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ABSTRACT

We analyze the environmental impact of capital inflows and investigate the halo effect (FDI improves the environment). We control for the type of FDI inflows, the EKC (Environmental Kuznets Curve) effect and country income level, and find (i) a differential industry effect: while total foreign investment in aggregate has a negative effect on all countries, this can be traced in particular to capital flows to manufacturing and nonfinancial services sectors.; (ii) an income inequality effect: foreign investment flowing into poorer countries has harmful effects on environment consistent with the race-to-the bottom argument, while capital flowing to richer countries has a beneficial effect and supports the halo effect; (iii) the EKC effect depends on the sector absorbing the FDI and again income level of the country. We show that studies relying only on firm level or aggregate data, miss the sectoral spillovers, and thus may lead to misleading conclusions.

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GLOBALIZATION AND THE ENVIRONMENTAL SPILLOVER OF SECTORAL FDI†

Introduction
The 2008 financial crises and extreme climate events such as floods, hurricanes and droughts that the world has been experiencing with an increased frequency since the beginning of the 21st century have one common message: with globalization, extreme events are no longer rare and can hit both industrialized and developing economies alike. Just as the financial crisis that originated in the United States has transformed into a global recession, the climate change that started a while ago is being felt now throughout the world at an ever-increasing rate. The main difference is that unlike recessions, a change in the climate may be irreversible.

The academic and public discourse link globalization and environment in several ways. Globalization is blamed to degrade the environment through two channels. (i) The pollution haven, or race-to-the bottom. Accordingly, with liberalized trade flows, businesses operating under tight environmental regulation in developed countries can shift polluting industries to countries with lax regulation; (ii) The “Environmental Kuznets Curve” (EKC), described by an inverse U-shaped relation between pollution and income, states that economic growth (often associated with globalization) increases pollution in low-income economies until they reach a certain level of development, and decreases it thereafter. Both channels, however, are mitigated by the more recent literature, which revealed a “halo effect”. The Halo Effect hypothesis states that multinational companies disseminate superior knowledge and apply environmentally friendly practices while improving the environmental performance of domestic business.

The globalization’s effect on the environment is mostly analyzed via the trade channel and less so via the capital flows channel, and more specifically, the foreign direct investment (FDI). All three effects can be triggered by multinational companies that invest in physical plants and equipment, and contribute to the production and growth in host countries, as well as affecting the environment. The view that multinationals impact the environment has its parallel in the literature that examines the productivity gains generated by foreign firms investing in host country, via spillovers of knowledge, knowhow, etc.

For a regulatory body it is crucial to know which effect is triggered by companies, whether foreign or domestic. For business, especially those operating internationally, it is critical to know its impact on carbon emissions and manage its risks. Business and investors are facing increased restrictions and regulations from authorities forced to cut emissions. Managing the climate-generated risk is becoming an important objective of companies and therefore, many businesses and insurers are supporting clear measures and regulations.

In this study, we propose to understand the impact of globalization on the host country’s environment by examining the halo effect of FDI inflows, controlling for a number of factors that may bias the results. More specifically, we analyze how sector-specific FDI inflows impact pollution in the countries in our sample and test whether a halo effect is present. Our study shows that unless it is considered at the sectoral level, the relation between foreign investment and the
environment is not clear-cut. Our results help identify the sectors where more or less regulation is required.

**Contribution of this study to the literature**

The review of the literature below highlights various drawbacks that prevent establishing a clear relation between pollution and capital flows. First, most studies that examined the impact of globalization on the environment considered these effects separately, with a plethora of data and samples at the firm level or country level, which makes it difficult to draw any consistent conclusion. Second, the methodology adopted is time-averaged cross-section approach, which is inadequate to analyze a dynamic phenomenon such as greenhouse gas emissions with little or no reversion. Finally, idiosyncratic shocks to different sectors may outweigh the regional shocks and conceal differences at the industry level, and may explain the reason behind inconclusive results in the literature. We address these drawbacks by adopting a unified framework and a dynamic model that allows the analysis of all three effects over time and a long span of data covering multi-country and industries. We identify the channels through which the halo effect manifests, controlling for the type of FDI inflows, the EKC effect and the level of development of the economies.

The work on the environmental impact of total FDI uses 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 impact of these decisions, which can only be observed at the more aggregate sectoral level and the intersectoral spillovers. Our industry analysis uses 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, 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).

Many of the previous studies struggle with 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. Independent variables may also affect each other: laws may influence the flow of FDI, high growth in turn can encourage FDI and lead to sectoral shifts in the economy impacting pollution. Such simultaneity problems can create substantial biases in the estimates, which make results meaningless. To address these issue, we adopt a dynamic panel data approach (Arellano and Bover, 1995; Blundell and Bond, 1998), a methodology that circumvents similar problems.\(^1\) We instrument FDI and GDP, which addresses endogeneity issues related to growth-FDI-pollution. Another advantage of the GMM estimator is that it exploits both the time series dynamics and the pooled country characteristics of the data while controlling for endogeneity and omitted variable biases. This allows us to retain the time-series aspect of the data and the dynamic aspects of changes in the sectoral flows of FDI, a feature that the traditional approach of the cross-sectional time-averaging methodology is not able to capture. In addition, by breaking down the FDI data according to industries and categorizing the economies according to time-varying country income levels (see below for more details) we indirectly control for potential biases caused by sectoral shifts that occur due to economic development.
We show that results on the capital flow-pollution nexus depend critically on the type of FDI flows and income distribution. First, we find a differential industry effect: while total foreign investment in aggregate has a negative effect on all countries, this can be traced in particular to capital flows to manufacturing and nonfinancial services sectors. Second, we uncover a striking income inequality effect: foreign investment flowing into poorer countries has harmful effects on environment consistent with the race-to-the bottom argument, while capital flowing to richer countries has a beneficial effect and supports the halo effect. Third, we find that the EKC effect depends on the sector absorbing the FDI and again income level of the country. Evidence supports EKC effect (i.e. pollution decreases with economic development) in services in the full sample, in low-income countries, and in manufacturing in high-income countries. In all other instances it is not validated by the data.

