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Moving to Greener Pastures?

Multinationals and the Pollution-haven Hypothesis

Gunnar S. Eskeland
Ann E. Harrison

Eskeland and Harrison find almost no evidence that investors in developing countries are fleeing environmental costs at home. Instead, the evidence suggests that foreign-owned plants in four developing countries are less polluting than comparable domestic plants.

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Summary findings

Are multinationals flocking to "pollution havens" in developing countries? Using data from four developing countries (Côte d'Ivoire, Mexico, Morocco, and Venezuela), Eskeland and Harrison examine the pattern of foreign investment. They find almost no evidence that foreign investors are concentrated in "dirty" sectors.

They also examine the behavior of multinationals doing business in these four countries, testing whether there is any tendency for foreign firms to pollute more or less than their host-country counterparts. To do this, they use consumption of energy and "dirty fuels" as a proxy for pollution intensity. They find that foreign plants in these four developing countries are significantly more energy-efficient and use cleaner types of energy than their domestic counterparts.

Eskeland and Harrison conclude with an analysis of U.S. outbound investment between 1982 and 1994. They reject the hypothesis that the pattern of U.S. foreign investment is skewed toward industries in which the cost of pollution abatement is high.

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Moving to Greener Pastures?
Multinationals and the Pollution Haven Hypothesis

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Harrison: Columbia University and the NBER, 615 Uris Hall, New York, NY. 10027; Eskeland: (GESKELAND@WORLDBANK.ORG) The World Bank: 1818 H Street, N.W., Washington, D.C. 20433. We would like to thank Ricardo Sanhueza for superb research assistance. We are greatly indebted to David Wheeler and Manjula Singh for helpful conversations, for making their database available, and for estimating the results based on U.S. data. We would also like to thank Tarhan Feyzioglu for very helpful comment on an earlier draft of this paper.

I. Introduction

Passage of the North-American Free Trade Agreement (NAFTA) reawakened fears that multinationals would flock to Mexico to take advantage of lax environmental standards. This is the so-called *pollution haven hypothesis*, which states that environmental regulations will move polluting activites to poorer countries. Although existing studies suggest little or no evidence of industrial relocation, arguments over pollution havens persist. Why?

One answer lies in the fact that the existing literature is primarily based on anecdotes and scattered case studies. Even the best studies, such as Leonard (1988), make no effort to assess statistically the relationship between the distribution of US foreign investment and pollution intensity. Most of these studies make no attempt to control for other factors which may play a role in determining foreign investment, such as large protected markets. Many of the earlier studies (Pearson, 1985 and 1987; Walter, 1982) use evidence from the 1970s and early 1980s, when the flow of foreign investment to developing countries was not as high as it is today. One exception is the recent work by Grossman and Krueger (1993), which focuses on maquiladora activity in Mexico. Yet their research also serves to highlight the difficulty in explaining the pattern of US investment abroad. They show that neither pollution abatement costs nor other likely determinants can adequately explain the pattern of maquiladora activity in Mexico.

Although there is a growing literature on the determinants of global environmental quality, little research has been done to test the pollution haven hypothesis.[2] Our research focuses on three

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[2] Instead, much of the literature focuses on the relationship between income growth and pollution. Grossman and Krueger (1995) postulate an inverted 'u-curve'. This empirical relationship has found support in other studies as well (see Selden and Song, 1994; The World Bank, 1992). The hypothesis, supported by their empirical analysis, states that pollution will first increase with income, then decrease at higher income levels. The initial upward relationship occurs because of a positive relationship between output and emissions. The downward tendency occurs when higher demand for environmental quality at higher income levels forces the introduction of cleaner technologies (the technique effect) and an output combination which is less polluting (the composition effect).

A related literature examines the relationship between openness and environmental quality. Again, the links can be related issues. We begin by presenting a simple theoretical model which shows that the effect of environmental regulations imposed at home on outward investment is ambiguous. Depending on possible complementarities between capital and pollution abatement, environmental regulation could lead to an increase or a decline in investment in both the host (developing) country and the originating (developed) country.

To resolve the theoretical ambiguity, we turn to an empirical analysis of the pattern of foreign investment. We begin by analyzing the pattern of foreign investment in a number of developing countries--looking for evidence which reflects increasing costs of pollution-intensive activities at home. To control for other factors which may be important in helping to attract foreign investment, we create measures of trade policies, industrial concentration, the domestic regulatory environment, factor endowments, and wages at home. We use data from four host countries: Cote d'Ivoire, Morocco, Mexico, and Venezuela.

Second, we compare the behavior of multinational firms in developing countries with their counterparts in the host country. In particular, we focus on the emissions behavior of foreign and domestic plants within the same manufacturing sector. Since emissions across a wide range of

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decomposed into an output- a composition- and technique effect. In the case of trade reform, however, the composition effect is of a different nature, since openness to trade itself changes sectoral composition. A number of empirical studies suggest that openness reduces pollution (Wheeler and Martin, 1992; Birdsall and Wheeler, 1992), while others claim evidence to the contrary (Rock, 1995). Theoretical models have a different flavor, with results depending on whether pollution problems are national or transnational, and on the assumed regime for environmental management. Copeland and Taylor (1994) present a model in which pollution problems are national and national pollution control is optimal in both countries. It is, thus, a model with no coordination problem, emphasizing comparative advantage as in a traditional trade model. Then, one effect of openness is that the poor country will be offered a higher premium for undertaking polluting activities, the effect that is presumed in *the pollution haven hypothesis*. However, openness will also leave both countries wealthier, and thus more interested in changing both techniques and composition in the direction of less pollution.

Concerns along the lines of openness and pollution also touch on concerns for competitiveness, and the introduction of measures such as harmonization of environmental standards in trade negotiations. Kanbur, Keen and Wijnbergen show that coordination of environmental standards may be justified to avoid damaging "environmental competition", but suggest that (complete) harmonization would not be the preferred way of coordination. Extending such analysis with a supranational body such as the European Community, Ulph (1995) shows that information asymmetries between the higher body and the nations can lead to a greater harmonization than one would see in the case with full information. Markussen, Morey and Olewiler extend the open-economy analysis to include endogenous market structure.

countries and activities are not available, we use energy consumption and the composition of fuel types as a proxy for emissions. We present evidence from the US to justify that fuel-and energy-intensity can be used as proxies for differences in pollution intensities within an industry.

Third, we test whether the pattern of outbound US investment during the 1980s and early 1990s can be explained by variations in pollution abatement costs across different sectors of the economy. If environmental legislation in the 1980s led to higher costs of doing business in the United States, then we would expect that foreign investment leaving this country would be concentrated in sectors where pollution abatement costs are significant.

Our focus is consequently on two related issues: (1) the impact of pollution abatement costs on the composition of foreign investment and (2) the role played by foreign investors in improving the environment by using more energy-efficient technology as well as cleaner sources of energy. Grossman and Krueger (1993) label these two issues as a "composition" and a "technique" effect. They show that NAFTA is likely to affect Mexico's environment by changing both the composition of output as well as the overall level of technology.

The remainder of the paper is organized as follows. Section II presents a simple modelling framework, describes the empirical specification, and discusses the data. Section III examines the factors which affect the stock of foreign investment in four developing countries. Section IV presents the methodology for analyzing the relative pollution intensity of foreign and domestic firms within an industry, and then presents the results. Section V presents the analysis of outbound US investment. Section VI concludes.

II. A Modelling Framework

In conventional terms, a country has comparative advantage in an activity which uses intensively factors that the country has in relative abundance. Trade theory shows how all countries gain if each exploits its comparative advantage. The *pollution haven hypothesis* is, perhaps, best seen as a corollary to the theory of comparative advantage: as pollution control costs begin to matter for some industries in some countries, other countries should gain comparative advantage in those industries, if pollution control costs are lower there (for whatever reason).

