Globalization and the Environmental Spillovers of sectoral FDI

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Abstract

We analyze the relation between inflows of capital at the sectoral level and environmental degradation and examine the halo effect (FDI brings in clean technology and improves environmental standards), the pollution haven argument (capital flows to poor countries with environmentally lax standards) and the Environmental Kuznets Curve, EKC (pollution increases with economic growth, and declines after a certain threshold of wealth is reached). We find that (i) FDI flows into manufacturing support the pollution haven argument, while those flowing into services support the halo effect hypothesis; (ii) FDI flowing in poorer countries has more harmful effects on environment, while those flowing to richer countries have a beneficial effect and support a halo effect; (iii) When air pollution is measured by CO instead of CO2, FDI flows to OECD countries raise the pollution level in countries receiving investment flows into mining and services, supporting the pollution haven hypothesis; (iv) EKC results hold at an early level of development for most types of capital inflows. As countries become wealthier, EKC is supported if countries allow capital inflows in traditionally dirty industries, such as mining and manufacturing.

Introduction

Globalization is a phenomenon that generates heated discussions, both for and against. Financial crises, social unrest and environmental degradation are some of the many concerns voiced by its opponents. Although crises tend to be self-correcting over time, and social problems can be resolved with economic progress, the same cannot be argued for the degradation of the environment. Arguably, the ecological impact of human activity accumulates through time without trend-reversing (Figure 1). The role of the human factor leading to high correlation between extreme temperatures and soaring levels of atmospheric carbon dioxide is an intensely contentious issue. Critics claim that globalization can have an unfavorable impact on the environment through two channels. (i) The pollution haven, or race-to-the bottom argument. Accordingly, in an environment of liberalized trade flows, tightening of environmental regulation in developed countries can shift polluting industries to countries where regulation is relatively lax; (ii) The "environmental Kuznets curve" (EKC), described by an inverse U-shaped relation between pollution and income. Based on this argument, if globalization contributes to economic growth, it will increase pollution in low-income economies until their level of development reaches a certain level.

Both channels, however, are mitigated by the more recent literature, which revealed what is called a "halo effect". The halo effect hypothesis states that multinational companies disseminate superior knowledge, which applies environmentally friendly practices, while improving the environmental performance of domestic firms. This view parallels the literature examining the productivity gains generated by foreign firms in host country via spillovers of knowledge, knowhow, etc.

In this study we explore the impact of globalization on the host country's environment by combining both strands of the literature. Often the foreign direct investment (FDI) is directly associated with globalization. All three arguments, pollution haven hypothesis, EKC and halo effect, are pertinent for the multinational companies that invest in physical plants and equipments, contributing to the production and growth in host countries. We thus choose FDI as a proxy for globalization and look at the impact of FDI inflows on air quality, controlling for nonlinear income terms. While our goal is to assess the halo effect, and the EKC, our analysis also fits in the pollution haven strand because we examine the role of the FDI and its effect on the pollutants in the host country.

Contribution of this study to the literature

This is the first study that tests both hypotheses in a dynamic framework with a rich sample of multi-country, industry data. We adopt a methodology that circumvents biases plaguing most of the existing studies and a dynamic model, which captures the widely ignored nonlinearities and dynamics in the data. Both the methodology and our data help uncover hitherto unknown interactions.

The studies that examine this question through total FDI use an aggregate measure, which conceals sectoral effects. At the other end of the spectrum, the analyses that examine the investment decisions at the firm level miss the sectoral impact of these decisions and their sectoral implications. In this study, our first contribution is to go well beyond aggregate growth studies by examining not only total, but also sectoral FDI. We conduct a comprehensive industry analysis using the largest and the longest data span available. Growth studies have shown that FDI that flows to different sectors have different impact on sectoral and aggregate growth, often manifesting themselves through spillovers to different industries (Doytch and Uctum, 2011). Likewise, we expect different effect by different sectoral FDI inflows on pollution (e.g., financial FDI might impact the environment even though it goes to a non-polluting services industry).

Second, many of the previous studies are plagued by problems of endogeneity and simultaneity. The explanatory variables used in the empirical studies are likely to influence each other, or the dependent variable can affect the independent variables. For example, a country with restrictive environmental laws may reduce pollution but they may be also a reaction to pollution; or pollution may change by FDI but it can also determine the amount of FDI inflows. We can also have independent variables affecting each other: laws may influence the flow of FDI, high growth can encourage FDI. The simultaneity problem can create substantial biases in the estimates, which make results meaningless. Our second contribution is, therefore, to adopt a dynamic panel data approach (Arellano and Bover, 1995; Blundell and Bond, 1998), a methodology that circumvents this problem. [1]

Last but not least, the most important drawback of the traditional approach of the cross-sectional time-averaging methodology is that by its nature, it cannot capture the dynamic aspects of changes in the sectoral flows of FDI. By contrast, the GMM estimator exploits both the time series dynamics and the pooled country characteristics of the data while controlling for endogeneity and omitted variable biases.

We show that results depend critically according to the type of capital flow and income category. Foreign investment that flow into clean industries such as services support the halo effect hypothesis, while those flowing into traditionally dirty industries such as manufacturing are consistent with the pollution haven hypothesis. In general, foreign investment flowing into poorer countries has harmful effects on environment, while those flowing to richer countries have a beneficial effect and support the halo effect. Evidence also suggests that as countries become wealthier, the EKC is supported (i.e. pollution decreases with economic development) in countries where capital was

[1] One notable exception is the study by Frankel and Rose (2005), which examines the effect of trade (openness) on environment. Endogeneity of trade and income is controlled for by instrumental variable approach within a cross-country estimation in 1990. Although our approach is parallel to Frankel and Rose, it differs in several ways. First, we do not take a single year of data but examine the evolution of the phenomenon through time, over the course of 38 years. Second, our analysis involves dynamics and is not static. Third, our analysis is sectoral and thus is able to capture the intersectoral spillovers.

flowing in dirty industries, such as mining and manufacturing. If the flows are in traditionally clean industries, the EKC is not supported. This result shows that the ambiguity in the literature is removed if the industry specificity of FDI is accounted for.