**Literature Review**

The two hypotheses discussed above, the Halo Effect 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. Positive environmental impact is triggered if the multinational corporations (MNCs) encourage the dissemination of environmentally clean technologies and management practices. This occurs when 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 by the MNC’s 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, 2005) or because of a direct competition of domestic firms with the MNCs.

The literature on environmental impact of FDI confines mainly to case studies of specific countries’ manufacturing industry firms. The evidence with respect to the halo hypothesis has been mixed (Paigel and Wheeler, 1996). In a limited Indonesian manufacturing firms study conducted 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 comes from the study by Cole et al. (2008) who assess the extent to which foreign ownership influences the energy intensity in Ghana. The authors focus on the extent to which workers with experience in a foreign owned firm transfer their knowledge to benefit the local environment. They find the foreign training of firm's decision maker does reduce fuel use especially in foreign owned firms.

Finally, in a sample of Argentinian 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 more likely adopt environmental management systems; (iii) firms’ absorptive capacity, ownership and export status also influence the extent to which they benefit from environmental spillovers.3
Additional factors such as economic growth and exogenously imposed emission targets also lead to a shift in the mix of sectoral capital flows. Our methodology controls to a large extent for such exogenous factors. FDI and GDP are instrumented, which makes them exogenous to pollution. We tested for the Kyoto protocol with a dummy and found no significant effect.

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 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 (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).

As this brief overview of the literature indicates, most studies and in particular those in environmental spillover literature are conducted at firm level. They give partial, industry-specific insight into the experience of a given country. It is not surprising that literature cannot provide us with a lesson about the global nature of capital flows, which could help us understand events in other contexts. For this, a multi-country, sectoral approach is more appropriate. Our study remedies this weakness and conducts such a sectoral level analysis of the impact of FDI on environmental performance of domestic economies, measured by the levels of air pollution.  

Conceptual framework
Our approach is in the spirit of Marcusen et al. (1995) extended to two imperfectly competitive firms operating in two countries in a partial equilibrium model. A domestic and a foreign firm compete in both markets with heterogeneous products that are imperfect substitutes for each other. Each individual firm can affect the price of its own product in the market it is competing. Each firm can choose whether to produce only domestically or to build plants in both countries and produce both locally and in the foreign country. Following the literature, we will denote the firm as “national” if it is producing domestically and as “multinational” if it is producing domestically and in the foreign country. The model considers only horizontal FDI and ignores vertical FDI following the evidence in the literature (see Markusen, 1995, Carr et al., 2001).

Pollution is a by-product of the production of goods as assumed in the literature and created by local production. We keep the model as simple as possible and abstain from any strategic considerations between firms or governments, or issues around abatement or spatial effects. Pollution $Z_{it}$ at time $t$ in country $i$ depends on total production $Q$ and on an exogenous component $D$.

$$Z_{it} = D + \psi Q_t$$

Total production in the host economy consists of the production of the domestic firm, which may or may not be a multinational, and the production of the foreign multinational firm:

$$Q_t = X_t + X_{ft}$$
where $X, X_f$ are, respectively, the domestic production of the domestic firm and the local production of the foreign firm if it is a multinational, or its export to the domestic country if it is a foreign-national firm. Since the goal of this study is to examine the environmental impact of FDI inflows, we consider the specific case where the foreign firm is a multinational firm producing both at home and in the host country and the domestic firm is a national firm that produces locally. Both firms produce with the same technology using capital, $K$ and labor, $L$ and the pollution level ($Z_D$ and $Z_f$) that minimize their cost. We consider pollution as an input to the production process but it could also be equivalently considered as a joint production technology (Siebert et al., 1980, Copeland and Taylor 2004). In a static equilibrium, ignoring the time subscript the cost minimization of the domestic firm can be written as:

$$C = WL + RK + TZ$$

subject to the resource constraint:

$$Z_D^g G(K, L)^{1-\alpha} \geq \tilde{X}$$

$$Z_D \leq \tilde{Z}_D$$

where $G(.)$ is increasing, concave and homogenous, $0 < \alpha < 1$, $W$, $R$ and $T$ denote the wage rate, capital rental rate and cost (price) of pollution, $\tilde{X}$ is the target output level and $Z_D$ and $\tilde{D}$ are, respectively, pollution produced by domestic firm and the target or maximum allowable emission level for this firm. Substituting the conditional demands into the production function gives the optimal output of the domestic firm:

$$(3) \quad H = H(\Gamma, \tilde{Z}_D, \tilde{X})$$

where $\Gamma$ is a vector of domestic cost of production.

Foreign firm produces domestically and in the host country and thus contributes to emissions in both countries. For its production in the host country, it uses the local labor and pays the local wages. For its production in its home economy, it hires labor and pays salary of the foreign country. Since goods are imperfect substitutes, the cost function is separable. The foreign multinational firm minimizes

$$C_f = (WL_f + W^* L^*) + (R^* K_f + R^* K^*) + (TZ_f + T^* Z^*)$$

Subject to:

$$Z_f^g F(K_f, L_f)^{1-\alpha} \geq \tilde{X}_f$$

$$Z^* \alpha F(K^*, L^*)^{1-\alpha} \geq \tilde{X}^*$$

$$Z_f \leq \tilde{Z}_f$$

$$Z^* \leq \tilde{Z}^*$$

To produce $X_f$ in the host country the multinational firm employs labor from the host country, $L_f$, at the prevailing local cost, $W$ and brings in FDI, $K_f$, which it rents at its home market at the rate $R^*$. It also produces $X^*$ in its home market with labor and capital, at the cost of $W^*$ and $R^*$. Both plants contribute to the emissions by $Z_f$ in the host country, and $Z^*$ in the home country of the multinational where the firm faces similarly target levels of emissions and output, and pays a price of $T^*$. To focus on the pollution produced in the host country, we will ignore the production activity of the multinational firm in its home country.
We substitute the optimal factor demands into the production functions to get the optimal output for each firm. After appropriate substitutions and log linearizing we can obtain a pollution equation of the form:

\[ z = \alpha_0 + \alpha_1 y + \alpha_2 y_f + \alpha_3 x \bar{f} + \alpha_4 z_d + \alpha_5 \bar{z}_f + \alpha_7 f \]

where lower case-letters are the logs of the upper-case letters, \( f \) is FDI inflows (see Appendix 1 for the derivation and the definition of coefficients in the equation).