The hypothesis raises several contentious issues, some of which are of an empirical nature, while others have political and possibly ethical connotations. The empirical question addressed in this paper is whether relocation of pollution intensive industries is of importance quantitatively. Other political and ethical issues about environmental quality can hardly be of great importance if the migration south of polluting industries is not of significant quantitative importance.

In this section, we first present a simple model with a homogeneous good and perfect competition. We show that the impact of abatement costs on industrial relocation is ambiguous. For example, if abatement costs fall with the scale of output, then the home country firm may find it more advantageous to expand locally when facing tougher environmental regulations. These results are similar to those of Motta and Thisse (1994), showing that delocation is not an obvious outcome once a model is equipped with some realistic features.

We then introduce the modelling elements required in an empirical model with multiple outputs; we need proxies for other factors that attract foreign investors, such as regulatory environment, market size and concentration.

II.1 A simplified model[3]

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[3] The material in this section is from the appendix "Regulation and foreign investment: A more general model" (available from the authors upon request).

We shall first think of a market for a homogenous good that is served by several types of firms: one type produces in country *H* (in which environmental regulation occurs), another produces abroad (*A*), and finally some firms have production facilities in both countries. The market is perfectly competitive, implying that firms with different cost structures adjust so that they have equal marginal costs.

Let the profits of a firm located in country *H* be:

$$\pi^{H}=px^{H}-c^{H}(x^{H},k^{H},a^{H})-rk^{H} \tag{1}$$

where p denotes the price of output, x^H denotes the firms' sales, c^H is the firm's operating (i.e. non-capital) costs, k^H denotes the firms's stock, r is the cost of capital, and a^H stands for pollution abatement - the resources needed to meet the country's pollution regulations. c^H is continuous, twice differentiable and convex, so this will be the case for π^H as well. We shall furthermore assume

that

$$\frac{\partial c^{H}}{\partial x^{H}}\geq 0,\ \frac{\partial c^{H}}{\partial k^{H}}\leq 0,$$

and

$$\frac{\partial c^{H}}{\partial a^{H}}\geq 0 .$$

The meaning of these assumptions are that short term marginal operating costs are positive, that capital reduces operating costs, and that abatement increases operating costs.

Most of the insights from this model can be gleaned from figure 1[4]. Short run marginal costs (SRMC) and average costs (AC) are drawn for the firm's present level of capital. A demand schedule is not drawn, but we assume that there are many other firms in perfect competition - at least in the short term sense - so the individual firm effectively faces infinitely elastic demand. Since the firm is in a short term equilibrium, it will be somewhere on its short term marginal cost curve, SRMC. Furthermore, if the equilibrium is one with zero excess profits for the present level of capital, then the firm will adjust to the point where average costs (AC) are minimized, i.e. where the short term marginal cost curve cuts the average cost curve from below. Finally, if the firm is in a long run competitive equilibrium, then also the firm's capital will minimize average costs. We have alluded to this possibility by showing the firm's equilibrium output for a given capital level: however, the diagram does not show whether this level of capital minimizes average costs. In the three dimensions, however, the average cost surface would form a bowl, and a long run competitive equilibrium would imply that the firm's output and capital would be where SRMC cuts this bowl from below at its absolute minimum.

Environmental regulations are a part of this picture. The parameter a^H represents a shift parameter controlled by the government. Increasing the required pollution abatement, a^H, could change both the shape and position of the average cost curve (or, more precisely, the average cost surface). The only assumption made a priori is that a^H shifts total operating costs upwards - which also means that average costs shift upwards.

As the firm's average costs and total costs are not a part of its conditions for optimality, the firm might respond only passively to a change in environmental regulations. If only average costs rise (as if abatement increases fixed costs only) the firm would spend the required resources on pollution

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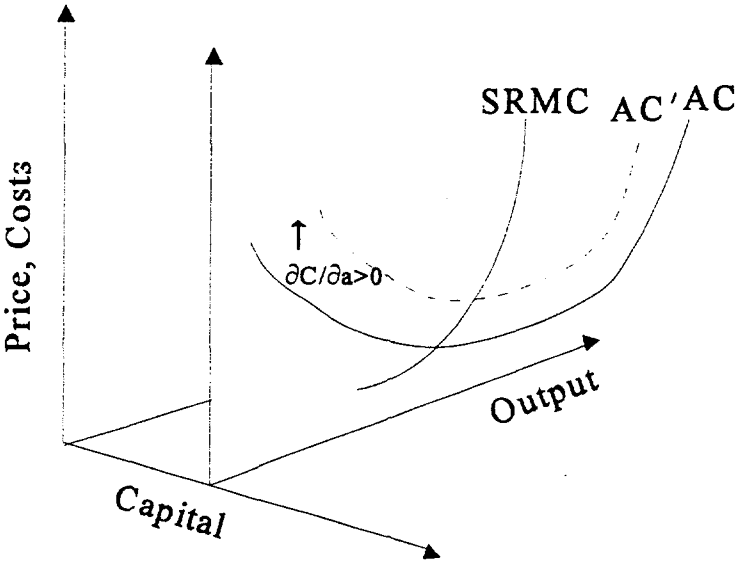
[4] The model is solved by deducing the first-order conditions for profit maximum with respect to capital and output, differentiating these with respect to the regulatory parameter a^H, and finally solving for the effect on investment and output decisions. Details are shown in an Appendix, available from the authors upon request.

Figure 1



abatement, but make no change in its output and investment. Its output could also change in the short run, of course, if the price of output changed (not shown) or if its marginal costs shifted by a^H. The change in the firm's output is ambiguous if the short run marginal cost curve also shifts upwards, and if firm-specific capital responds to changes in abatement.

To see what happens to the firm's investment, we need to bring into consideration that capital in the outset may have been minimizing average costs, given the original abatement requirement. If this is the case, then the firm's position would be at the bottom of a bowl over the output-capital plane. As a consequence of increased abatement requirements, we could see the bottom of the bowl shifting outwards or inwards - meaning that the firm would increase or decrease its output - and/ or to the left or right - meaning that the firm could employ less or more capital.

Results for short term equilibrium (meaning that capital adjusts, but no condition of zero profit has been included) are displayed below in equations (2) and (3).

$$\frac{dx^H}{da^H} = \frac{\left(\frac{dp}{da^H} - \frac{\partial^2 c^H}{\partial x^H \partial a^H}\right)\frac{\partial^2 c^H}{\partial k^{H2}} + \frac{\partial^2 c^H}{\partial k^H \partial a^H}\frac{\partial^2 c^H}{\partial x^H \partial k^H}}{\frac{\partial^2 c^H}{\partial x^{H2}}\frac{\partial^2 c^H}{\partial k^{H2}} - \frac{\partial^2 c^H}{\partial x^H \partial k^H}{}^{2}} , \tag{2}$$

and

$$\frac{dk^H}{da^H} = \frac{-\left(\frac{dp}{da^H} - \frac{\partial^2 c^H}{\partial x^H \partial a^H}\right)\frac{\partial^2 c^H}{\partial k^H \partial x^H} - \frac{\partial^2 c^H}{\partial x^{H2}}\frac{\partial^2 c^H}{\partial k^H \partial a^H}}{\frac{\partial^2 c^H}{\partial x^{H2}}\frac{\partial^2 c^h}{\partial k^{H2}} - \frac{\partial^2 c^H}{\partial x^H \partial k^H}{}^{2}} . \tag{3}$$

The denominator in (2) and (3) is positive by the second-order conditions for profit maximum, and the effect on output is ambiguous. To obtain the effect generally expected in the pollution haven hypothesis, it is sufficient (but not necessary) to assume that the output price does not change,

$$\frac{dp}{da^{H}}=0,$$

that there is no interaction between capital and abatement,

$$\frac{\partial^2 c^{H}}{\partial k^{H}\partial a^{H}}=0,$$

and that abatement increases marginal operating costs

$$\frac{\partial^2 c^{H}}{\partial x^{H}\partial a^{H}}>0.$$

Without these restrictive assumptions, however, a firm's output may increase simply because its marginal costs have increased less than the output price[5]. Also, (2) shows us, output may increase if there is an interaction between abatement and output (one such case would be if abatement makes more capital attractive - as when capital intensive technologies are less polluting) and capital

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[5] We do not show the modelling of the output price, as it is awkward when there is heterogeneity among firms (with homogenous firms, modelling is shown in the appendix). As is apparent from equations (2) and (3), ambiguouity with respect to sign remains even if we assume that the output price increases by as much as marginal operating costs are shifted upwards.

reduces marginal costs.

