a p-value of 0.151. The estimate suggests that a 1% higher ratio of SO_2 emissions to share of coal and oil in total energy production in the recipient nation in year 't-1' explains a 0.095% rise in FDI from the US to the recipient nation in year 't'. Though the expected relationship between environmental stringency and FDI is observed, it is too weak to conclude any causal links. GDP of the recipient nation is significant at the 1% level and its coefficient estimate suggests that a 1% rise in GDP of the recipient nation explains a 0.74% rise in FDI from the US to the recipient nation during year 't' (compare this with GLS estimate of 0.81%). Inflation is significant at the 10% level such that a 1% rise in inflation explains a 0.22% decline in FDI from the US to the recipient nation during year 't'. Population density, again, has a negative sign but is insignificant. GDP of the US is insignificant at the 10% level but a 1% rise in GDP is observed to predict a 0.56 % rise in

FDI. Distance between the nations has a positive sign, contrary to expectations, but is insignificant. Common language dummies are both insignificant at the 10% level. A nation with English as the official language is expected to experience a 0.79% higher inflow of FDI, from the US, than one that does not have English as its official language. Nations sharing common ethnic languages with the US are expected to experience a 0.51% higher flow of FDI than nations that do not. The square of capital labor ratio has a positive sign, as expected, but is insignificant. It is still pertinent to note that a 1% rise in capital labor ratio explains a 0.07% rise in FDI. Finally, difference in GDP per capita explains a 0.28% rise in FDI though it is insignificant at the 10% level.

The random effects estimation produces the most reliable results and a Haussman test is employed to check whether coefficient estimates from the fixed and random effects regressions are significantly different from one another. The test fails to reject the null hypothesis of no systemic difference such that estimates from the random effects regression can be considered as reliable.

Discussion

This analysis reveals several complexities with the investigation of a potential relationship between FDI and environmental regulation at the country level. Firstly, there is a dearth of literature that specifically considers FDI and environmental regulation, which hinders the construction of a theoretically complete model to investigate the relationship in question. However, there is a strong theoretical and intuitive argument in favor of the use of the Gravity Model to predict FDI flows. The double-log form of the Gravity Model allows a reduction in the variance of the dependent (FDI) and key independent variables (GDP of both nations and distance between the nations). It also allows for the study of FDI as a flow variable, between country pairs, to investigative a potential causal relationship between nation specific environmental regulation and FDI. The model also works well with panel data as it allows for cross-sectional and time variation. Additionally, Subasat and Bellos (2013) and Gao (2009) find the base-line specification to be a strong and significant predictor of FDI flows. Therefore, this analysis applies the Gravity Model to the study of the pollution haven hypothesis with respect to FDI flows.

Furthermore, I select country-level data to provide insight into a macroeconomic perspective on environmental regulation. The results of my analysis can potentially answer the question: does FDI undermine the ability of a nation to regulate the environment. Intuitively, assuming the pollution haven hypothesis holds, if the US increases environmental regulation and FDI flows to the recipient nation are found to have a significant relationship with the environmental stringency of that nation, US regulation would be undermined as FDI flows engender environmental degradation in the global commons by transferring emissions to a nation with a weak regulation regime.

Selection of country-level data has an important implication for the construction of my environmental regulation variable. The regulation must affect a pollutant that is not endemic to a few nations or a few sectors and one that has a widespread effect on the environment across the sample. Quiroga et al (2007) argue that the pollutant must be from a process of production and require abatement efforts that substantially increase production costs so as to feature in a firm's decision-making process. The abatement techniques must be widely used and the detrimental effects of the pollutant recognized. In order to conform to all the above, SO_2 emissions are selected. An output-oriented regulation variable is selected as it effectively captures stringency and regulatory efficiency while an input-oriented variable simply considers the efforts in environmental protection such as legislation. The output-oriented variable is constructed by taking a ratio of SO_2 emissions to the share of coal and oil in total energy production. The nature of this variable allows the analysis to consider the ability of a nation, between energy production and final SO_2 emissions, to effectively regulate emissions.

The most reliable estimates for the investigation of interest are from random effects as it controls for time-invariant unobservables (omitted variables constant over time) but also allows for time invariance in the independent variables (ldistcap). Thus, random effects produces reliable results by preventing omitted variable bias from variables constant over time but might still have a bias from omitted variables that vary over time.