GDP shares of FDI across sectors and income levels

Figure 1 displays the FDI net flows since 1995 separated as all countries (upper left panel), high-income countries (upper-right panel) and middle-income and low-income countries (lower panels). Since the 1990s, the FDI/GDP ratio has been increasing up until 2007 and abruptly fell during the crisis. The substantial rise in the early 2000 (and the subsequent fall) is predominantly led by FDI in financial services sector, followed by the nonfinancial services sector. FDI inflows into manufacturing, mining and agriculture, the traditionally dirty industry sectors have been declining or stable and insignificant. On this account, we should expect, on average a reduction in the pollution trends, since the services sector uses relatively clean technology.

Disaggregating the data according to the income distribution, however, gives quite a different picture. The sectoral FDI/GDP patterns in the high-income countries follow closely those of the total sample, suggesting that FDI is likely to have a halo effect in wealthy economies. This is also consistent with the EKC hypothesis. The aggregate pattern is somewhat replicated in the middle-income countries, which enjoy a rise in the nonfinancial services FDI inflows. However, the small but positive trend in the polluting industries such as mining mitigates the halo argument. The case with low-income economies, however is starkly opposite to the rich countries. Despite a general decline in overall FDI flows, substantial increase in FDI flows to mining in the early 2000 and a leap in late 2000, dominates all flows to other industries, suggesting that support for the pollution haven argument is not that farfetched.

Literature Review

All three hypotheses discussed above, namely, the halo effect, the pollution haven hypothesis and the Environmental Kuznets Curve (EKC) are interrelated.

The halo effect follows the productivity literature in spirit, which examines the productivity spillovers by FDI both at the firm and macroeconomic levels.[2] The rationale behind potential environmental spillovers is that the possibility that multinaltional

[2] Firm level studies find mixed evidence of productivity spillovers, ranging from limited positive (Haskel et al., 2007; Blalock and Gertler, 2003), to no or negative spillovers (Aitken and Harrison, 1999; Gorg and Strobl, 2001; Lipsey, 2003, 2004). At the aggregate level, the evidence has been overwhelmingly in support of positive impact by FDI inflows (Borensztein et al., 1998; Blomstrom et al., 1994, Alfaro et al., 2008). The sectoral level analysis reconciles these inconsistent results. Manufacturing FDI has positive spillovers that spur through its own sector, while financial services have a positive effect that spreads though services, whereas nonfinancial services drain resources from manufacturing and can have a negative effect on growth (Doytch and Uctum, 2011).

corporations (MNCs) encourage the dissemination of environmentally clean technologies and management practices (Garcia-Johnson, 2000). This occurs if the foreign firm engages in contracts only with environmentally responsible domestic counterparts. This may happen under shareholder pressure at the MNC or because of practices established at the MNCs based on its home country environmental regulations and standards. Further environmental knowledge can disseminate through the movement of trained workers from foreign to domestic firms (Görg and Strobl, 2004) or because of a direct competition of domestic firms with the MNCs.

The literature on environmental spillovers from FDI confines to only case studies of specific countries' manufacturing industry firms. The evidence with respect to the halo hypothesis has been mixed. In a limited Indonesian manufacturing firm study conducted on plant-level for the period 1989-90 with respect to water pollution, Hartman et al. (1997) conclude that "abatement... is... unaffected by foreign links (in ownership financing)". Dasgupta et al. (2000) examine the impact of regulation, plant-level management policies, and other factors on the environmental compliance of Mexican manufacturers and find no significance for the foreign ownership variable as well.

More recently, however, Eskeland and Harrison (2003) analyze outbound US FDI and find that foreign plants are significantly more energy efficient and cleaner in their energy uses than their domestic partners, which supports the halo hypothesis. Another supporting evidence for the halo hypothesis is from the study by Cole et al. (2008) who assess the extent to which foreign ownership influences the energy intensity of firms in Côte d'Ivoire, Mexico and Venezuela, and Ghana. In each country they find that foreign ownership reduces the energy intensity of plants. Finally, in a sample of Argentinean firms, Albornoz et al (2009) find supporting evidence that (i) foreign-owned firms are more likely to implement environmental management systems compared to domestic firms; (ii) firms that supply sectors with high multinationals and regularly meet with their customers are more likely to adopt environmental management systems; (iii) firms' absorptive capacity, ownership and export status also influence the extent to which they benefit from environmental spillovers.

EKC, the second but the older line of research in environmental economics, states that the quality of the environment worsens as the economy grows and once a certain threshold is reached, it starts improving, resulting in an inverse U-shaped pollution-GDP per capita pattern. This line of argument parallels that of the structural change in development whereby the share of manufacturing in the economy grows in the initial phase of development but later decreases as the services overtake the role of manufacturing in growth. The implication of EKC is that environmental quality increases with economic growth after a threshold. The estimation model consists typically of the cubic or quadratic income terms and their lagged values, and a vector of control variables including policy, trade, and institutional variables. The initial research corroborated the EKC argument (Selden and Song, 1995, Shafik, 1994, Grossman and

Krueger, 1995, Holtz-Eaking and Selden, 1995, Hilton and Levinson, 1998). More recent research, however casts doubt on the existence of a neat inverse U-shaped relation (Stern, 1998, Harbaugh et al. 2002, Hettige et al. 2000).

The original pollution haven hypothesis (Copeland and Taylor, 1994) states that as trade is liberalized, industries that pollute shift from rich countries with tight regulation to poor countries with weak regulation and conversely, clean industries migrate towards rich countries. The studies address pollution haven in three ways. (i) Some studies analyze the relation between exports and regulation. Since regulation increases cost, the exports of countries with more stringent regulations become relatively more expensive than those with lax regulation. Therefore their exports decline and their imports of relatively dirty goods rise. In the survey of the literature Jaffe et al. (1995) show that there is an insignificant relation between environmental regulation and exports in manufacturing. Notably, Grossman and Krueger (1993), Tobey (1990) find an insignificant effect, while Kalt (1988) finds a counterintuitive significant effect when manufacturing, the industry with the highest abatement cost, is excluded. (ii) Other studies examine the shift in the pattern of trade in pollution-intensive goods: despite evidence supporting this hypothesis (Low and Yeats, 1992), this may be due to various factors such as increase in demand for products in the developing countries, development of endowments that develop these industries. (iii) A third group of studies explore firms' location decision. Accordingly, high regulatory costs are likely to deter firms' investment decisions. At the international level, the specific question that is addressed is whether FDI in polluting industries increased towards developing countries. There is some evidence that FDI to the United States is likely to be affected by environmental regulations (List and Co, 2000, Keller and Levinson, 2002, List and McHone, 2000). The literature survey by Jaffa et al., however, indicates either small or insignificant effect of environmental regulations on FDI, and more recent studies find a significant but small effect (List et al., 2004, Becker and Henderson, 2000, Greenstone, 2004, Levinson and Taylor, 2008).