The effect of increasing abatement costs on capital investment is also ambiguous. It is possible that an increase in abatement costs could raise investment in the home country. One such possibility is when capital lowers abatement costs *and* marginal operating costs. It is also possible to show in this framework that domestic investment could rise even if output falls, if a sufficiently large increase in capital intensity is induced.

As an illustration of these "complementarities", assume that a higher quality, more expensive furnace is available to a steel producer. It is more expensive, has lower emissions than the "normal" model and is also more energy efficient, so it will have lower variable costs once it is installed. Assume further that at low levels of environmental regulations, the higher energy efficiency is not sufficient to make the higher quality furnace attractive to the firm. Higher abatement requirements could make this cleaner technology attractive (increasing investment, and capital intensity in production), and output might then expand as a consequence of lower operating costs. The parameters of the model will determine whether the firm keeps the old furnace and pays higher abatement costs, invests in a new furnace and remains at home, or moves to another location and shuts down the existing plant.

We do not show the results for firms based abroad, as these are rather intuitive. The possibility that output and investment expands abroad as a result of environmental regulation at home, as supposed in the pollution haven hypothesis, exists. However, as it is also possible that firms in the home country expand both investments and output, it is also possible that firms abroad reduce both output and investment - the opposite of what is assumed in the pollution haven hypothesis.

We shall touch briefly on the possible existence of integrated firms, firms with production resources in both countries, using them in an integrated way to produce the final output[6].

$$\pi = px - c(x, k^H, k^A, a^H) - r(k^H + k^A). \tag{4}$$

With integrated firms, the situation is much more complex, since capital in the two locations will be adjusted, and there are more types of interactions. In the integrated firm's cost function, the possibility exists that capital at home is complementary to capital abroad, or that the two forms are substitutable, in addition to the possibilities that capital is substitutable to or complementary to abatement.

As an important example, consider the case in which i) capital at home is complementary to abatement (Then, ceteris paribus, abatement requirement makes more capital at home attractive); capital at home lowers short term marginal costs (Then, ceteris paribus, more capital at home makes higher production at home more attractive) and; iii) capital at home and abroad is substitutable. In this case, we could see the firm investing at home in order to make abatement requirements less expensive to comply with, taking advantage of the (thereby) reduced short term marginal costs by increasing output at home, and finally reducing capital abroad due to the substitutability of capital in the two locations. Such a structure would, thus, lead to the opposite effect of the pollution haven effect in both locations.

II.2 Elements of an empirical model

The simplified model showed how the effect of environmental regulation on the location of polluting industries is ambiguous even in a one-output, simple theoretical model. In our empirical

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[6] If a multinational is modeled simply as the sum of the two previously described profit functions, then one implicitly assumes that $\partial^2 c/\partial k^H \partial k^A = 0$, $\partial^2 c/\partial k^A \partial a^H = 0$. The results will be a blend of the results in the two previous sections. To justify this more general formulation, think of a firm producing both a final output and intermediate inputs in both countries (for cars that are assembled and sold in both countries, chassis are produced abroad, engines at home).

testing, we need to exploit information on investment in industries that are too broad to comprise merely one homogenous output. Also, we shall exploit variation across industries. Thus, the modelling framework needs to be expanded to include other potential determinants of foreign investment. In this subsection, we lay out how such determinants have been introduced in the literature, and how they will be used in our subsequent analysis.

Although trade theories which predict the pattern of trade do not focus in general on ownership, the same factors which have been used to explain trade have also been used to explain foreign investment. For example, higher labor costs should increase a country's imports of labor intensive goods from a labor-rich country. This factor proportions explanation for trade has also been used to explain the pattern of foreign investment. Everything else equal, we would expect that foreign investors would locate in countries where factors they use in high proportions are cheaper than at home. The importance of factor proportions in explaining the pattern of foreign investment can be captured through such variables as skill intensity, capital-labor ratios, and wage differentials between countries.

It is clear, however, that factor proportions alone yield an unsatisfactory explanation of foreign investment. The majority of foreign investment both originates from and locates in industrial countries. Thus, if intra-industry trade and trade between similar countries is a challenge to basic trade theories, basic theories of foreign investment face similar challenges. More recent theories about foreign investment focus on the role of ownership itself. An important role is played by "intangible assets" such as managerial abilities, technologies and business relationships. It is essential that the assets be intangibly related to the control of production; otherwise they could be sold at arms length or rented so that the link to plant ownership and control is severed. For example, in countries where patent protection is weak, research-intensive goods might be sold via direct investment rather than via a licensing agreement with a local firm. To capture the importance of such intangibles in guiding the foreign investment decision, we will use the share of research and development expenditures in value-added whenever such data is available.

A third factor which has been the focus of considerable debate is the attraction of protected domestic markets, particularly if they are large. A large share of foreign investment flows in the early 1990s, for example, were targeted either at the European Union in expectation of EC92 or at the US and Mexico in anticipation of NAFTA. Much of the early literature focuses on the fact that DFI gravitates towards protected sectors. Helleiner (1989), in his review of the role of foreign investment in developing countries, points out that "the prospect of large and especially protected local markets are the key to most import-substituting manufacturing firms' foreign activities".

Finally, recent studies of foreign investment also focus on the role played by economies of scale and the concentration amongst firms within a sector. We will, as is done elsewhere in the literature, use variables such as the numbers of employees per plant, or the Herfindahl index, which measures the size distribution of plants in a particular sector.

III. <u>Foreign Investment and Pollution Abatement in Four Developing Countries</u>

The Approach: We to examine the pattern of foreign investment in four developing countries: Mexico, Morocco, Cote d'Ivoire and Venezuela. In Mexico and Venezuela, the majority of foreign investment originated in the United States; in Cote d'Ivoire and Morocco, most foreign investments are of French origin.

For all four countries, the following general specification was adopted:

$$(10)\ \mathrm{DFI} = \alpha_1\mathrm{ABCOST} + \alpha_2\mathrm{IMPENET} + \alpha_3\mathrm{HERF} + \alpha_4\mathrm{IMPENET{*}HERF} + \alpha_5\mathrm{LAB/CAP} + \alpha_6\mathrm{REGUL} + \alpha_7\mathrm{MARKETSIZE} + \alpha_8\mathrm{WAGE}$$

The independent variables, which vary by four-digit sector, include pollution abatement cost (ABCOST); import penetration (IMPENET) as a proxy for openness in the sector's product market; the Herfindahl index (HERF), equal to the sum of the square of firm market shares in each sector, as a measure of scale and concentration; the interaction of market concentration and import penetration (IMPENET*HERF); the labor-capital ratio (LABCAP) in the sector; a measure of regulatory barriers against DFI (REGUL) which varies from 0 (no restrictions) to 2 (foreign investment prohibited); a measure of market size (MARKETSIZE), which is defined as the lagged share of domestic sales in the sector j as a percentage of total manufacturing output and; wages in the sector j (WAGE) in the United States (for Mexico and Venezuela) and France (for Morocco and Cote d'Ivoire).