**Methodology**

Several FDI studies in the literature examine the impact of environmental regulation as an independent variable. These studies belong to the strand of the literature emphasizing 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.

To assess the impact of FDI and growth on pollution in a form comparable to the empirical studies in the literature, we can transform the equation (4) as follows (see Appendix 1):

\[ z_t = \alpha_0 + \alpha_1 y_t + \alpha_2 q_t + \alpha_7 f_t \]

where we used several assumptions: symmetric effect for each firm’s output and target emissions on total pollution \( \left( \frac{\partial z}{\partial z_d} = \frac{\partial z}{\partial z_f} \right) \) and \( \frac{\partial z}{\partial x} = \frac{\partial z}{\partial x_f} \), and the identities \( q = \bar{x} + \bar{x}_f \) and \( z = \bar{z}_d + \bar{z}_f \).

Although \( y \) is a vector that represents the country-fixed effects that proxy the production costs, it is commonly defined to include additional control variables such as institutional and demographic variables.

Equation (5) is based on a static optimization of the firm’s problem, which we use to guide us to determine the control variables consistent with the ones used in the literature. In order to capture the strong memory of pollution, as well as the EKC effect, we extend our model to include dynamic effects. The estimated form that we adopt is therefore

\[ \log(poli_{it}) = \beta_0 + \beta_1 \log(poli_{i,t-1}) + \beta_2 \log(q_{it}) + \beta_3 \left[ \log(q_{it}) \right]^2 + \beta_4 f^{it}_t \]

\[ + \beta_5 corr_t + \beta_6 dens_t + \beta_7 D^t + \mu_i + \varepsilon_{it} \]

with \( \mu_i \sim i.i.d(0, \sigma_{\mu_i}) \), \( \varepsilon_{it} \sim i.i.d(0, \sigma_{\varepsilon_i}) \), \( E[\mu_t|\varepsilon_{it}] = 0 \) and where where \( i \) is the country subscript, the subscript \( f \) stands for an index for total, agricultural, mining, manufacturing, total services, financial services, non-financial services FDI. The variable \( poli_t \) is a measure of air pollution, \( q_{it} \) is log of per capita GDP, \( f^{it}_t \) is the net capital inflow share of GDP. The remaining variables are the explicit components of \( y_t \). 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, a proxy for demographic factors, \( D^t \) is a time dummy and \( \mu_i \) 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 $\beta_4 < 0$. 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.

We use the GMM methodology because it is more suitable for our purposes. Panel data is to be preferred to cross-sectional when analyzing change in the dependent variable because of the correlation between lagged dependent variables and the unobserved residual. Cross-section estimates produce a bias, caused by the correlation between $pol_{i,t-1}$ and $\mu_t$, 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 (Arellano and Bond, 1991) 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). For these reasons we are using the Alonso-Borrego and Arellano, and Blundell and Bond methodology. For this, we transform the regression equation in first difference while including the lagged levels of the dependent variable according to the lags in the instrumental matrix. Because of these lagged level equations we are able to keep the fixed-country-effect in the regressions.

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 instrument both income and FDI with GMM style instruments, which will account for reverse causality between these variables and the pollution variable. We impose a limitation on the number of lags used to preserve degrees of freedom. We use three lags and perform robustness checks removing the restriction on the lags.

**Data and Sources**

The data are yearly, multi-country, span a long period from 1984 to 2011, and come from various sources. The key independent variables are disaggregated FDI flows share of GDP denominated in current USD. All FDI series are net flows, accounting for the purchases and sales of domestic assets by foreigners in the corresponding year. FDI is defined 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 a long-term relationship between the direct investor and the enterprise and a significant influence on the management of the enterprise. 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. CO2 emissions are measured in kilotons (kt).

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 are from the International Country Risk Group (ICRG). Following the FDI and pollution literature, we adopted the control of corruption as an independent variable and we conducted robustness check with law and order (see below). This measure is indexed from 0 to 6, 0 representing the countries with worst corruption and 6 representing countries with the best practices. Corruption includes financial corruption, favoritism, nepotism, etc. Descriptive statistics of all variables are presented in Table 1A and Table 2A in Appendix.

We use an income distribution country classification, provided by the World Bank. We categorize all countries following the current World Bank income brackets for "Low"; "Lower Middle"; "Upper Middle" and "High" income countries that are respectively GNI<=$1,045; $1,045 < GNI<= $4,125; $4,125< GNI<= $12,736; and GNI >$12,736, where GNI, the gross national income, is computed based on the "World Bank Atlas" method. Since there are few observations in the lower-middle income category, we combine it with the low-income category and label it “low-income” and label the World Bank’s "Upper-Middle Income" category as "Middle-Income". Our last category "High-Income" countries is the same as that of the World Bank.

Since our sample spans a long period of time, several countries move up the brackets during this period. To account for the change in the income level of each economy, instead of taking the income distribution among countries as static, we evaluate each country’s GNI at each time period to determine the category it falls. This gives us a more appropriate time-varying income-level classification. Appendix 2 displays the list of countries in the sample and the income categories they fall in following our methodology.

**Empirical Results**

The idiosyncratic shocks to different sectors may overweigh the regional shocks, conceal 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 impact on industry pollution of sectoral and aggregate FDI, given a set of control variables. We examine the primary, secondary (manufacturing) and tertiary (services) sectors by further disaggregating the primary sector into agriculture and mining, and the tertiary sector into financial
and nonfinancial sectors. Our results below show substantial intersectoral differences not detectable in the aggregate FDI data.

To control for heterogeneity caused by 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, lower-middle-income, upper-middle-income, high-income. Since the number of countries in lower income category is small, we combine the low-income with the lower-middle-income countries and report the combined results. Breaking down the data in three income categories reveals stark differences between them. We find that poor countries’ environment is degraded by capital inflows while that of the rich countries’ improves. These findings are consistent with the argument that capital flows to countries with lax environmental restrictions.