In our study we conduct a sectoral level analysis on the impact of FDI on environmental performance of domestic economies, measured by the levels of air pollution.

Model and Methodology

Several FDI studies in the literature attempted at examining the impact of environmental regulation as an independent variable. The emphasis of these studies falls in the category of the literature on the determinants of FDI. Our emphasis differs in the sense that what we want to examine is how capital flows directly affect pollution in a country, while controlling for the EKC effect. It is clear that these factors are simultaneously determined and their nonlinear interaction is not addressed. The methodology outlined below is designed to control such biases.

We capture the effect of globalization on the environment by controlling for FDI and economic growth:

$$(1) \quad \log(pol_{i,t}) = \beta_0 + \beta_1 \log(pol_{i,t-1}) + \beta_2 \log(y_{it}) + \beta_3 log\left[y_{i,t-1}^2\right] \quad + \beta_4 f_{it}{}^j \\ +\beta_5 corr_t + \beta_6 dens_t + \beta_7 D^t + \mu_i + \varepsilon_{it}$$

with $\mu_i \sim i.i.d(0,\sigma_{\mu_i})$, $\varepsilon_{it} \sim$ i.i.d.$(0,\sigma_\varepsilon)$, $E[\mu_i\varepsilon_{it}]=0$ and where pol_t is a measure of air pollution, y_t is log of per capita GDP, $f_{it}{}^j$ is the net capital inflow share of GDP, the subscript j stands for an index for total, agricultural, mining, manufacturing, total services, financial services, non-financial services FDI. The variable $corr_t$ is "control of corruption", a proxy for the institutional variable. It is indexed between 1 and 10, 10 being the highest control of corruption; $dens_t$ represents population density, D^t is a time dummy and μ_i is an idiosyncratic country specific effect.

The level and the square of GDP capture the EKC hypothesis, $\beta_2 > 0$, $\beta_3 < 0$, which leads to an inverse-U shaped relation between *pol* and *y*. For the halo effect to hold, the null hypothesis is $\beta_4 < 0$. Albeit not a direct test, a positive sign is consistent with the pollution haven hypothesis. We expect $\beta_5 < 0$, that is, for an increase in the control of corruption to improve the institutions of a country and hence to reduce pollution through more stringent regulation to protect the environment, and $\beta_6 > 0$, population density to increase the pollution level.

The simplest methodology, more suitable for cross-sectional than for panel data analysis, is the *pooled OLS* estimation. However, this method fails to account for the time-series dimension of data since it puts all observations together into a "pool" and creates two major flaws: (i) it fails to account for the unobserved country-specific (fixed) effects that cause an omitted variable bias, which then is picked up by the error term; (ii) it fails to control for the potential endogeneity problem. The correlation between some of the independent variables and country-specific effects is again picked up in the error term.

The method of *fixed effects* is designed to control for the unobserved country-specific time-invariant effects in the data. However, it corrects for the possible correlation between these effects and some of the independent variables, conditioning them out by taking deviations from time-averaged sample means. The result of applying such a procedure is that the dependent variable is stripped of its long-run variation – an approach that may be inappropriate for studying a dynamic concept such as capital flows. A technical consequence of the within transformation is that it increases standard errors by exacerbating any measurement errors. This is especially problematic in the case of data with a small time dimension. Another technical issue is that this approach is not informative when we deal with variables with little time variation or ones that are not measured frequently enough. Without an instrument, this approach does not address the problem of endogeneity either, and without time dummies it does not control for the unobserved common time effects among countries, which are then mistakenly picked up by a positive cross-sectional correlation. Overall, both cross-section approaches are not a good tool for analyzing a dynamic relationship between variables and where time-averaging is conceptually not sensible.

The correlation between lagged dependent variables and the unobserved residual is precisely the reason why panel data is to be preferred to cross-sectional when analyzing change in the dependent variable. Cross-section estimates produce a bias, caused by the correlation between $pol_{i,t-1}$ and μ_i, which disappears in samples with large time-dimension but does not disappear with time-averaging. Thus, if such a correlation exists, the true underlying structure has a dynamic nature and time-averaging cross-section techniques introduce a bias that cannot be removed by controlling for fixed-effects. Therefore, to avoid these pitfalls, we adopt the GMM methodology.

A potential problem of the Arellano-Bond difference GMM estimator is that, under certain conditions, the variance of the estimates may increase asymptotically and create considerable bias if: (i) the dependent variable follows a random walk, which makes the first lag a poor instrument for its difference, (ii) the explanatory variables are persistent over time, which makes the lagged levels weak instruments for their differences, (iii) the time dimension of the sample is small (Alonso-Borrego and Arellano, 1996 and Blundell and Bond, 1998).

An additional necessary condition for the efficiency of the Blundell-Bond system GMM estimator is that, even if the unobserved country-specific effect is correlated with the regressors' levels, it is not correlated with their differences. The condition also means that the deviations of the initial values of the independent variables from their long-run values are not systematically related to the country-specific effects. We are instrumenting both income and FDI with GMM style instruments, which would account for reverse causality between these variables and the pollution variable. [3]

A problem with System GMM estimator can arise if the instruments are too many, leading to overfitting of the model (Roodman, 2006). Unfortunately, there is little guidance in the literature to determine how many instruments are "too many" (Roodman

[3] These sets of conditions are: (i)*The standard GMM conditions* of no second order autocorrelation in the error term: $E[pol_{i,t-s}\ (\varepsilon_{it} - \varepsilon_{i,t-1})] = 0$ for s≥2 and t=3,….T ; $E[y_{i,t-s}(\varepsilon_{it} - \varepsilon_{i,t-1})] = 0$ for s≥2 and t=3,….T; $E[f^j_{i,t-s}(\varepsilon_{it} - \varepsilon_{i,t-1})] = 0$ for s≥2 and t=3,….T, where y_{it} , f^j_{it} stand for the level of income and for FDI, respectively and where for instruments we use their past levels and differences. To instrument the FDI and the lagged output we used Stata's *GMM-style option*, and to instrument the remaining variables, corruption and elements of the x_{it} matrix, we used the *iv-style option.* (ii) *Additional conditions* of no correlation of the unobserved country-specific effect with their difference $E[(pol_{i,t-1} - pol_{i,t-2})(\mu_i + \varepsilon_{it})] = 0$; $E[(y_{i,t-1} - y_{i,t-2})(\mu_i + \varepsilon_{it})] = 0$; $E[(f^j_{i,t-1} - f^j_{i,t-2})(\mu_i + \varepsilon_{it})] = 0$; (iii) The last condition allows using lagged first differences as instruments for levels.