Data Issues. We focus on four developing countries which collect data on foreign ownership in their manufacturing censuses: Cote d'Ivoire, Venezuela, Morocco and Mexico. The time period covered in the estimation is slightly different across the four countries. Cote d'Ivoire covers 1977 through 1987; Venezuela covers 1983 through 1988; and Morocco covers 1985 through 1990. In Mexico, although we have a panel of plants from 1984 through 1990, ownership information was only collected in 1990. Data is reported at the plant level, and when sector level estimates are needed, these are obtained by aggregating over plant observations, using a concordance to four-digit ISIC classification. Foreign investment is converted to a share variable by dividing by the total foreign investment in that country and year.

In 1987, the share of foreign investment in manufacturing varied from 38 % in Cote d'Ivoire to 7 percent in Venezuela. Morocco lies somewhere in between: in 1988, foreign investment accounted for 15 % of total assets in manufacturing. In 1990, foreign investment accounted for 10 % of total assets in manufacturing in Mexico. Since these censuses typically only cover the largest plants, our measure of DFI may be biased. The smaller plants and informal sector plants are excluded, so it is likely that the importance of foreign investment in the manufacturing sector as a whole may be over-stated. For Mexico, the sample excludes many "maquiladora" plants - firms under special arrangements to assemble inputs imported from the United States for re-export.

The independent variables vary across industrial subsectors and over time. For all four countries, all dependent and independent variables were redefined to be consistent with the ISIC classification, including US abatement costs. Import penetration, the Herfindahl index (HERF), the labor-capital ratio (LABCAP), and market size were calculated using both the censuses and trade information from the source country. The measure of regulations against DFI (REGUL) was taken from both policy reports and various publications for potential investors. Manufacturing wages by sector and time period in France and the United States were taken from ILO publications.

The data source for pollution abatement expenditures is the Manufacturers' Pollution Abatement Capital Expenditures and Operating Costs Survey (referred to as the PACE survey) administered by the U.S. Department of Commerce. Following earlier studies, we defined pollution abatement costs as the dollar amount of operating expenditures normalized by industry value-added. We feel justified in excluding capital expenditures for several reasons. First, the majority of abatement expenditures are for operating costs, not for capital expenditures. Second, the pattern of costs across industries is very similar across operating and capital costs. Data was available for 1976 through 1993, excluding 1987 when no survey was conducted. Since pollution abatement costs were not available for France, we used the same abatement cost measure, defined in Section II, in all four host countries. By using the same measure of abatement costs, we are assuming that abatement costs follow a similar pattern across sectors in the United States and elsewhere. This assumption is supported by Sorsa (1994), who finds that differences in environmental spending among industrial countries are minor. We also assume that the pattern is a good proxy for the pattern of cost savings associated with localizing production in the host country. While the validity of these two assumptions cannot be tested separately, we will test the hypothesis that the sectoral distribution of foreign investment is positively associated with high abatement costs in the U.S., against the alternative hypothesis that there is a negative or no association.

Results: The results are reported in Table 1. In columns (8) and (9), we pool all four countries, but include country dummies to allow for systematic differences across countries. For both the pooled sample and the individual country results, we report the estimates with and without dummy variables for year and industry effects. For Mexico, however, the data is only available as a cross-section for 1990. Consequently, we cannot control for time and industry effects.

Across all specifications, for all four countries and the pooled data set, pollution abatement costs are insignificant in determining the pattern of foreign investment. Thus, the data suggest no robust association between the pattern of pollution abatement costs and investment. Other factors, however, significantly affect the pattern of investment. For example, the results show that import penetration is negatively related to DFI, suggesting that foreign investors locate in sectors with little competition from imports. The results also point to a negative correlation between the Herfindahl index and DFI, suggesting that foreign investors are less likely to locate in concentrated sectors typically characterized by entry barriers and economies of scale.

In all four countries, the single biggest draw for foreign investors was the size of the domestic market. Foreign investors tend to concentrate in sectors with large total sales. However, controlling for market size could be unjustified if the size reflects that domestic firms *also* invest in pollution-intensive activities--reflecting a country's comparative advantage in producing "dirty" products. Consequently, the analysis was redone excluding MARKETSIZE, but the results were unaffected.

Using Measures of Pollution Intensity: To test whether the costs of environmental regulations lead firms to move plants abroad, this paper focuses on the relationship between pollution abatement costs and the pattern of foreign investment. An equally interesting, but slightly different question would be to ask whether "dirtier" sectors--measured using actual pollution emissions--are more likely to attract foreign investors.[7] We thus redid the analysis using three different measures of pollution emissions: total particulates, which is a measure of air pollution; biological oxygen demand, which is a broad measure of water pollution; and total toxic releases.[8]

Total particulates (TP), which captures small and large dust particles, is closely related to phenomena such as the (now historic) London smog, and to air pollution in cities with emissions from fuel- and diesel oil combustion, from energy-intensive processes such as steel and cement, from two-stroke engines, coal use, and burning of wood and residues. Analysis in the World Bank and elsewhere indicates that particulates is the main air pollution problem (as judged by health impact) in many third world cities (See, for instance, World Bank 1992, Ostro 1994 and Ostro et al 1994). Biological Oxygen Demand (BOD) indicates how discharges to water bodies deplete their oxygen levels, and is widely accepted as a broad measure of water pollution. Total toxic releases (TOX) is an unweighted sum of releases of the 320 compounds in the U.S. EPA's toxic chemical release inventory. All of these measures are by weight. In order to normalize, emissions are divided by the total output of the firm, measured in monetary terms, to arrive at sector-specific *emission intensities* for the three pollutants.

Regretfully, no comprehensive data on manufacturing emissions exists for developing countries. We assume that the sector specific emission intensities estimated from data on manufacturing in the United States can serve as proxies for the relative emission intensities for the same sectors within the LDC host countries. Sector specific emissions intensities are calculated using

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[6] One might conjecture that industries with high abatement costs are industries with high pollution intensities, but this need not be the case, given that abatement could be effective in removing pollution. If abatement is socially optimal, then an industry will be ranked high in terms of abatement costs and low in terms of pollution intensity if marginal benefits equal marginal costs at a point with much abatement and little remaining pollution.

[7] See Hettige, Martin, Singh and Wheeler, (1995) for more details on the database.

a plant-level data set resulting from a merger of data sets of the Bureau of the Census and U.S. EPA[9].

Such "imported" *emission intensities* (for individual inputs, technologies, or outputs, as applied here) are routinely used in environmental analysis when local and more specific emission measurements are not available.[10] It may certainly be argued that emission intensities are higher in developing countries, due to less progress with emission controls, older technologies and lower skill levels. The working hypothesis is still plausible, however, that relative emission intensities among sectors are similar across countries. It is certainly the case that industries such as cement, industrial chemicals, fertilizer and pesticides, pulp and paper, refineries and primary metals--which have the highest abatement costs in the U.S--are same industries where abatement costs are high in other industrialized countries (See Sorsa, 1994). Briefly stated, we assume that these sectors in developing countries are also likely to be heavy polluters.

Table 2 reports the correlations between the three measures of emission intensity and pollution abatement costs. The table shows that, in a comparison among 4-digit ISIC sectors in the US, there is no significant correlation between air pollution, water pollution, and toxicity. Thus, although these three measures of pollution are very broadly defined, there is no general tendency that a sector which pollutes in one medium also pollutes another medium. However, Table 3 does report a statistically significant correlation between abatement costs and toxic releases. Industries which on average have high abatement costs typically also emit toxic substances.

Table 3 repeats the specification in Table 1, but replaces pollution abatement costs, the

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[8] The emissions data are from three separate data-bases generated by the United States Environmental Protection Agency (U.S. EPA): The Aerometric Information Retrieval System (Air), The National Pollutant Discharge Elimination System (water) and the Toxic Chemical Release Inventory (irrespective of medium). These have been linked with the Longitudinal Research Data Base on manufacturing firms (Bureau of the Census, Center for Economic Studies) by a World Bank research project: The Industrial Pollution Projection System (IPPS), see Hettige, Martin, Singh and Wheeler, 1995.