To give an overall view of the estimated regression equation, Table 1 displays the full regression results for aggregate and sectoral FDI for all countries. The full sample results are broadly consistent with the expected signs of the coefficients. They indicate a strong persistence effect (1st row), underlying the cumulative nature of environmental degradation.

In our analysis, we concentrate on the estimates of the pollution effect of FDI flows $\beta_4$ (row 6). Results in aggregate, manufacturing and non-financial sectors suggest that flows into these industries degrade the environment in the host country. A negative value suggests that the data supports the Halo Effect hypothesis. In Table 1 we do not find evidence corroborating this hypothesis. The breakdown with time-varying income distribution will help further disentangle these results.

There is weak evidence supporting the EKC hypothesis when inflows of investment are in the primary sector, services and at the aggregate level (rows 2, 3). The two other control variables, corruption and population density are either insignificant or come with the wrong sign in the full regression results. As we will see below, signs and significance vary at the sectoral level.

In Table 2 we summarize the estimate of $\beta_4$ across sectors and income distribution. In Table 3 we present the EKC estimates according to income distribution.

(i) FDI impact on pollution

*The effect of total FDI on CO2 pollution*

The first row in Table 2 reproduces the same results as row 6 in Table 1. Column 2 presents the breakdown of the impact of total FDI on the environment according to income categories. The impact of total capital flows in the full sample on environmental degradation (1st cell) is replicated only in one income level. Evidence shows a significant positive impact in low-income countries, suggesting that FDI inflows deteriorate the environment in the poorer countries, while they do not have the same harmful impact in wealthy countries. Results at the aggregate level thus support the view that capital flows to poorer countries and pollute the environment. How robust is this result across industries? Next, we turn to the sectoral level analysis.

*The effect of primary sector FDI on CO2 pollution*

FDI inflows to both agriculture and mining do not have a significant effect on air pollution in the full sample. (Table 2, first row, columns 2 and 3). However, the impact of capital flows in these industries is clearly beneficial to the environment in the high-income countries corroborating the halo hypothesis (row 4, columns 2 and 3). Capital flows to low- and middle-income countries do
not have any significant effect. Thus, evidence supports the view that FDI inflows in agriculture and mining, traditionally dirty industries, bring in clean technology in the wealthy countries.

The effect of manufacturing FDI on CO2 pollution
Most of the negative impact of capital inflows on air pollution in host countries is generated by manufacturing FDI (column 4). Inflows of foreign investment into this sector raises the pollution level significantly in the full sample (1st row). This result is traced back to both low and high-income countries where manufacturing FDI significantly pollutes the environment. Manufacturing FDI is the only type of investment flow that does not benefit the rich countries.

The effect of tertiary sector FDI on CO2 pollution
In the full sample, the effect of FDI in services on the environment is insignificant (column 5, 1st row). Yet this result conceals significant results at the more disaggregated levels. A halo effect in the middle-income countries is strongly counteracted by a pollution-haven effect in the poorer countries (row 2) and are mitigated at the aggregate level. The harmful effect in poorer countries can be traced back to non-financial services (last column, row 2) and also shows up in full sample (last column, first row). There is weak evidence that the halo effect in services in the middle-income countries is coming from the finance industry (column 6). In rich countries, by contrast, both financial and nonfinancial service FDI significantly benefit the environment by bringing in clean technology (columns 6 and 7, last row).

Summary and discussion of results on the impact of sectoral FDI on CO2 pollution and income distribution
Our findings can be interpreted in two ways: at the sectoral level and at the income distribution level depending on whether the reader examines the results vertically or horizontally. Examining the columns, at the industry level our results suggest that, foreign investment inflows into manufacturing is most likely to increase pollution and refute the Halo Effect hypothesis. The picture with the services is less straightforward and requires examination of the data by income levels, which we do by considering the rows.

Poor countries’ environment is harmed by FDI flows that use dirty technologies in manufacturing and services and more specifically, the nonfinancial services (2nd row). In the middle-income countries, FDI inflows increase pollution in agriculture and mining but bring in environmentally friendly technology in the service industry, most likely in finance (3rd row). By contrast, rich countries benefit from all types of FDI inflows, except manufacturing, with a significant effect in the financial services, nonfinancial services, and in agriculture and mining, and enjoy the halo effect (last row). FDI inflows do not have a significant effect on middle-income countries’ environment, except a halo effect in services.

(ii) The EKC hypothesis and alternative measures of pollution and robustness tests
The hypothesis that pollution worsens during the initial growth process followed by an improvement as income rises is not strongly supported by the data (Table 3) but the results depend on the type of capital flows the countries receive and their level of development. In the full sample the EKC is present in countries receiving services FDI, which was also shown in Table 1. Poor countries exhibit EKC effect when FDI flows to financial and nonfinancial services sector. EKC
is strongly supported in high-income countries in manufacturing and weakly when we consider the impact of total FDI. EKC is mostly inexistent in middle-income countries. In other words, EKC is a phenomenon that appears mainly in poor and middle-income countries and mostly inexistent in high-income countries, except when they host FDI in manufacturing, a traditionally dirty industry.

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. Since data are available only for the OECD countries, we were able to conduct the analysis only at the sectoral level and not income levels. We found that 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 in host countries, raising a broader concern on FDI-induced air pollution.

We 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 favored the latter in line with the literature.

We also examined if the Kyoto Protocol signed in 1997 by 191 countries and entered into force in 2005 had any impact on the estimates and parameter stability. If the protocol had a significant impact, possible changes we expected were an increase in the production costs of polluting industries, therefore a decline in the positive coefficients, and/or a decrease in the costs of clean industries and a rise in the negative coefficients. To our surprise, our results remained unchanged. This may mean either that the protocol has been ineffective, or it did not have time to work through the estimated coefficients.