2006, Rudd 2000). A recommended rule of thumb by Roodman is that instruments should not outnumber individuals (or countries). We experimented both with different numbers of lags in the instrumental matrix and results are largely consistent. We present here a set of results based on the minimum optimum lags, an approach that we selected to preserve the degrees of freedom.

Data and Sources

The data are yearly, multi-country and span a long period from 1970 to 2000. Appendix 1 displays the list of countries in the sample. The series come from various sources.

The key independent variables are disaggregated FDI flows as a share of GDP denominated both in current USD. All *FDI* series are *net flows*, accounting for the purchases and sales of domestic assets by foreigners in the corresponding year. The general definition of FDI is as investment that "reflects the objective of obtaining a lasting interest by a resident entity in one economy (‘‘direct investor") in an entity resident in an economy other than that of the investor (‘‘direct investment enterprise")" (OECD, *International direct investment database,* Metadata). This lasting interest implies the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence on the management of the enterprise.

Direct investment involves both the initial transaction between the two entities and all subsequent capital transactions between them and among affiliated enterprises, both incorporated and unincorporated. A direct investment enterprise is defined as an incorporated or unincorporated enterprise in which a foreign investor owns 10 per cent or more of the ordinary shares or voting power of an incorporated enterprise or the equivalent of an unincorporated enterprise. A direct investment enterprise may be an incorporated enterprise - a subsidiary or associate company - or an unincorporated enterprise (branch). The data on sectoral FDI inflows to agriculture, mining, manufacturing, financial services and nonfinancial services FDI are compiled from *United Nations Conference on Trade and Development* (UNCTAD), *Organization for Economic Cooperation and Development* (OECD), *The Association of Southeast Asian Nations* (ASEAN), and individual national statistical agencies web sites.

The dependent variable, carbon dioxide (CO2) emissions are from OECD and World Development Indicators (WDI). CO2 emissions are defined as the emissions stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. [4] CO2 emissions are measured in kilotons (kt). For robustness checks, we also

[4] CO2 emissions accumulates in four kinds of carbon sinks: the atmosphere; the terrestrial biosphere (including freshwater systems and non-living organic material, such as soil carbon); the oceans- the largest sink (including dissolved inorganic carbon and living and non-living marine biota); and the sediments (including fossil fuels). Man-made CO2 emissions are produced through fossil fuel burning and clearing forests for crop use. The carbon dioxide that is unabsorbed by natural sinks remains in the atmosphere, where it traps heat. The most vulnerable ecosystem is the ocean ecosystem, which become more acidic with

tested the significance of the FDI coefficient with other pollutants such as carbon monoxide (CO), sulphur and nitrogen oxides (SO2 and NO2), which are among the most studied air pollutants. They are being linked to the so called green house effect and their significant rise over the past century is being blamed on human activity. This data are obtained from the *OECD* database.

Population density (people per sq. km of land area) is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

Institutional variables come are from the *International Country Risk Group* (ICRG). Following the FDI and pollution literature, we adopted control of corruption as an independent variable and we did robustness check with law and order. Both measures are indexed from 0 to 6, 0 representing the countries with worst corruption and law and order practices, 6 representing countries with the best practices. Corruption includes financial corruption as well as favoritism, nepotism, etc. Law and order are assessed separately, each rated from 0 to 3 and involve the judicial system, and the crime rate.

Empirical Results

The idiosyncratic shocks to different sectors may overweigh the regional shocks and conceal the differences at the industry level, and may explain the reason behind inconclusive results in the literature. Our aim is to expose such effects if they exist. For this, we now turn to analyzing the industry spillover of sectoral FDI, given a set of control variables. We examine the effects on the host country’s pollution measures of sectoral and aggregate FDI, respectively. We examine the primary, secondary (manufacturing) and tertiary (services) sectors. We further disaggregate the primary sector into agriculture and mining, and the tertiary sector into financial and nonfinancial sectors.

To control for heterogeneity due to the level of development, we break down the data according to income distribution measures and examine the same effects in four income categories ranging from lowest to highest income countries following the World Bank specification: low income countries, lower-middle income countries, upper-middle

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rapid absorption of CO2. It has been estimated that atmospheric CO2 concentration has increased from 280ppmv to more than 380ppmv, since 1880, the sources being burnt coal, oil, and gas and that each doubling of atmospheric CO2 concentration raises Earth’s mean temperature by 3ºC (NASA web site?). Rising temperatures have potential implications for ice sheet and glaciers melting and shifting seasonal and weather patterns.

income countries, high income countries. Since the number of countries in lower income countries is small, we also combine the low-income with the lower-middle income countries and report these results.

Using a sample of OECD countries, we also redo the same exercise with alternative measures of pollution to see whether FDI inflows to different sectors affect different pollutants as an additional robustness check. The measures we consider are carbon dioxide (CO2), carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen dioxide (NO2).

We present in Table 1 the results for the estimates of β_4, the pollution effect of FDI flows, based on the GMM approach. A negative value suggests that the data supports the halo effect, while a positive sign is consistent with the pollution haven hypothesis, even though it is not a direct test. To save space, in this table we summarize all the regressions based on sectors and income distribution and emphasize only the spillover effect. To give an overall view of the estimated regression equation, and examine the EKC effect, Table 1A in the appendix displays the full regression results for aggregate and sectoral FDI for all countries. Table 2 displays the EKC estimates and Table 3 summarizes the sectoral effect of FDI with the four other measures of pollutants.

The overall regression results for the full sample of countries are overall consistent with expected signs of coefficients (Appendix, Table 1A). Evidence indicates a very strong persistence effect (1^{st} row), underlying the cumulative nature of environmental degradation. The EKC hypothesis is supported by the data when inflows of investment are in agriculture and services (column 2 and 5). The institutional variable, control of corruption, comes in with significantly and with the right sign for the regression with the total FDI (column 1), suggesting that less corrupt countries are also those implementing stricter measures against pollution. Indirect support for the pollution haven and direct support for the halo effect are found in the presence of manufacturing FDI and services FDI, respectively.