[9] Such transferred intensities and coefficients are used in engineering analysis as well as in more superficial economic analysis, and in industrial as well as developing countries. See, for instance, for engineering analysis, U.S. EPA's AP-42, on industrial emission coefficients for air pollution.

endogenous variable, with our three different measures of emission intensities. We only report the coefficients on the three measures of pollution emissions, since the coefficients on the other variables are similar to those reported in Table 1, and not of primary interest. We report the results both with and without industry and time dummies. Since our emission intensity proxies do not change over time (in contrast to pollution abatement costs, which vary across industries and over time) the panel estimates without industry dummies are most meaningful.

In general, the relationship between emission measures and the pattern of foreign investment is either insignificant or negative--high levels of water pollution (proxied by BOD), for example, are associated with less foreign investment, not more. The only exception is for air pollution: SUSSPART is significantly and positively correlated with the pattern of foreign investment. The country-by-country results show that this is due to a relationship between SUSSPART and the pattern of foreign investment in Morocco. The positive association relationship between air pollution emissions and foreign investment in Morocco is driven by one observation: a high concentration of foreign investment in the cement industry. Yet it is arguably unlikely that French investors flocked to Morocco to take advantage of lax environmental standards in this particular industry, since cement exports back to France are essentially zero. Instead, the cement industry is attractive to French investors due to the fact that import competition is slim and there are few domestic competitors.[11] The positive association between air pollution and foreign investment disappears in these models if the Moroccan cement industry is excluded from the sample.

IV. Energy use and pollution intensity: proxies for differencies within Industries

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[11] Cement is a low-price, bulky commodity, with the result that transportation costs will be high as a share of the final price. For this reason - as well as due to policy intervention - many countries are close to self-sufficient in cement.

Our discussion so far ignores one potential benefit from the entry of industrial country firms into developing countries. If industrial country plants use cleaner technology than their local peers, they may help the host country environment. This would be true if foreign entrants replace older, "dirtier" local competitors, and even more so if they also influence domestic plants in their choice of fuels or technology.

Unfortunately, data on emissions by ownership is not currently available for our four sample countries. One way to address the problem is to find a proxy for emissions at the plant level. In this section, we propose using fuel and energy intensity as a proxy for emissions at the plant level. We first make the case for these proxies using evidence from the U.S.

The relationship between energy use and air pollution assumed in most technical and economic studies is not well defined. The standard reference in the technical literature on this topic is EPA's handbook AP-42, which prescribes emission factors for various industrial processes (combustion and others). For most processes, AP-42 proposes an *emission function* (or a range, given that a limited number of measurements have given widely varying results), as follows:

(11)

$$e_i = e_i(x_1, x_2, ..., x_n, a_j, t_j), = \sum_j f_{ij}(a_j, t_j) \cdot x_j.$$

where e_i are emissions of pollutant i (say dust, in kilograms), x_j is the quantity of fuel j (say diesel oil, in tons), a_j is a variable denoting the type of abatement equipment in place, if any (say, filters, precipitators, baghouses), and t_j is (a vector) denoting other relevant aspects of technology and equipment. In our work we shall use energy intensity, defined as energy use per unit of output, as a proxy for emissions. We discuss the validity of this assumption below.

Based on technically oriented source literature like the U.S. Environmental Protection Agency's AP-42 (U.S. EPA, 1986) and more basic texts, it has been customary to associate air pollution with fuel use, and to assume proportionality (as in the second equality of 11)[12]. For some pollutants, such as CO_2 (the main contributor to global warming) and to a certain extent sulphur emissions, the proportionality assumed in (11) between fuel use and emissions is quite accurate[13]. For other air pollutants, however, the relationship is more dubious; measured coefficients may be scattered, and theory as well as experience suggests that coefficients are sensitive to equipment specifications and operating conditions (as one can observe when behind buses and trucks).

From the point of view of economic modelling, it is important to be aware that (11) describes a technical relationship, not an economic one. While (11) implies that the partial derivative of emissions with respect to the use of fuel oil *from a technical perspective* is a constant, this may not be true from an economic perspective. From an economic perspective, it would be necessary to ask: what is it that we imagine is changing, which in turn changes the use of fuel oil? For instance, if the factory owner faced rising fuel oil prices, he might respond by renewing his boiler equipment, in which case both fuel oil consumption *and* his emission intensity would be reduced. In contrast, if he faced declining markets for his final products, he might reduce fuel consumption by reducing daily operating hours, thus holding the emission intensity constant.

In our cross-section comparisons between firms, several factors are worth mentioning. First,

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[12] Notable studies are Jorgenson and Wilcoxen (1993), Gloemsroed, S., T. Johnsen and H. Vennemoe (1992), Manne and Richels (1990).

[13] Two main "break points" between energy intensity and emissions, when the former is measured by energy cost shares, and emissions, is variations in fuel type, and emission control devices. The number of carbon atoms in the fuel is fixed, and carbon dioxide is the end product of the combustion process. The combustion process may not be complete, however, to allow a certain amount to be released as hydrocarbons, carbon monoxide, or in the form of particulates. Similarly, for sulphur, the number of atoms in the fuel is given. However, some of these may be trapped by emission control devices, or, as in the cement industry, in the end product of the process. There are polluting processes, such as the cement industry, for which the majority of the emissions are not combustion residuals. The cement industry is, however, apart from extremely polluting, extremely energy intensive. Moreover, more modern plants will, irrespective of control devices, be both less polluting and more energy efficient.

it would be important to distinguish between energy sources - which we will be able to do only for some of the data sets. Thus, to the extent that firms in the same manufacturing subsector use different fuels, our "emission factor" is a weighted average, at best[14]. Secondly, we shall be unable to observe some "other" differences between the firms that may lead to different levels of emissions, such as abatement equipment or machinery type. However, we will be able to control for other factors which may be important, such as capital intensity, imported machinery, research and development, the plant's age.

An important determinant of air pollutant emissions, emission control equipment, is not reflected when energy is used as an indicator. However, even in industrialized countries, emission control equipment first gains importance for a low number of large "high-stack" polluters, such as the steel, cement and thermo-electric power plants, leaving most firms untouched for decades. We conjecture that in the less developed countries of our study, air pollution control equipment will, at best, be in place (and effective) in a small fraction of manufacturing firms.

We shall show, however, that even in the U.S., where respectable air pollution control programs have been in place for more than 20 years, and the choice of fuels and electricity is very varied, there is a strong statistical relationship between air pollution coefficients and energy use. We may argue that due to the lower prevalence of emission control devices in developing countries, and the likely lower variation in fuel choice within an industry, the relationship between air pollution and energy use in these countries is likely to be even stronger[15].

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[14] Our data results from fuel and energy *cost shares*. Thus, to the extent that firms in the same subsector use different fuels, rather than different amounts, our estimates will be biased if and when fuel unit prices are correlated with emission factors. Unit prices for fuels are likely negatively correlated with emission factors, with "cleaner fuels" (gas, light fuel oils) typically more expensive than dirtier (coal, heavy fuel oil). Our test is based on the assumption that there is a greater tendency that firms in the same industry use the same, or similar combinations of fuels. Our results give some support for our methodology, since strong correlation between pollution and energy use is found, even when energy is measured in cost terms (this test is arguably, a strong test, since U.S. is a large country with big local variations in prices of natural gas and coal.

[15] Guo and Tybout (1994), Moss and Tybout (1994) and Eskeland, Jimenez and Liu (1994) have studied fuel choice in Chile and Indonesia, data bases in which details on fuel choice is available, but ownership data is not.