As my research is unable to establish a significant relationship between environmental regulation and FDI, based on results from random effects, it cannot conclusively assert that FDI undermines a nation's ability to regulate the environment. However, this result must be viewed in light of the fact that missing data and possible omitted variable bias limit the potential for extrapolation. As corporate tax is dropped due to missing data, a key determinant of international capital flows between firms is not included. Hypothetically, the corporate tax rate is expected to have a negative correlation with FDI, as explained before, but a positive relation with environmental regulation as a government with greater tax revenues has greater resources at its disposal and would be expected to better regulate the environment. Thus, the corporate tax rate might be downward biasing the coefficient on the environmental stringency variable.

Other sources of potential omitted variable bias are proxies of ease of doing business, quality of public administration and corruption. These are not included in my analysis as the data to construct them are not available to me and the data that is available via the World Bank is only available for a small fragment of the time-series considered. Inclusion of these variables in regression specifications reduces the sample size to the extent that the estimation techniques become unreliable. Therefore, the coefficient estimates reported in the estimations section could be severely biased.

There are further complications as estimates of some control variables take on signs in a direction opposite to theoretical expectation. This is particularly true for population density that was expected to have a positive sign but robust estimates portray a negative relationship between population density and FDI at the country level. The logical explanation for this observation is that population density, at the country level, captures more than just agglomeration economies and market size. Furthermore, different sectors in an economy may respond positively or negatively to greater population density. For example, agriculture would suffer if population density were high, in urban areas, due to a scarcity of infrastructure in rural areas and sometimes simply the lack of arable land. The following and final section of this analysis places the results in the bigger picture and attempts to identify future avenues of research.

Conclusion

In light of the above crucial considerations, my analysis reports a weak, positive relationship between FDI and weaker environmental regulation such that countries that either weakly enforce environmental protection policies, or weakly regulate polluting industries are likely to receive greater FDI from the US. This relationship is insignificant at the 10% level such that there isn't enough statistical evidence to establish, beyond a doubt, a relationship between FDI and my environmental stringency variable. Though this analysis is unable to establish the expected relationship, it sheds light on issues that must be critically considered in order to continue the process of investigation.

As mentioned before, missing data is a crucial problem and may well be the largest contributor to the scarcity of evidence, in combination with the endogeneity problem, of the expected relationship in this case. An oversimplified solution to this is just that we need more data, at the country level. A more careful analysis would ask the question: is investigating such a relationship at the country-level the best possible method of analysis? I do not believe so.

While I was unable to investigate the potential for the expected relationship at the sector-level due to a lack of experience handling sector-level data, several other studies using sector-level data, including Kheder (2005), have reported that FDI tends to flow to nations with weaker environmental regulation regimes. Sector-level analysis may well be more complete as it allows a sector-by-sector breakdown of data from firms, where missing data is not as much of an issue. Once sectors are isolated, some variables that behave differently for different sectors can be considered with greater analytical strength, evidence of this was seen in our case of population density. Also, a closer analysis of heavy polluting sectors might have policy benefits in that it could offer a targeted solution to a problem that seems to be extremely complex at the general level. Analysis at a sector-level will allow the construction of an environmental stringency variable that can be tailor-made for each sector based on global emissions. Furthermore, data on control variables may be more easily available and results would reveal very specific information about a potential relationship such that regulation would be a lot easier.

In the bigger scheme of things, conclusions from this analysis are dependent on deductions made about the insignificance of the results. As I stated before, omitted variables bias with missing corporate tax data could well be downward biasing my coefficient estimate on environmental stringency making it statistically insignificant. As I expect future studies to employ more data sets for FDI flows, between other nations and country pairs, while also including the omitted variables, the standard errors would go down such that the coefficient estimates of environmental regulation may well be significant.

The above expectation has important ramifications for policy conclusions. A major question surrounding the investigation of this relationship is whether FDI flows undermine the ability of a nation to independently regulate the environment. If the expectation is that further study of FDI will find evidence for the pollution haven hypothesis, the implication is that nations cannot independently regulate the environment. Thus, a global network of mutually agreed rules on environmental regulation, keeping in account the ability of economic integration to undermine them, might be the solution to this problem that continues to plague the global commons.