Since all three hypotheses will be discussed below in detail, here we will briefly review the remaining parameters. All results, which we do not report for sake of preserving space, are available from the authors. The persistence of pollution is highly robust to income distribution. Control of corruption is strongly significant in reducing pollution in upper middle income countries, host to FDI in mining and all services sectors and in high income countries, host to FDI in manufacturing and in both services subsectors. Control of corruption in general has no effect on environmental degradation in poorer countries. Population density increases pollution in lower-middle income countries receiving manufacturing and agricultural FDI, but it has a negative impact on pollution in high income countries and in high-middle income countries.

(i) FDI impact on pollution

The effect of total FDI on CO2 pollution

Not surprisingly, the overall aggregate impact of capital flows in the full sample is insignificant when all countries are taken together (Table 1, 1st cell, first column). However, a significant positive impact can be observed in middle income countries and a significant negative impact is present in high income countries (first column), suggesting that FDI inflows deteriorate the environment in the relatively poorer countries, while they improve it in the wealthy countries. Evidence at the aggregate level thus supports the halo effect hypothesis in rich countries and is consistent with the Pollution Haven hypothesis in poor countries. How robust is this result across industries? We now turn to the sectoral level analysis.

The effect of primary sector FDI on CO2 pollution

In both agriculture and mining, the FDI inflows continue not having a significant effect on air pollution in the full sample. (Table 1, first row, columns 1, 2). FDI inflows in agriculture mimic the results of aggregate FDI (column 2). They worsen the CO2 conditions in middle income countries, while improving it in the high income countries where the halo effect continues to be relevant. In mining, by contrast, data supports the halo effect more frequently (column 3). Lower middle income countries and high income countries benefit from FDI inflows into mining, where they presumably bring in "clean" technology, and there is weak evidence that it does it also in the poorer countries as well. However, upper middle countries do not benefit from this technology where FDI inflows contribute to the air pollution. Thus, in the primary sector, FDI inflows, by and large parallel the aggregate FDI results. The lower middle income countries net effect gets canceled out, the high income countries receive cleaner technology while the upper middle income countries get dirtier technology.

The effect of manufacturing FDI on CO2 pollution

Most of the negative impact of capital inflows on air pollution in a country is generated by manufacturing FDI (column 4). Inflow of foreign investment into this sector raises the pollution level in the full sample (1st row). This result is replicated in low and lower-middle income countries and high income countries. Manufacturing FDI is the only type of investment flow that does not benefit the rich countries. Surprisingly, a strong halo effect is present in the upper middle countries.

The effect of tertiary sector FDI on CO2 pollution

Overall, the FDI in services benefits the environment (column 5, 1st row). A strong Halo effect in the full sample can be traced back to poor economies and upper middle income countries. There is no significant environmental deterioration due to service sector FDI inflows. At the disaggregated level, however, positive spillovers are harder to detect. Only lower middle-income countries appear to benefit from the financial FDI flows even though there is some weak support for the halo effect argument in poorer economies (column 6). The only significant impact of nonfinancial FDI is to increase pollution in poor economies, consisting of low and low-middle income countries (last column).

Summary of findings on the impact of sectoral FDI on CO2 pollution

Our results suggest that at the industry level, foreign investment inflows into manufacturing are most likely to increase pollution and refute the halo effect hypothesis. Evidence supports the halo effect for FDI in services in general. FDI flowing into lower and low-middle host countries have more harmful effect, while flows into high income countries are environmentally friendly, consistent with the halo effect hypothesis. The environmental benefits/costs of capital flows into lower and middle income countries are mixed. Except for agricultural FDI, which brings in dirty technology, mining and manufacturing FDI have opposing effects in these income categories.

(ii) The Environmental Kuznets Curve Hypothesis

The hypothesis that pollution worsens during the initial growth process followed by an improvement as income rises is verified frequently and follows a surprising pattern (Table 2). As indicated before, in the full sample, the EKC is strongly present in countries receiving agriculture and services FDI. The same pattern is repeated in low income and lower middle income countries, and in each subsector of the services industries. In other words, the EKC is verified in the relatively poor countries, especially those receiving FDI flows in agriculture, and financial and nonfinancial services. Interestingly, upper middle income countries exhibit the EKC only when FDI flows to mining and manufacturing. Another intriguing finding of our study is to show that EKC is mostly inexistent in high income countries, except when they host FDI in manufacturing. The traditional EKC results thus still hold at an early level of development, for most types of capital inflows. As countries become wealthier, EKC is supported if countries allow capital inflows in traditionally dirty industries, such as mining and manufacturing.

The richness of our findings reveals a more complex set of interactions between the level of development and pollution in a context of globalization and provides a compelling explanation for the ambiguity in the EKC literature. They show that the EKC hypothesis depends on the type of capital flows the countries receive and their level of development, and thus highlights the importance of accounting for heterogeneity, regional effects and dynamics in the data.

(iii) Additional robustness check: alternative measures of pollution and institutional variables

Does FDI inflows change air pollution caused by particles other than CO2, such as SO2 (sulfur dioxide), NO2 (nitrogen dioxide) and CO (carbon monoxide)? Although most of the discussion about man-made climate change centers around the impact of CO2, the other particles are greenhouse gases directly generated by industrial pollutants. Unfortunately, data are readily available only for the OECD countries. Table 3 displays estimates of the sectoral FDI's impact on pollution in full sample regressions with the same control variables. In order to have a meaningful comparison within the same subsample of countries, we reran the regressions for the CO2 measure for the OECD countries (first row). The halo effect of FDI occurs frequently in this subsample for all particles. All categories of FDI reduce CO2 pollution albeit this effect is significant mainly in the recipients of services FDI. Moreover, the halo effect is visible in services FDI also with SO2 and NO2 pollutants, especially in nonfinancial flows, whereas financial FDI contributes to a decline in NO2. In contrast, data reflects a bleak picture for the CO pollution. Evidence suggests that among OECD countries, FDI flows into mining and services raises the levels of CO significantly, lending support to the pollution haven argument.

We also tried alternative measures of institutional variables. One such measure from the same data source is law and order. Results were largely consistent but with fewer significant coefficients. Since this is a variable more broadly defined and less precise than the corruption measure we used, we thus chose to keep the latter.