We begin by presenting the evidence on the relationship between energy use and pollution emissions across U.S. industries. As in the earlier tables, we use three different measures of emissions: particulates, which measure air pollution; BOD, which measures water pollution; and toxics. As before, particulates are defined as annual pounds of particulates divided by thousands of dollars of total output in the sector. BOD intensity is defined as daily kilograms per thousands of dollars of output. Two different measures of toxics are reported, TOXLB and TOXUB. Both measures are computed as annual pounds of toxics divided by total output in thousands of dollars. TOXLB ("lower bound"), however, is computed using total toxics reported by the Toxic Release Inventory (TRI), divided by total output in the sector. While TOXUB ("upper bound") is computed using only those plants present in both the TRI database and the LRD database.

The rank correlations between these alternative measures of emissions and different factor inputs, including energy, are reported in Table 4. We report the correlations between emissions and six different factor inputs: the share of unskilled labor in total value of shipments, the skilled labor share, capital share, manufactured input shares, raw material input shares, and the share of energy inputs in total output. Energy use is highly correlated with different measures of emissions. The correlation between energy use and particulates is .58; between toxics and energy use the correlation varies between .52 and .55. The correlation with BOD is lower, though also significantly different from zero, at .22. Table 4 also shows that the correlation between pollution and energy use is much higher than for other factor inputs.

In Table 5, we use OLS to estimate the relationship between energy intensity and emissions after controlling for other factor inputs. For particulates, energy intensity is the only input which is statistically significant in explaining emissions. However, neither energy nor any other factor input is a good indicator of BOD, which measures water pollution. Finally, the results in columns 3 and 4 indicate that while energy is significantly correlated with toxics after controlling for other factors, both capital and raw material inputs are also correlated with toxic emissions.

The results in Tables 4 and 5 suggest that energy intensity, measured as the share of energy inputs in total output, is highly correlated with the suggested measures of emissions. In a cross-section of industries, energy intensity is significantly correlated with air pollution and toxic emissions, but not with water pollution. In addition, energy intensity is more highly correlated with air pollution than other inputs, such as capital or raw materials.

Yet even if energy intensity could provide a good proxy for emissions across industries, energy intensity may not be a good proxy for differences in emissions between plants within the same industry. To investigate this issue, we used a cross section of U.S. manufacturing firms to examine the relationship between different types of factor inputs and plant-specific emissions, one industry at a time. The results are reported in Table 6. The strength of the relationship between energy use and emissions varies with the type of industry. In a cross section of all firms, including SIC sector dummies, energy intensity is a strong predictor of particulates emission. However, when the relationship is estimated in a separate equation for each of the 17 SIC industries, emissions of particulates are highly correlated with energy use at the plant level for only four industries: chemicals, petroleum refining, lumber and wood products, and non-electrical machinery. Two of the most polluting activities in manufacturing--chemicals and petroleum refining--are included in these four sectors.

We have argued that energy use, from a technical perspective, might be a useful proxy for emission intensity between as well as within industries. The results presented in Tables 4, 5 and 6 suggest that energy intensity is highly correlated with particulates emissions, although that relationship is only significant at the intra-industry level for four industries. It should be emphasized that such an association is likely to vary over time. However, until actual emissions data by ownership type at the plant level become available, this approach can be justified on the basis of evidence from US plants.

We thus turn to an analysis of foreign direct investment and energy intensity in developing countries building on these findings.

Table 7 presents evidence on the determinants of energy intensity at the plant level. In this estimation, we include only plants in the chemical, petroleum refining, wood and lumber, and non-electrical machinery sectors, since these were the sectors for which the proxy was significant when comparing plants within sectors in the U.S. data sets. Independent variables include ownership, plant size, capital intensity, age of the plant, machinery imports, research and development, and the electricity price. Morocco is excluded from the analysis due to lack of information on plant-specific energy use. Since data availability varies across the three data sets, not all variables could be included for each country. The data from all four sectors are pooled, and all estimates include sector dummies at the four-digit SIC level.

Table 7 reports results on two separate tests. First, we measured the determinants of energy intensity, defined as the share of energy inputs in total output (in value terms) for each plant. Second, we examined the extent to which ownership affects the use of cleaner types of energy--in particular, electricity and natural gas.

The negative and statistically significant coefficient on foreign ownership (see equation (1) of Table 7 for each country) shows that foreign ownership is associated with lower levels of energy use in all the three countries in our sample. To the extent that energy use is a good proxy for air pollution emissions, this suggests that foreign-owned plants have lower levels of emissions than comparable domestically owned plants. The results are robust to the inclusion of plant age as well as capital intensity--suggesting that foreign plants are more fuel efficient even if we control for the fact that foreign plants tend to be younger and more capital-intensive.

We also test (see column (2) for both Mexico and Venezuela) whether foreign ownership is associated with using "cleaner" types of energy. For Mexico, we test whether foreign firms have a higher share of electricity in their energy bill. In Venezuela, we test whether foreign firms have a higher share of electricity and natural gas in their total energy bill. For both countries, we find that foreign ownership is associated with the "cleaner end" of the range of energy types.[16]

V. The Impact of Pollution Abatement Costs on US Outbound Foreign Investment

A potential problem of the preceeding analysis is its inability to distinguish foreign direct investment by country of origin. We are forced to assume that most DFI originates in industrialized countries, and that the distribution of abatement costs in industrialized countries is similar to the pattern in the United States. Although both assumptions are plausible, in this section we address these problems by examining foreign investment originating in the United States.

If environmental legislation has led to higher costs of doing business in the United States, then we would expect that foreign investment leaving this country would be concentrated in sectors where pollution abatement costs are high. One simple way to test this hypothesis is to measure the statistical correlation between the pattern of outbound foreign investment and pollution abatement costs across different sectors. In the United States, the Department of Commerce gathers information on both the stock and flow of outgoing foreign investment, and publishes the data at the level of three-digit SIC sector codes.[17] For the manufacturing sector, the PACE survey described earlier was used as a source for pollution abatement expenditures.

Foreign investment outflows were available for 1982 through 1994, recorded on a historical cost basis. As earlier, to normalize the foreign investment data, we divided investment for each three

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[17] At the point where it is used, electricity is a "clean" fuel, though it may be more or less polluting than others where it is produced (See Eskeland, Jimenez and Liu, 1994). Natural gas is a "clean" fuel by all standards.

17. The time series data on outbound U.S. DFI is not reported by recipient country. Thus, a detected pattern on this data would have to reflect a general tendency for DFI to locate in countries with less abatement costs, since one cannot distinguish recipient countries.

digit sector by the year's total for foreign investment. Consequently our foreign investment data measures the distribution of direct foreign investment (DFI) across subsectors. We also redid the analysis using other measures of foreign investment, such as foreign investment income and sales. However, since using these alternative measures did not affect our results, they are not reported in the paper.

Although both DFI and abatement costs are recorded using the same Standard Industrial Classification (SIC), SIC codes were revised in 1987. New codes were added and others were deleted, making it difficult to create an unbroken time series for the whole period. We addressed this problem by deleting SIC codes where the change in classification creates a time series which is not comparable before and after 1987. This led to the elimination of about 30 percent of the SIC codes with available data.

Using data for the 1982-1994 period, we estimated the strength of the relationship between the pattern of foreign investment and pollution abatement costs in several different ways. The results are reported in Table 8. We began by regressing annual foreign investment outflows on pollution abatement costs, without controlling for other factors. Pollution abatement costs were measured, as before, as the sectoral share of abatement costs in manufacturing value-added.

As indicated in Table 8, there is a statistically significant correlation between abatement costs and the pattern of foreign investment if no control variables are included. The results are similar if foreign investment is measured as a flow (column (1)) or as a stock (column (4)). The magnitudes, however, are small. If abatement costs doubled from a mean of 1.3 percent of value-added, the distribution of outbound DFI would move towards dirtier industries by 0.2 to one half of 1 percent.