Finally, we briefly review the remaining parameter estimates in the income categories. We find that the persistence of pollution is highly robust to income distribution. Control of corruption reduces pollution in poor countries if FDI flows in to services. In wealthy countries control of corruption reduces pollution in the full sample and also if FDI flows in to manufacturing. The sign of the estimate does not comes in with the expected sign at the aggregate level. Control of corruption in general has no effect on environmental degradation in middle-income countries. Population density increases pollution in the full sample and in poor countries when capital flows in to services, but it has the opposite effect if it flows in services in middle-income and rich economies and mining in high-income countries.
Conclusion

The literature on the effect of globalization on the environment is ambiguous, partly due to the range of different approaches followed and partly due to the drawbacks of methodologies. We address these issues by adopting a unified framework and a dynamic model that allows the analysis of various effects over time, and a long span of data covering multi-country and industries. 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. We identify the channels through which the halo effect manifests by controlling for the type of FDI inflows, the EKC effect and the time-varying income level of the economies.

We find that results vary critically according to the type of capital flow and income category. On aggregate, foreign investment that flows into manufacturing and nonfinancial services tend to degrade the environment (negative halo effect). When data is disaggregated at the income category level, our study shows that foreign investment benefits the environment in wealthy countries across industries, but degrades it in poor countries. Thus evidence supports a halo effect in rich countries and is consistent with the race-to-the bottom argument in low-income countries. We also find that the traditional EKC results hold at an early level of development if capital flows into services sector. As countries become wealthier, EKC is supported if countries allow capital inflows in traditionally dirty industries, such as manufacturing.

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

1. One notable exception is Frankel and Rose (2005), which examines the effect of trade 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 is dynamic and not static. Third, our analysis is sectoral and thus is able to capture the intersectoral spillovers.

2. Firm level studies find mixed evidence of productivity spillovers, ranging from limited positive to no or negative spillovers. At the aggregate level, the evidence has been overwhelmingly in support of positive impact by FDI inflows. The sectoral level analysis reconciles these inconsistent results. Manufacturing FDI has positive spillovers that spur growth through its own sector, while financial services have a positive effect that spreads through services, whereas nonfinancial services drain resources from manufacturing with a negative effect on growth (see Doytch and Uctum, 2011 for a survey of the relevant literature and new results).

3. 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. Although related to the halo effect, our emphasis will not be on the impact of regulation on environment and investment decisions. For a survey of the earlier literature see Jaffee et al. (1995) and more recent literature Dong et al. (2012) and Chung (2014).

4. The only study that examines the relationship of FDI by sectors with CO2 emissions is Blanco et al. (2013). The study is specific to Latin America and the Caribbean and examines FDI in various manufacturing industries. The study uses a simple Granger causality framework and finds a positive effect of "dirty" sectors FDI on pollution, but does not look into intersectoral spillovers.

5. These sets of conditions are: (i) No second order autocorrelation in the error term: 
   \[ E[pol_{i,t-2} (\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \] for \( s \geq 2 \) and \( t = 3, \ldots, T \); 
   \[ E[y_{i,t-2} (\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \] for \( s \geq 2 \) and \( t = 3, \ldots, T \), where \( y_{it} \) and \( f_{it} \) are the level of income and FDI, respectively
   and where for instruments we use their past levels and differences. To instrument 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) No correlation of the unobserved country-specific effect with their difference \( E[(pol_{i,t-1} - pol_{i,t-2})(\mu + \varepsilon_{i,t})] = 0 \); \( E[(y_{i,t-1} - y_{i,t-2})(\mu + \varepsilon_{i,t})] = 0 \); \( E[(f_{i,t-1} - f_{i,t-2})(\mu + \varepsilon_{i,t})] = 0 \); (iii) The last condition allows using lagged first differences as instruments for levels. Estimation is conducted on Stata with the xtabond 2 command.

6. We present here a set of results based on the minimum number of lags and a collapsed matrix for GDP per capita, an approach suggested by Roodman (2009).
References


Appendix 1

The optimal output of the multinational in the host country’s market is:
\[ H_f = H_f [\Gamma_f, K_f, Z_f, X_f] \]  
(1a)
where \( \Gamma_f \) is a vector of cost of production of the multinational in the host country. Since \( K_f \) will be a covariate in our reduced form pollution equation, we do not replace it in the output equation. The pollution equation is obtained by substituting equations (2), (3), and (1a) into (1):
\[ Z = D + \psi [H[\Gamma, Z_D, X]] + H_f [\Gamma_f, K_f, Z_f, X_f]] \]
Substituting for the optimal demand for FDI is equivalent to instrumenting \( K_f \) using factor prices. Instead, the GMM methodology that we adopt computes internal instruments. The instrumental matrix consists of lagged levels and lagged differences of FDI, where current levels of FDI are instrumented by lagged differences and current differences of FDI are instrumented by lagged levels.

Log-linearizing both sides of the equation around the steady-state we get:
\[ \frac{dz}{z} = \frac{dD}{D} + \psi \delta \left\{ \epsilon_Y \frac{d\Gamma}{\Gamma} + \epsilon_Z \frac{dZ_D}{Z_D^2} + \epsilon_X \frac{dX}{X} \right\} + \psi (1 - \delta) \left\{ \phi_{\Gamma_f} \frac{d\Gamma_f}{\Gamma_f} + \phi_{Z_f} \frac{dZ_f}{Z_f} + \phi_{X_f} \frac{dX_f}{X_f} + \phi_{K_f} \frac{dK_f}{K_f} \right\} \]
where \( \delta, 1 - \delta \) are the share of domestic firm’s and the multinational firm’s respective outputs in total output \( Q \); \( \epsilon_j, \phi_j \) for \( j = \{\Gamma, Z, Z_D, X \text{ and } X_f\} \) are, respectively, the elasticities of optimal output of domestic and foreign firms with respect to \( j \).