Conclusion

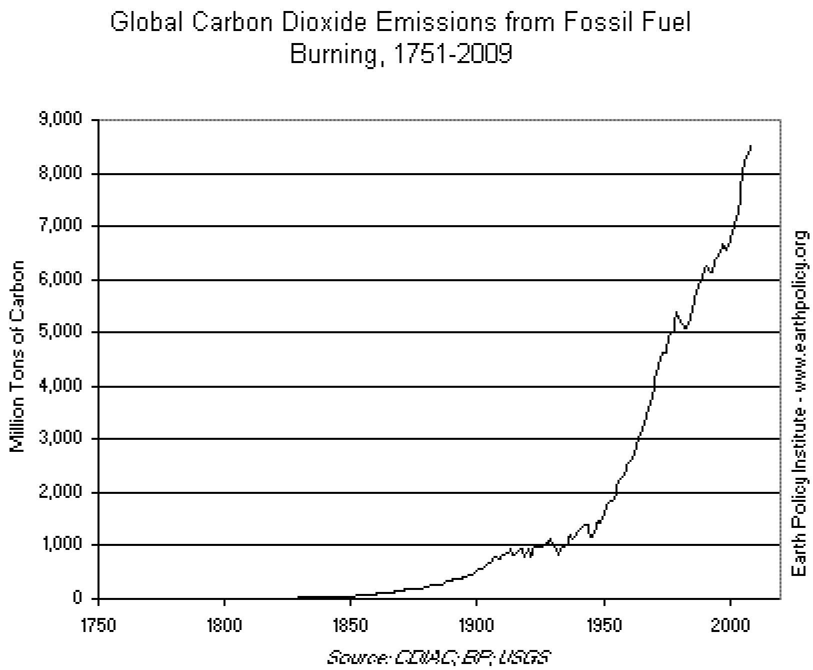
In this study we examined the relation between globalization as represented by inflows of capital and environmental degradation, represented by the CO2 air pollution. Our study tests the halo effect hypothesis, which argues that foreign direct investment is beneficial to the host country because by bringing in clean technology and know-how, it improves the environmental standards. This view stands in contrast to the pollution haven hypothesis, which states that tight environmental regulations in developed countries shift dirty industries to poorer countries with lax policies.

By using a methodology that allows us to exploit a rich data set, we examine the impact of sectoral direct investment flows on air pollution. We find that results vary critically according to the type of capital flow and income category. Foreign investment flows into manufacturing tend to support the pollution haven argument, while those flowing into services support the halo effect hypothesis. In general, foreign investment flowing in poorer countries has more harmful effects on environment, while those flowing to richer countries have a beneficial effect and support a halo effect. However, when air pollution is measured by CO instead of CO2, FDI flows to OECD countries raise the pollution level, in countries receiving investment flows into mining and services, supporting the pollution haven hypothesis.

Furthermore, in our analysis, we shed light on the inconclusive results of the EKC (environmental Kuznets curve) literature, which examines the inverse U-shaped relation between pollution and the income in a country. We show that the traditional EKC results hold at an early level of development for most types of capital inflows. As countries become wealthier, EKC is supported if countries allow capital inflows in traditionally dirty industries, such as mining and manufacturing

Our results thus suggest that studies relying simply on aggregate data or on firm level data to analyze the relation between the environment and globalization miss the subtle characteristics of the data due to interaction of sectoral flows and their impact on the environment. These studies can lead to wrong or inconclusive inference and thus to misleading policy prescriptions, with long lasting impact.

Figure 1



Global Carbon Dioxide Emissions from Fossil Fuel Burning, 1751-2009
Million Tons of Carbon
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1750
1800
1850
1900
1950
2000
Source: CDIAC; BP; USGS
Earth Policy Institute - www.earthpolicy.org

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OECD. Organization for Economic Cooperation and Development, International Energy Agency Statistics.

Appendix 1: Country list

Full Sample

Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, The, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Cameroon, Canada, Chile, China, Colombia, Congo, Dem. Rep., Congo, Rep., Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Estonia, Ethiopia, Finland, France, Gabon, Gambia, The , Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong SAR, China, Hungary, Iceland, India, Indonesia, Iran, Islamic Rep., Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Rep., Kuwait, Latvia, Lebanon, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Namibia, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russian Federation, Saudi Arabia, Senegal, Sierra Leone, Slovak Republic, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syrian Arab Republic, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, RB, Vietnam, Zambia, Zimbabwe.

Low Income Countries

Bangladesh, Burkina Faso, Congo, Dem. Rep., Cote d'Ivoire, Egypt, Arab Rep., Ethiopia, Gambia, The, Ghana, Guinea, Guinea-Bissau, Haiti, Honduras, India, Kenya, Liberia, Madagascar, Malawi, Mali, Mongolia, Mozambique, Niger, Nigeria, Pakistan, Papua New Guinea, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Vietnam, Zambia, Zimbabwe.

Lower Middle Income Countries

Albania, Algeria, Angola, Armenia, Azerbaijan, Belarus, Bolivia, Cameroon, China, Colombia, Congo, Rep., Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Indonesia, Iran, Islamic Rep., Iraq, Jamaica, Jordan, Moldova, Morocco, Namibia, Nicaragua, Paraguay, Peru, Philippines, Sri Lanka, Suriname, Syrian Arab Republic, Thailand, Tunisia.

Upper Middle Income Countries

Argentina, Botswana, Brazil, Bulgaria, Chile, Costa Rica, Croatia, Gabon, Hungary, Kazakhstan, Latvia, Lebanon, Libya, Lithuania, Malaysia, Mexico, Oman, Panama, Poland, Romania, Russian Federation, Slovak Republic, Turkey, Uruguay, Venezuela, RB.

High Income Countries

Australia, Austria, Bahamas, The, Bahrain, Belgium, Brunei Darussalam, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Korea, Rep., Kuwait, Luxembourg, Netherlands, New Caledonia, New Zealand, Norway, Portugal, Qatar, Saudi Arabia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States.