For a subset of the period, we were able to include other variables which also affect the pattern of foreign investment. To capture the role of factor endowments, we included measures of human capital and physical capital. Human capital is measured as the lagged share of skilled labor in value added. Physical capital is measured as the lagged share of capital in value added. Research and development expenditures, as a share of value added (RNDSHARE) capture the importance of intangible assets in motivating foreign investment. Scale economies are proxied by the number of employees per firm (SCALE).

Without more detail on the destination of foreign investment, it is difficult to formulate measures of protection in destination markets. However, to the extent that markets are in general open towards US products in a particular category of manufacturing, one good measure would be outbound exports from the United States. If foreign investment is attracted to protected markets, we would then expect a negative relationship between US exports and the pattern of outbound foreign investment. Export volumes may also reflect other factors, such as transport costs and U.S. comparative advantage. If transport costs are large enough to encourage foreign investment and discourage exports, this would also be reflected in a negative coefficient on export shares. Exports (lagged) are measured as the share of export sales in total U.S. output.

If we introduce these additional variables, the relationship between abatement expenditures and the pattern of outbound US investment becomes insignificant if DFI is measured as a flow. However, the relationship between the stock of foreign investment and pollution abatement costs remains significant. As predicted by theory, foreign investment outflows are significantly and positively correlated with research and development expenditures, but SCALE has no impact. Foreign investment outflows are negatively associated with export shares and positively associated with the share of physical capital in value added.

Adding time and industry dummies further reduces the statistical significance of the abatement cost variable, which then becomes insignificant for both definitions of DFI. This result, then, indicates that sector-specific changes in abatement cost are not significantly associated with outbound U.S. DFI. Some other variables, however, retain their significance in explaining the pattern of foreign investment. The flow of DFI is again negatively correlated with exports, suggesting that outbound foreign investment is a substitute for exports. The stock of foreign investment is significantly and positively correlated with RNDSHARE. In general, however, adding time and industry dummies reduces the statistical significance of all the variables. In part, this may be because there is not sufficient sector-specific time variation in the panel when other controls are added. Adding controls reduces the number of years available to only five. One future area for research would be to create longer time series for trade variables, which are only available for a more limited time period due to changes in the way trade is classified.

The results in Table 8 suggest that there is no robust relationship between the magnitude of expenditures on pollution abatement and the volume of US investment which goes abroad. In addition, the point estimates suggest that any impact of abatement costs on the distribution of DFI is very small, if not zero. These results are not surprising in light of the fact that pollution abatement expenditures are only a tiny fraction of overall costs. In 1988, for example, the industry with the highest expenditures on pollution abatement (as a share of value-added) was the cement industry. Yet even in the cement industry, pollution abatement costs accounted for only 3.2 percent of value-added. This evidence appears to confirm the conclusions reached by earlier studies such as Walter (1982), who argued that other factors (such as market size or political risk) were simply more important in determining industrial relocation.

VI. Concluding Remarks

This paper presents new evidence on whether multinationals are flocking to developing country "pollution havens" to take advantage of lax environmental standards. We begin by examining the pattern of foreign investment in four developing countries: Mexico, Venezuela, Morocco and Cote d'Ivoire. This approach allows us to control for country-specific factors which could affect the pattern of foreign investment. We find no evidence that foreign investment in these developing countries is related to abatement costs in industrialized countries. Furthermore, we find almost no evidence that foreign investors are concentrated in "dirty" sectors. The only exception is Morocco, where the tendency is caused by one observation: the heavy concentration of foreign investment in the cement industry.

We proceed to test whether, within industries, there is any tendency for foreign firms to pollute less or more than their peers. Our proxy for pollution intensity is the use of energy and 'dirty fuels', and we find that foreign plants are significantly more energy efficient and use cleaner types of energy.

We then turn to an analysis of the 'originating country' by examining the pattern of outbound US investment between 1982 and 1994. We reject the possibility that the pattern of US foreign investment is skewed towards industries with high costs of pollution abatement.

Our theoretical model indicates that the pollution haven hypothesis is unambiguous only in a very simplistic model of the multinational firm. In a more realistic model the effect of regulation on foreign investment could be either positive or negative, depending on complementarities between abatement and capital. For example, if abatement costs fall with the scale of output, then the home country firm may find it more advantageous to expand locally when facing tougher environmental regulations. Thus, our finding of no significant correlation between environmental regulation in industrialized countries and foreign investment in developing countries need not reflect that relocation due to environmental regulation is 'too small' to be noticed in the data set. The relationship between investment and regulation is not as simple as assumed in a naive model. It depends on a number of factors, the combined effects of which may be positive, zero or negative.

In a variety of empirical tests, we have found almost no evidence of pollution havens. Instead, we find that foreign firms are less polluting than their peers in developing countries. This does not in any way mean that 'pollution havens' cannot exist, or that we should cease to worry about pollution in developing countries. Our research does lend some support to the view traditional in public finance, however, that in both industrial and less developed countries, policy makers can pursue pollution control policy focusing on pollution itself, rather than on investment or particular investors.

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Table 1: Panel Regressions for DFI and Pollution Abatement Costs

	Cote d'Ivoire		Morocco		Venezuela		Mexico	Pooled Sample[1]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Herfindahl Index (Hindex)	-0.65 (0.4)	-0.03 (0.0)	-7.81 (2.3)	-3.32 (0.8)	-11.75 (2.8)	-8.25 (1.8)	-4.71 (0.6)	-3.22 (2.0)	-2.87 (1.7)
Import Penetration (MPEN)	0.41 (0.5)	0.16 (0.1)	-2.95 (3.6)	-2.84 (2.5)	0.91 (0.9)	-3.17 (2.1)	0.63 (0.3)	-0.85 (1.7)	-1.36 (2.0)
Hindex*MPEN	-0.98 (.4)	-1.22 (0.4)	-2.20 (0.2)	-7.50 (0.4)	10.3 (1.7)	3.76 (0.6)	-7.86 (0.3)	2.11 (0.8)	2.06 (0.8)
Regulatory Barries Against DFI	--	--	-0.55 (1.2)	0.45 (0.7)	2.03 (2.0)	2.09 (1.3)	1.1 (1.2)	-0.54 (1.4)	-0.25 (0.6)
Labor/Capital Ratio	-0.03 (1.4)	-0.04 (1.4)	0.00 (0.0)	0.06 (0.3)	-0.84 (1.6)	0.29 (0.4)	1.80 (0.6)	-0.07 (1.7)	-0.05 (1.1)
Market Size	77.07 (16.6)	70.73 (15.0)	9.61 (0.9)	16.27 (1.5)	70.35 (4.6)	73.20 (4.7)	47.44 (3.2)	59.38 (11.1)	60.58 (10.9)
Source Wage	-0.02 (.7)	-0.02 (.1)	-0.16 (2.0)	0.26 (1.6)	-0.02 (0.5)	0.01 (0.03)	0.32 (0.2)	-0.04 (1.4)	-0.06 (1.4)
Pollution Abatement Costs	7.24 (1.5)	8.95 (0.3)	5.04 (0.3)	-5.20 (0.1)	-18.53 (1.3)	-29.76 (0.3)	23.27 (1.2)	-1.04 (0.2)	-3.04 (0.1)
Year and Industry Dummies	No	Yes	No	Yes	No	Yes	No	No	Yes
N	210	210	145	145	203	203	44	558	558
Adjusted R-Square	.76	.79	.15	.18	.22	.35	.33	.29	.31

Note: T-statistics given in parenthesis. Dependent variable is the share of aggregate foreign investment in a given year assigned to each individual industry.

[1] Includes country dummy variables.

Table 2: Correlations Between Pollution Emission Intensities and Abatement Costs

	Suspended Particles (SUSSPART)	Biological Oxygen Demand (BOD)	Total Toxic Releases (TOX)
BOD	-0.08		
TOX	0.03	-0.10	
Pollution Abatement Costs	0.12	-0.13*	0.80*

Note: A "*" indicates statistical significance at the 5 percent level.