Integrating both sides and rearranging, we get the equation (4) in the text:
\[ z = a_0 + a_1 Y + a_2 Y_f + a_3 X + a_4 X_f + a_5 Z_D + a_6 Z_f + a_7 f \]  
(2a)
where lower case variables are the natural logs of higher-case variables and the elasticities are defined as:
\[ \begin{align*}
&\alpha_0 = \frac{\partial z}{\partial z}; \\
&\alpha_1 = \psi \delta \epsilon_Y; \\
&\alpha_2 = \psi (1 - \delta) \phi_{\Gamma_f}; \\
&\alpha_3 = \psi \delta \epsilon_X; \\
&\alpha_4 = \psi (1 - \delta) \phi_{X_f}; \\
&\alpha_5 = \psi \delta \epsilon_{Z_D}; \\
&\alpha_6 = \psi (1 - \delta) \phi_{Z_f}; \\
&\alpha_7 = (1 - \delta) \phi_{K_f}
\end{align*} \]
Assuming symmetric effect for costs, output and target emissions (\( a_1 = a_2, a_3 = a_4, a_5 = a_6 \)) we can rewrite equation (2a) as
\[ z_t = a_0 + a_1 Y_t + a_2 q_t + a_3 f_t \]  
(3a)
where
\[ \begin{align*}
&\alpha_0 = \frac{a_0}{a_5}, \quad \alpha_1 = \frac{1}{a_5}, \quad \alpha_3 = \frac{a_5}{a_5} \\
&\quad \text{and } \gamma_{1t} = [Y, Y_f]
\end{align*} \]
Appendix 2: Country list by time-varying levels of development

Low & Lower Middle Income Countries

Upper Middle Income Countries

High Income Countries:
### Appendix Table 1A: Summary Statistics of Sectoral FDI by Country Level of Development

<table>
<thead>
<tr>
<th>Category</th>
<th>All Countries</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total FDI share of GDP</td>
<td>6348</td>
<td>0.038</td>
<td>0.194</td>
<td></td>
</tr>
<tr>
<td>Agricultural FDI share of GDP</td>
<td>1341</td>
<td>0.001</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>Mining FDI share of GDP</td>
<td>1552</td>
<td>0.009</td>
<td>0.031</td>
<td></td>
</tr>
<tr>
<td>Manufacturing FDI share of GDP</td>
<td>1909</td>
<td>0.007</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>Total Services FDI share of GDP</td>
<td>1711</td>
<td>0.037</td>
<td>0.270</td>
<td></td>
</tr>
<tr>
<td>Financial Services FDI share of GDP</td>
<td>1553</td>
<td>0.024</td>
<td>0.272</td>
<td></td>
</tr>
<tr>
<td>Nonfinancial Services FDI share of GDP</td>
<td>1307</td>
<td>0.017</td>
<td>0.036</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Low-Income Countries</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total FDI share of GDP</td>
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<td>0.121</td>
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</tr>
<tr>
<td>Agricultural FDI share of GDP</td>
<td>481</td>
<td>0.003</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td>Mining FDI share of GDP</td>
<td>581</td>
<td>0.014</td>
<td>0.042</td>
<td></td>
</tr>
<tr>
<td>Manufacturing FDI share of GDP</td>
<td>606</td>
<td>0.007</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Total Services FDI share of GDP</td>
<td>618</td>
<td>0.013</td>
<td>0.017</td>
<td></td>
</tr>
<tr>
<td>Financial Services FDI share of GDP</td>
<td>471</td>
<td>0.003</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>Nonfinancial Services FDI share of GDP</td>
<td>417</td>
<td>0.011</td>
<td>0.014</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Middle-Income Countries</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total FDI share of GDP</td>
<td>1088</td>
<td>0.039</td>
<td>0.065</td>
<td></td>
</tr>
<tr>
<td>Agricultural FDI share of GDP</td>
<td>335</td>
<td>0.001</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Mining FDI share of GDP</td>
<td>376</td>
<td>0.007</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td>Manufacturing FDI share of GDP</td>
<td>464</td>
<td>0.009</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Total Services FDI share of GDP</td>
<td>439</td>
<td>0.024</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td>Financial Services FDI share of GDP</td>
<td>421</td>
<td>0.008</td>
<td>0.013</td>
<td></td>
</tr>
<tr>
<td>Nonfinancial Services FDI share of GDP</td>
<td>378</td>
<td>0.017</td>
<td>0.027</td>
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</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>High-Income Countries</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total FDI share of GDP</td>
<td>1773</td>
<td>0.054</td>
<td>0.321</td>
<td></td>
</tr>
<tr>
<td>Agricultural FDI share of GDP</td>
<td>525</td>
<td>0.001</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>Mining FDI share of GDP</td>
<td>595</td>
<td>0.005</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
<td>Manufacturing FDI share of GDP</td>
<td>839</td>
<td>0.006</td>
<td>0.038</td>
<td></td>
</tr>
<tr>
<td>Total Services FDI share of GDP</td>
<td>654</td>
<td>0.068</td>
<td>0.434</td>
<td></td>
</tr>
<tr>
<td>Financial Services FDI share of GDP</td>
<td>661</td>
<td>0.050</td>
<td>0.416</td>
<td></td>
</tr>
<tr>
<td>Nonfinancial Services FDI share of GDP</td>
<td>512</td>
<td>0.022</td>
<td>0.051</td>
<td></td>
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</table>
Table 2A: Summary Statistics as of the beginning and end of the period (years 1984 and 2011).

<table>
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<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP per capita, 2005 $</td>
<td>148</td>
<td>8655.45</td>
<td>13855.07</td>
<td>182</td>
<td>10684.09</td>
<td>15570.78</td>
</tr>
<tr>
<td>Anticorruption Index</td>
<td>112</td>
<td>3.242</td>
<td>1.557</td>
<td>139</td>
<td>2.684</td>
<td>1.131</td>
</tr>
<tr>
<td>Population Density</td>
<td>204</td>
<td>293.124</td>
<td>1473.61</td>
<td>213</td>
<td>400.832</td>
<td>1898.149</td>
</tr>
<tr>
<td>Total FDI share of GDP</td>
<td>129</td>
<td>0.007</td>
<td>0.016</td>
<td>174</td>
<td>0.093</td>
<td>0.545</td>
</tr>
<tr>
<td>Agricultural FDI share of GDP</td>
<td>13</td>
<td>0.012</td>
<td>0.043</td>
<td>48</td>
<td>0.0008</td>
<td>0.002</td>
</tr>
<tr>
<td>Mining FDI share of GDP</td>
<td>10</td>
<td>0.004</td>
<td>0.005</td>
<td>65</td>
<td>0.006</td>
<td>0.012</td>
</tr>
<tr>
<td>Manufacturing FDI share of GDP</td>
<td>24</td>
<td>0.004</td>
<td>0.009</td>
<td>72</td>
<td>0.007</td>
<td>0.020</td>
</tr>
<tr>
<td>Total Services FDI share of GDP</td>
<td>22</td>
<td>0.001</td>
<td>0.001</td>
<td>71</td>
<td>0.133</td>
<td>0.847</td>
</tr>
<tr>
<td>Financial Services FDI share of GDP</td>
<td>10</td>
<td>0.0002</td>
<td>0.0007</td>
<td>58</td>
<td>0.133</td>
<td>0.916</td>
</tr>
<tr>
<td>Nonfinancial Services FDI share of GDP</td>
<td>7</td>
<td>0.001</td>
<td>0.001</td>
<td>55</td>
<td>0.026</td>
<td>0.058</td>
</tr>
</tbody>
</table>
Table 1*: Full regression results “All countries”