Appendix 2: Table 1A*

Full regression results “All countries”

Log CO2 All countries	Total FDI/GDP	Agriculture FDI/GDP	Mining FDI/GDP	Manuactur. FDI/GDP	Services FDI/GDP	Finance FDI/GDP	Nonfinancial FDI/GDP
$\log(CO2_{t-1})$	1.005*** (140.23)	1.006*** (148.66)	1.014*** (129.78)	1.003*** (205.47)	1.001*** (183.70)	1.005*** (188.40)	1.004*** (152.65)
$log\ (Real\ GDP\ per\ capita)$	-.010 (-0.16)	.252*** (3.21)	.064 (0.72)	.025 (0.36)	.104** (2.34)	.082 (1.16)	.108 (1.27)
$[log\ (Real\ GDP\ per\ capita)]^2$	.001 (0.42)	-.015*** (-3.33)	-.005 (-1.15)	-.0009 (-0.20)	-.007** (-2.40)	-.005 (-1.23)	-.006 (-1.32)
$log\ (Control\ of\ corruption)$	-.044*** (-2.60)	-.011 (-0.52)	.026 (1.63)	-.057 (-1.53)	.009 (0.35)	-.026 (-1.31)	-.016 (-0.61)
$log(Density)$	-.005 (-0.84)	-.004 (-1.02)	-.004 (-1.22)	-.001 (-0.48)	-.001 (-0.57)	-.004 (-1.49)	-.003 (-1.26)
$log\left(\frac{FDI}{GDP}\right)_{t-1}$	.008 (1.39)	-.002 (-0.64)	-.0008 (-0.21)	.017** (2.55)	-.015* (-1.95)	.001 (0.39)	.009 (1.59)
# Observations	2479	714	796	1084	1108	933	859
#Countries	131	78	74	86	86	77	76

* Figures in parentheses are t-statistics; * and ** denote significance at the 10 % and 5 % respectively. Results are robust to heteroscedasticity.

Table 1: Effect of FDI on CO2 emissions*

$log\ CO2$	Total FDI/GDP	Agriculture FDI/GDP	Mining FDI/GDP	Manufact. FDI/GDP	Services FDI/GDP	Finance FDI/GDP	Nonfinancial FDI/GDP
All countries	0.008	-0.002	-0.001	0.017**	-0.015*	0.001	0.009
	(1.39)	(-0.64)	(-0.21)	(2.55)	(-1.95)	(0.39)	(1.59)
#obs.	2479	714	796	1084	1108	933	859
#countries	131	78	74	86	86	77	76
AR(2)	0.646	0.712	0.338	0.567	0.434	0.656	0.108
Lower and Lower middle countries	0.014*	0.0002	-0.005	0.012*	-0.015	-0.008	0.022***
	(1.92)	(0.03)	(-1.32)	(1.65)	(-0.86)	(-1.50)	(3.51)
# obs.	1307	227	301	325	341	236	212
#countries	68	32	31	35	35	27	26
AR(2)	0.563	0.330	0.312	0.295	0.703	0.788	0.471
Lower middle income countries	0.019*	0.008**	-0.005***	0.012**	0.012	-0.005*	0.031***
	(1.64)	(2.06)	(-2.77)	(1.97)	(1.32)	(-1.68)	(6.55)
# obs.	634	168	214	231	244	168	170
#countries	34	21	20	23	23	19	19
AR(2)	0.621	0.334	0.560	0.703	0.621	0.569	0.329
Upper middle income countries	0.016**	0.008*	0.008***	-0.009***	-0.007*	-0.001	0.000
	(2.12)	(1.88)	(3.21)	(-2.67)	(-1.73)	(-0.29)	(0.06)
# obs.	444	187	186	248	257	234	222
#countries	25	19	17	20	20	20	20
AR(2)	0.792	(0.329)	0.225	0.555	0.454	0.345	0.579
High income countries	-0.013**	-0.004*	-0.003*	0.010***	-0.004	-0.001	-0.003
	(-2.30)	(-1.88)	(-1.95)	(2.60)	(-1.15)	(-0.46)	(-0.81)
# observations	728	300	309	511	510	463	425
#countries	38	27	26	31	31	30	30
AR(2)	0.764	0.194	0.803	0.033	0.165	0.402	0.096

* The first entry in each cell is the estimate of the effect on pollution of FDI flows, estimated by the System GMM method. Figures in parentheses are t-statistics; * and ** denote significance at the 10 % and 5 % respectively. Results are robust to heteroscedasticity.

Table 2 : Environmental Kuznets Curve (EKC) and CO2 emissions*

$log\ CO2$	Total FDI/GDP	Agriculture FDI/GDP	Mining FDI/GDP	Manufact. FDI/GDP	Services FDI/GDP	Finance FDI/GDP	Nonfinancial FDI/GDP
All countries							
$log\ (Real\ GDP\ per\ capita)$	-0.010 (-0.16)	0.252*** (3.21)	0.064 (0.72)	0.025 (0.36)	0.104** (2.34)	0.082 (1.16)	0.108 (1.27)
$[log\ (Real\ GDP\ per\ capita)]^2$	0.001 (0.42)	-0.015*** (-3.33)	-0.005 (-1.15)	-0.001 (-0.20)	-0.007** (-2.40)	-0.005 (-1.23)	-0.006 (-1.32)
Low and lower middle-income countries							
$log\ (Real\ GDP\ per\ capita)$	-0.023 (-0.17)	0.462** (2.17)	-0.442 (-1.54)	-0.012 (-0.11)	0.314** (2.06)	0.320*** (2.67)	0.287** (2.15)
$[log\ (Real\ GDP\ per\ capita)]^2$	0.001 (0.16)	-0.033** (-2.02)	0.032 (1.53)	0.001 (0.18)	-0.025** (-2.07)	-0.021** (-2.38)	-0.021** (-2.11)
Lower middle-income countries							
$log\ (Real\ GDP\ per\ capita)$	0.215 (0.42)	1.834*** (2.81)	0.375 (0.71)	0.699 (1.22)	0.874 (1.47)	1.596*** (2.77)	1.440*** (2.87)
$[log\ (Real\ GDP\ per\ capita)]^2$	-0.014 (-0.40)	-0.126*** (-2.80)	-0.027 (-0.75)	-0.047 (-1.21)	-0.061 (-1.49)	-0.111*** (-2.77)	-0.099*** (-2.84)
Upper middle-income countries							
$log\ (Real\ GDP\ per\ capita)$	0.140 (0.25)	0.434 (0.63)	0.568** (2.23)	0.975*** (2.92)	0.507 (1.39)	0.333 (0.72)	0.595 (1.53)
$[log\ (Real\ GDP\ per\ capita)]^2$	-0.007 (-0.21)	-0.025 (-0.60)	-0.034** (-2.15)	-0.059*** (-2.91)	-0.031 (-1.42)	-0.020 (-0.74)	-0.035 (-1.50)
High income countries							
$log\ (Real\ GDP\ per\ capita)$	1.725 (1.54)	-0.028 (-0.14)	0.274 (1.20)	0.506* (1.87)	0.651 (1.34)	0.038 (0.14)	0.039 (0.13)
$[log\ (Real\ GDP\ per\ capita)]^2$	-0.089 (-1.53)	0.001 (0.06)	-0.014 (-1.20)	-0.026* (-1.92)	-0.034 (-1.36)	-0.002 (-0.15)	-0.002 (-0.16)

* Figures in parentheses are t-statistics; * and ** denote significance at the 10 % and 5 % respectively. Results are robust to heteroscedasticity.