Table 3: Cross-Section Time-Series Regressions for DFI with Alternative Measures of Pollution Emissions (Coefficients on Emissions Only)

	Cote D'Ivoire		Morocco		Venezuela		Mexico	Pooled Sample	
SUSSPART	0.060 (1.5)	-7.814 (-1.8)	0.158 (4.6)	0.366 (0.5)	0.014 (0.5)	0.841 (0.8)	0.015 (0.3)	0.085 (2.6)	0.364 (1.0)
BOD	-0.002 (-2.2)	0.019 (0.2)	0.001 (0.6)	-0.002 (0.5)	-0.003 (-1.6)	-0.001 (0.3)	-0.004 (-1.0)	-0.002 (-2.5)	-0.001 (0.5)
TOX	0.009 (1.1)	0.016 (0.5)	-0.028 (-1.4)	-0.019 (-0.4)	-0.028 (-1.4)	0.008 (0.2)	0.025 (0.6)	-0.013 (-1.8)	0.004 (0.3)
Year and Industry Dummy	No	Yes	No	Yes	No	Yes	No	No	Yes

Notes: T-statistics in parenthesis. Dependent variable is the share of foreign investment in a particular ISIC category. See Table 2 for full specification. The specification above reproduces the specification in Table 2, but replaces pollution abatement costs with three different measures of pollution emissions.

Table 4: The Relationship Between Energy Intensity and Pollution Emissions Across Industries: Rank Correlation Coefficients

	Particulates	BOD	TOXLB	TOXUB	Unskilled Labor	Skilled Labor	Capital	Manufaactured Inputs	Raw Material Inputs	Energy
Particulates	1.00									
BOD	0.29*	1.00								
TOXLB	0.27*	0.17*	1.00							
TOXUB	0.30*	0.19*	0.73*	1.00						
Unskilled Labor	-0.15*	-0.16*	-0.16*	0.10*	1.00					
Skilled Labor	-0.25*	-0.35*	0.01	0.05	0.36*	1.00				
Capital	0.28*	0.09	0.36*	0.38*	0.01	0.48*	1.00			
Manufactured Inputs	-0.19*	-0.13*	-0.00	0.06	-0.01	-0.20*	-0.33*	1.00		
Raw Material Inputs	0.44*	0.34*	0.26*	0.17*	-0.33*	-0.42*	0.06	-0.24*	1.00	
Energy	0.58*	0.22*	0.55*	0.52*	0.04	0.04	0.62*	-0.19*	0.34*	1.00

A "*" indicates statistical significance at the 5 percent level.

Table 5: Relationship Between Energy Intensity and Pollution Emissions Across Industries: Regression Coefficients

	Dependent Variable:			
	Particulates	BOD	TOXLB	TOXUB
Energy	1.80* (.26)	0.04 (.79)	1.72* (.37)	2.27* (.77)
Labor	-0.05 (.09)	-0.04 (.05)	-0.27 (.12)	-0.06 (.25)
Capital	-0.23 (.72)	-0.64 (.40)	3.49* (.95)	4.85* (1.98)
Manufactured Inputs	6.69 (6.46)	-5.36 (3.77)	6.06 (8.61)	32.55 (17.98)
Raw Material Inputs	3.16 (7.74)	-5.91 (4.36)	28.43* (10.79)	56.23* (22.55)
N	318	266	459	459
R-Square	.22	.02	.24	.10

Standard errors in ( ). A "*" indicates statistical significance at the 5 percent level.

Table 6: Energy Intensity as a Determinant of Emission Intensity at the Plant Level, US Data

	All Plants (1)	All Plants (2)	Lumber and Wood Products (Except Furniture) (3)	Chemicals and Allied Products (4)	Petroleum Refining and Related Products (5)	Non-Electrical Machinery (6)
Energy Intensity	1880 (29.4)	1859 (29.0)	774 (3.1)	2195 (33.8)	1349 (3.0)	3626 (2.0)
Material Inputs	72 (2.5)	--	-2 (-0.0)	112 (1.2)	-72 (1.0)	45 (0.3)
SIC Dummies	Yes	Yes	No	No	No	No
N	892	893	25	110	67	43
R-Square	.50	.50	.30	.91	.17	.09

Notes: T-statistics in parenthesis. All observations are by firm, for one year only. Columns (1) and (2) include all firms in 17 industries. Columns (3) through (6) are the four industries among 17 SIC industries for which a specification with energy and materials as independent variables yields a significant coefficient for energy.

Table 7: Determinants of Energy Intensity in Selected Manufacturing Sectors: Cote d'Ivoire, Mexico, and Venezuela

	Côte d'Ivoire	Mexico		Venezuela		
	(1)	(1)	(2)	(1)	(2)	(3)
Foreign Ownership	-0.0110*	-0.0033*	0.0496**	-0.0098*	0.2366*	0.0527*
	(.0039)	(.0005)	(.0096)	(.0015)	(0.0622)	(.0148)
Public Ownership	0.0019	-	-	-	-	-
	(.0128)					
Plant Size ('000 of Employees)	-0.0072*	-0.0001	0.0090	-0.0008	0.1721*	-0.1268*
	(.0029)	(.0003)	(.0055)	(.0013)		(.0476)
Capital Intensity	0.0167*	0.0026*	0.0288*	0.0127*	0.0056	0.0527*
	(.0030)	(.0002)	(.0040)	(.0002)	(.0080)	(.0129)
Age	0.0002*	-	-	0.00002*	0.0009	-0.0102*
	(.0001)			(.00001)	(.0010)	(.0023)
Machinery Imports	-	-0.0003	0.0014	-	-	-
		(.0003)	(.006)			
R and D Intensity	-	-0.0090	0.2606	0.3716*	-0.6099	-.0638
		(.0102)	(.1864)	(.0143)	(.6997)	(.1461)
Electricity Price	-	-0.0002*	-0.0008	0.0004*	-	0.0013*
		(.0000)	(.0007)	(.0000)		(.0004)
R-Square	0.24	0.14	0.14	0.18	.15	0.11
N	918	5,015	4,998	23,749	1,462	23,116

Notes:
In column (1), dependent variable is energy share in output
In column (2), the dependent variable is the electricity share in the plant's total energy use
In column (3), the dependent variable is the share of natural gas in total energy use
All models include sector dummy variables (4-digit SIC).
Standard errors are given in parentheses. A * indicates statistical significance at the 5 percent level.

Table 8: The distribution of US Outbound Foreign Investment and Pollution Abatement Costs

	Distribution of Foreign Investment (FLOW)			Distribution of Foreign Investment (STOCK)		
	(1)	(2)	(3)	(4)	(5)	(6)
Pollution Abatement Costs	0.224 (2.3)	0.170 (1.3)	0.423 (0.5)	0.450 (4.5)	0.368 (3.5)	0.029 (0.3)
Human Capital Share in Value-Added (Lag)	-	-0.060 (-0.7)	0.163 (.3)	-	-0.166 (-2.6)	-0.010 (-0.2)
Physical Capital Share in Value-Added (Lag)	-	0.057 (1.9)	0.400 (1.7)	-	-0.002 (-0.1)	0.024 (1.0)
Export Share (Lag)	-	-0.085 (2.5)	-0.628 (2.6)	-	0.048 (1.8)	0.013 (0.5)
RNDSHARE (Lag)	-	.436 (3.6)	0.631 (0.5)	-	0.498 (5.3)	0.247 (2.0)
SCALE (Number of employees per plant)		-0.003 (-0.1)	0.335 (1.5)		0.007 (0.3)	0.026 (1.2)
Year and SIC Dummies	No	No	Yes	No	No	Yes
N	392	154	154	197	149	149
R-Square	.01	.18	.20	.09	.30	.99

Notes: T-statistics in parenthesis.

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