<table>
<thead>
<tr>
<th>Log CO2 All countries</th>
<th>Total FDI/GDP</th>
<th>Agriculture FDI/GDP</th>
<th>Mining FDI/GDP</th>
<th>Manuactur. FDI/GDP</th>
<th>Services FDI/GDP</th>
<th>Finance FDI/GDP</th>
<th>Nonfinancial FDI/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(CO2_{t-1})</td>
<td>1.006***</td>
<td>0.999***</td>
<td>1.001***</td>
<td>1.008***</td>
<td>1.015***</td>
<td>0.996***</td>
<td>1.004***</td>
</tr>
<tr>
<td></td>
<td>(80.50)</td>
<td>(117.32)</td>
<td>(114.37)</td>
<td>(113.60)</td>
<td>(101.99)</td>
<td>(83.41)</td>
<td>(105.52)</td>
</tr>
<tr>
<td>log (Real GDP per capita)</td>
<td>0.182</td>
<td>0.068</td>
<td>0.082</td>
<td>-0.122</td>
<td>0.184</td>
<td>0.106</td>
<td>-0.023</td>
</tr>
<tr>
<td></td>
<td>(1.07)</td>
<td>(0.51)</td>
<td>(0.82)</td>
<td>(-0.95)</td>
<td>(1.42)</td>
<td>(0.58)</td>
<td>(-0.13)</td>
</tr>
<tr>
<td>[log (Real GDP per capita)]^2</td>
<td>-0.011</td>
<td>-0.007</td>
<td>-0.007</td>
<td>0.004</td>
<td>-0.013*</td>
<td>-0.008</td>
<td>-0.008</td>
</tr>
<tr>
<td></td>
<td>(-1.08)</td>
<td>(-0.86)</td>
<td>(-1.27)</td>
<td>(0.66)</td>
<td>(-1.69)</td>
<td>(-0.85)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>Control of corruption</td>
<td>-0.008</td>
<td>0.038**</td>
<td>0.028*</td>
<td>0.015</td>
<td>0.019</td>
<td>0.029**</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(-0.64)</td>
<td>(1.98)</td>
<td>(1.95)</td>
<td>(1.10)</td>
<td>(1.35)</td>
<td>(2.08)</td>
<td>(-0.12)</td>
</tr>
<tr>
<td>log(Density)</td>
<td>-0.003</td>
<td>0.000</td>
<td>0.000</td>
<td>-0.003</td>
<td>-0.000</td>
<td>-0.958</td>
<td>-0.001</td>
</tr>
<tr>
<td></td>
<td>(-0.78)</td>
<td>(0.01)</td>
<td>(0.04)</td>
<td>(-1.06)</td>
<td>(-0.01)</td>
<td>(-1.3)</td>
<td>(-1.00)</td>
</tr>
<tr>
<td>log (FDI GDP)_{t-1}</td>
<td>0.022*</td>
<td>-0.003</td>
<td>0.003</td>
<td>0.015*</td>
<td>0.004</td>
<td>0.002</td>
<td>0.024**</td>
</tr>
<tr>
<td></td>
<td>(1.82)</td>
<td>(-0.51)</td>
<td>(0.49)</td>
<td>(1.62)</td>
<td>(0.67)</td>
<td>(0.23)</td>
<td>(2.19)</td>
</tr>
</tbody>
</table>

Number of Observations 3037 847 1117 1432 1291 1179 991

Number of Countries 132 82 87 94 93 83 82

AR(2) 0.265 0.132 0.045 0.144 0.095 0.452 0.540

Sargan Test 0.002 0.000 0.993 0.558 0.369 0.014 0.583

* Figures in parentheses are t-statistics; * and ** denote significance at the 10 % and 5 % respectively. Results are robust to heteroscedasticity.
New Table 2: Effect of FDI on CO2 emissions with time-varying income levels*