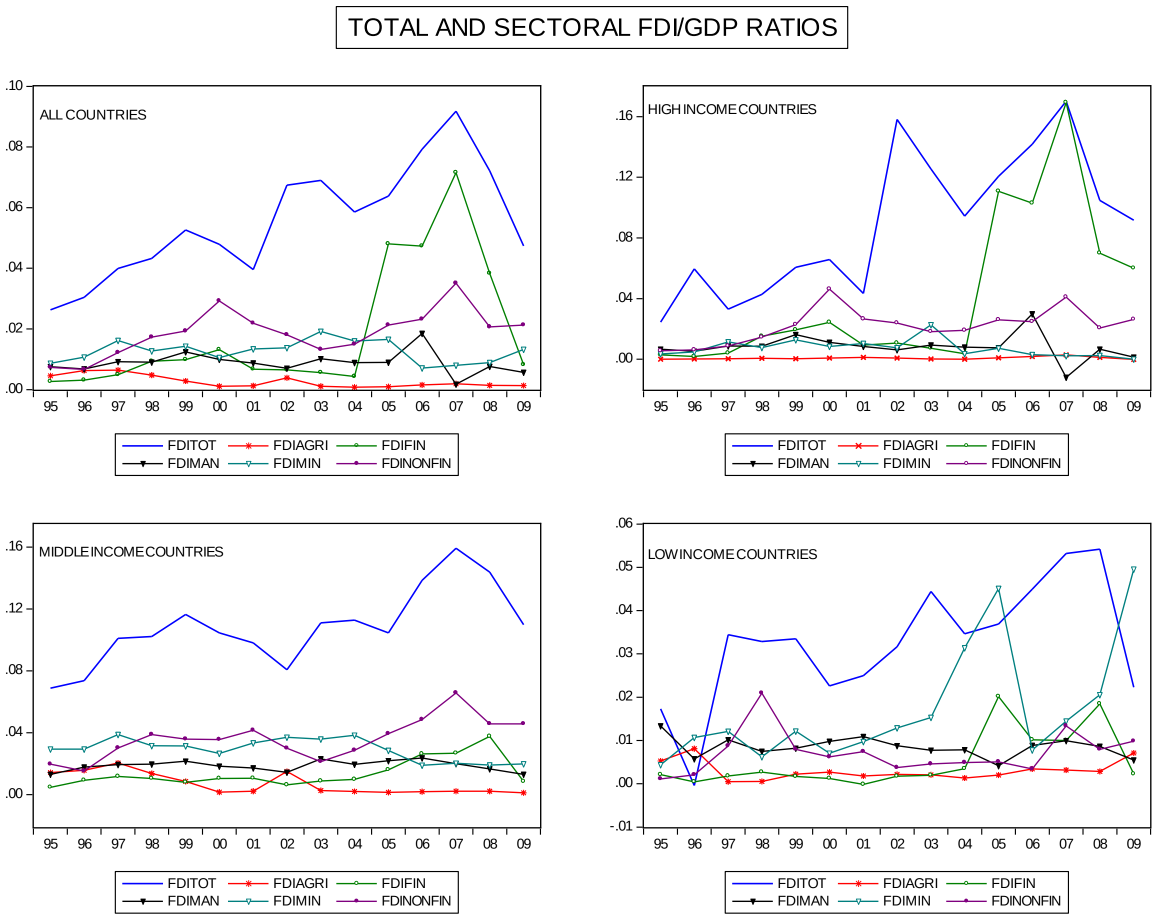
Table 3

Effect of FDI on emissions of various pollutants in the OECD countries*

	Total FDI/GDP	Agriculture FDI/GDP	Mining FDI/GDP	Manufact. FDI/GDP	Services FDI/GDP	Finance FDI/GDP	Nonfinancial FDI/GDP
$\log(CO2)$	-0.005 (-1.25)	-0.004 (-1.41)	-0.001 (-0.28)	-0.002 (-0.94)	-0.010*** (-2.94)	-0.001 (-0.68)	-0.005 (-1.48)
$\log(CO)$	0.010 (1.62)	0.003 (0.94)	0.007** (2.11)	0.003 (0.71)	0.011** (2.12)	0.004 (1.43)	-0.002 (-0.47)
$\log(SO2)$	-0.027*** (-2.90)	-0.013 (-1.54)	-0.001 (-0.30)	-0.011 (-1.27)	-0.018** (-2.06)	-0.009 (-1.39)	-0.041*** (-3.37)
$\log(NO2)$	-0.007 (-1.28)	-0.004 (-1.12)	-0.003 (-1.12)	-0.001 (-0.41)	-0.015** (-1.98)	-0.009*** (-2.65)	-0.023*** (-3.34)

* CO2 (CO), SO2, NO2 are carbon dioxide (carbon monoxide), sulfur dioxide and nitrogen dioxide. The first entry in each cell is the estimate of the effect on pollution of FDI flows, estimated by the System GMM method. Figures in parentheses are t-statistics; * and ** denote significance at the 10 % and 5 % respectively. Results are robust to heteroscedasticity.

FIGURE 1


TOTAL AND SECTORAL FDI/GDP RATIOS
ALL COUNTRIES
HIGH INCOME COUNTRIES
MIDDLE INCOME COUNTRIES
LOW INCOME COUNTRIES
95 96 97 98 99 00 01 02 03 04 05 06 07 08 09
FDITOT
FDIAGRI
FDIFIN
FDIMAN
FDIMIN
FDINONFIN