Table 1: Variables Description

Variable	Construction/Explanation	Source(s)
$lFDI_{usjt}$	Natural log of Foreign Direct Investment from US to recipient nation. The data was FDI stock and the flow variable was generated by first differencing this stock.	US BEA: http://www.bea.gov/iTable/index_MNC.cfm
$lgdp\_us_{t}$	Natural log of Gross Domestic Product of the US in current US dollars	CEPII
$lgdp\_r_{jt}$	Natural log of Gross Domestic Product of recipient nation in current US dollars	CEPII
ldist_cap	Natural log of distance between Washington D.C. and capital of recipient nation	CEPII
lPOPjt	Natural log of population density (population per square kilometer)	CEPII
lKLjt-1	Natural log of capital-labor ratio lagged by 1 year. Capital stock=2.5xinitial GDP based on Hummels and Levinsohn (1995). Depreciation of 13.33% used and new investment included. Capital then divided by labor force.	Capital: Penn World Table, Labor: World Bank
lKL_sqjt-1	Natural log of square of capital-labor ratio lagged by 1 year	
comlang_off	Dummy variable = 1 if US and recipient nation share common official language	CEPII
comlang_ethno	Dummy variable =1 if US and recipient nation share common ethnic language	CEPII
Inflationjt	% change in consumer price index for recipient nation	World Bank
lENVjt-1	Natural log of ratio of sulfur dioxide emissions to the share of coal and oil in total energy production lagged by 1 year	Sulfur dioxide: Stern (2005); Coal, Oil and Total Energy: EIA
lgdpcap_diffusjt	Natural log of difference between GDP per capita of US and recipient nation	CEPII
Taxjt	% Corporate tax rate in recipient nation	World Bank

Table 2: Robust OLS Estimates

Robust OLS Estimates		R^2=0.2579	
Dep Variable = Natural log of FDI from US to recipient nation			
Indep Variables	**Coeff**	**t-value**	**significance**
Natural log of US GDP	0.5580654	0.98	insignificant
Natural log of Recipient GDP	0.8103927	6.25	1%
Natural Log of distance between capitals of nations	0.0160556	0.04	insignificant
Natural log of population density	-2031.327	-1.38	insignificant
Natural log of capital labor ratio squared (lagged)	0.0710115	0.92	insignificant
Natural log of difference in GDP per capita	0.2826604	0.86	insignificant
Natural log of environmental stringency (lagged)	0.0878007	1.34	insignificant
Official Common Language	0.7876397	1.57	insignificant
Ethnic Common Language	0.5039651	1.37	insignificant
Natural log of Inflation	-0.2691984	-2.18	5%
Intercept	-16.91869	-1.97	5%

Table 3: GLS Estimates

GLS Estimates		Pseudo R^2=0.2579	
Dep Variable = Natural log of FDI from US to recipient nation			
Indep Variables	**Coeff**	**z-value**	**significance**
Natural log of US GDP	0.5580654	1.01	insignificant
Natural log of Recipient GDP	0.8103927	6.01	1%
Natural Log of distance between capitals of nations	0.0160556	0.04	insignificant
Natural log of population density	-2031.327	-1.42	insignificant
Natural log of capital labor ratio squared (lagged)	0.0710115	0.91	insignificant
Natural log of difference in GDP per capita	0.2826604	1.01	insignificant
Natural log of environmental stringency (lagged)	0.0878007	1.36	insignificant
Official Common Language	0.7876397	1.67	10%
Ethnic Common Language	0.5039651	1.29	insignificant
Natural log of Inflation	-0.2691984	-2.06	5%
Intercept	-16.91869	-1.91	5%

Table 4: Random effects estimates

Random Effects Estimates Dep Variable = Natural log of FDI from US to recipient nation		R^2=0.2579	
Indep Variables	**Coeff**	**z-value**	**significance**
Natural log of US GDP	0.5580654	0.99	insignificant
Natural log of Recipient GDP	0.8103927	5.9	1%
Natural Log of distance between capitals of nations	0.0160556	0.04	insignificant
Natural log of population density	-2031.327	-1.4	insignificant
Natural log of capital labor ratio squared (lagged)	0.0710115	0.89	insignificant
Natural log of difference in GDP per capita	0.2826604	0.99	insignificant
Natural log of environmental stringency (lagged)	0.0878007	1.33	insignificant
Official Common Language	0.7876397	1.64	insignificant
Ethnic Common Language	0.5039651	1.27	insignificant
Natural log of Inflation	-0.2691984	-2.02	5%
Intercept	-16.91869	-1.88	10%

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