<table>
<thead>
<tr>
<th>log CO2</th>
<th>Total FDI/GDP</th>
<th>Agriculture FDI/GDP</th>
<th>Mining FDI/GDP</th>
<th>Manufact. FDI/GDP</th>
<th>Services FDI/GDP</th>
<th>Finance FDI/GDP</th>
<th>Nonfinancial FDI/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>All countries</td>
<td>0.022*</td>
<td>-0.003</td>
<td>0.003</td>
<td>0.015*</td>
<td>0.004</td>
<td>0.002</td>
<td>0.024***</td>
</tr>
<tr>
<td>Observations</td>
<td>(1.82)</td>
<td>(-0.51)</td>
<td>(0.49)</td>
<td>(1.61)</td>
<td>(0.67)</td>
<td>(0.23)</td>
<td>(2.19)</td>
</tr>
<tr>
<td>Countries</td>
<td>3037</td>
<td>847</td>
<td>1117</td>
<td>1432</td>
<td>1291</td>
<td>1179</td>
<td>991</td>
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<tr>
<td>AR(2)</td>
<td>0.265</td>
<td>0.132</td>
<td>0.045</td>
<td>0.144</td>
<td>0.095</td>
<td>0.452</td>
<td>0.540</td>
</tr>
<tr>
<td>Sargan Test</td>
<td>0.002</td>
<td>0.000</td>
<td>0.993</td>
<td>0.558</td>
<td>0.369</td>
<td>0.014</td>
<td>0.583</td>
</tr>
<tr>
<td>Low-income countries</td>
<td>0.032**</td>
<td>-0.003</td>
<td>-0.003</td>
<td>0.016**</td>
<td>0.034***</td>
<td>-0.003</td>
<td>0.026***</td>
</tr>
<tr>
<td>Observations</td>
<td>(2.03)</td>
<td>(-0.63)</td>
<td>(-0.70)</td>
<td>(1.95)</td>
<td>(3.77)</td>
<td>(-0.48)</td>
<td>(3.81)</td>
</tr>
<tr>
<td>Countries</td>
<td>1488</td>
<td>316</td>
<td>411</td>
<td>434</td>
<td>445</td>
<td>314</td>
<td>287</td>
</tr>
<tr>
<td>AR(2)</td>
<td>0.875</td>
<td>0.252</td>
<td>0.376</td>
<td>0.580</td>
<td>0.414</td>
<td>0.696</td>
<td>0.561</td>
</tr>
<tr>
<td>Sargan Test</td>
<td>0.001</td>
<td>0.000</td>
<td>0.941</td>
<td>0.049</td>
<td>0.410</td>
<td>0.020</td>
<td>0.143</td>
</tr>
<tr>
<td>Middle-Income countries</td>
<td>0.002</td>
<td>0.004</td>
<td>0.005</td>
<td>0.001</td>
<td>-0.009*</td>
<td>-0.013</td>
<td>-0.004</td>
</tr>
<tr>
<td>Observations</td>
<td>(0.45)</td>
<td>(0.64)</td>
<td>(0.90)</td>
<td>(0.19)</td>
<td>(-1.72)</td>
<td>(-1.04)</td>
<td>(-0.32)</td>
</tr>
<tr>
<td>Countries</td>
<td>579</td>
<td>222</td>
<td>277</td>
<td>333</td>
<td>308</td>
<td>301</td>
<td>252</td>
</tr>
<tr>
<td>AR(2)</td>
<td>0.339</td>
<td>0.070</td>
<td>0.068</td>
<td>0.465</td>
<td>0.380</td>
<td>0.661</td>
<td>0.153</td>
</tr>
<tr>
<td>Sargan Test</td>
<td>0.051</td>
<td>0.000</td>
<td>0.928</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.010</td>
</tr>
<tr>
<td>High-income countries</td>
<td>-0.006</td>
<td>-0.007*</td>
<td>-0.017**</td>
<td>0.022**</td>
<td>0.001</td>
<td>-0.011**</td>
<td>-0.015*</td>
</tr>
<tr>
<td>Observations</td>
<td>(-0.56)</td>
<td>(-1.75)</td>
<td>(-2.20)</td>
<td>(2.40)</td>
<td>(0.19)</td>
<td>(-2.22)</td>
<td>(-1.82)</td>
</tr>
<tr>
<td>Countries</td>
<td>970</td>
<td>309</td>
<td>429</td>
<td>665</td>
<td>538</td>
<td>564</td>
<td>452</td>
</tr>
<tr>
<td>AR(2)</td>
<td>0.135</td>
<td>0.218</td>
<td>0.081</td>
<td>0.164</td>
<td>0.179</td>
<td>0.292</td>
<td>0.238</td>
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<tr>
<td>Sargan Test</td>
<td>0.254</td>
<td>0.040</td>
<td>0.979</td>
<td>0.880</td>
<td>0.656</td>
<td>0.008</td>
<td>0.460</td>
</tr>
</tbody>
</table>

* 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 3: Environmental Kuznets Curve (EKC) with CO2 emissions*  
With Time-varying income levels

<table>
<thead>
<tr>
<th>log CO2</th>
<th>Total FDI/GDP</th>
<th>Agriculture FDI/GDP</th>
<th>Mining FDI/GDP</th>
<th>Manufact. FDI/GDP</th>
<th>Services FDI/GDP</th>
<th>Finance FDI/GDP</th>
<th>Nonfinancial FDI/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>log (Real GDP per capita)</td>
<td>0.182** (1.07)</td>
<td>0.068 (0.51)</td>
<td>0.082 (0.82)</td>
<td>-0.122 (-0.95)</td>
<td>0.184 (1.42)</td>
<td>0.106 (0.58)</td>
<td>0.023 (-0.13)</td>
</tr>
<tr>
<td>[log (Real GDP per capita)]^2</td>
<td>-0.011 (-1.08)</td>
<td>-0.007 (-0.86)</td>
<td>-0.007 (-1.27)</td>
<td>0.004 (0.66)</td>
<td>-0.013* (-1.69)</td>
<td>-0.008 (-0.85)</td>
<td>0.000 (0.03)</td>
</tr>
</tbody>
</table>

** Low-income countries**

| log (Real GDP per capita) | 0.335 (0.69) | 0.518 (1.24) | -0.436** (-2.45) | -0.439* (-1.89) | 0.215 (0.43) | 0.409* (1.62) | 0.681* (1.66) |
| [log (Real GDP per capita)]^2 | -0.027 (-0.77) | -0.039 (-1.38) | 0.032** (2.39) | 0.028* (1.72) | -0.014 (-0.40) | -0.030* (-1.62) | -0.049* (-1.69) |

** Middle-income countries**

| log (Real GDP per capita) | -0.750 (-0.59) | 0.026 (0.02) | 1.279 (1.33) | 0.977 (0.72) | -1.766 (-0.99) | -1.602 (-0.71) | -1.682 (-0.90) |
| [log (Real GDP per capita)]^2 | 0.042 (0.57) | -0.004 (-0.06) | -0.076 (-1.34) | -0.058 (-0.75) | 0.101 (0.98) | 0.092 (0.70) | 0.096 (0.89) |

** High-income countries**

| log (Real GDP per capita) | 2.226 (1.57) | 0.325 (0.53) | 0.197 (0.25) | 0.952* (1.94) | 0.829 (1.05) | -0.106 (-0.24) | -0.081 (-0.27) |
| [log (Real GDP per capita)]^2 | -0.110 (-1.58) | -0.018 (-0.58) | -0.012 (-0.31) | -0.047* (-1.90) | -0.044 (-1.08) | 0.003 (0.15) | 0.002 (0.18) |

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