U.S. Environmental Regulation and FDI: Evidence from a Panel of U.S. Based Multinational Firms

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Abstract

This paper measures the response of U.S. based multinational firms to the Clean Air Act Amendments (CAAA), which dramatically strengthened U.S. environmental regulation. Using a panel of firm-level data over the period 1966-1999, I estimate the effect of regulation on a multinational's foreign production decisions. The CAAA induced substantial variation in the degree of regulation faced by firms, allowing for the estimation of econometric models that control for firm-specific characteristics and industrial trends. I find that the CAAA caused regulated multinational firms to increase their foreign assets by 5.3% and their foreign output by 9%. In aggregate, this increase represents approximately 0.6% of the stock of multinationals' domestic assets in polluting industries. Contrary to common beliefs, I find that heavily regulated firms did not disproportionately increase foreign investment in developing countries. Finally, this paper presents limited evidence that U.S. based multinationals increased imports of highly polluting goods when faced with tougher U.S. environmental regulation. Overall, these results are consistent with the view that U.S. environmental regulations cause U.S. firms to move capital and jobs abroad.

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1 Introduction

Do tougher environmental regulations cause firms to flee the country? Although several studies document the impact of environmental regulation on domestic production,[1] the question of whether firms increase foreign manufacturing in response to new domestic regulation has remained unanswered. Consequently, our understanding of the efficacy of environmental policy is limited, as is our understanding of the distributional impacts of "local" environmental policies. In an attempt to offer evidence on this question, this paper uses firm-level data and a differences-in-differences strategy to test whether firms increase manufacturing abroad in response to tougher environmental regulations at home, with a particular focus on whether firms shift manufacturing to developing countries, which typically have weaker environmental laws.

U.S. environmental regulations are often met with the claim that, by making domestic production more costly, they force firms to shift manufacturing abroad. Firms can shift production through two possible mechanisms. First, a firm may contract production to foreign manufacturing firms (outsourcing). Second, a firm may invest in foreign manufacturing facilities, and directly produce goods overseas (foreign direct investment, or FDI). While understanding both mechanisms is necessary to evaluate the effects of local environmental regulation, the lack of data and the inherent difficulty of measuring a firm's exposure to regulation have previously hindered rigorous statistical analysis of either mechanism.

This paper compiles detailed firm-level regulation data to investigate the link between regulation and a firm's foreign production decisions. Specifically, I test whether the Clean Air Act Amendments (CAAA)—legislation that dramatically strengthened environmental regulation in the United States—resulted in increased foreign direct investment (FDI) by U.S. based multinational firms. In addition, I evaluate claims that the regulations spurred firms to disproportionately increase manufacturing in developing countries, which would have important distributional effects.

I find evidence that the CAAA legislation increased the outbound FDI of U.S. based multinational firms in dirty industries. In particular, the analysis in this paper suggests that the CAAA regulations caused multinationals to increase their foreign assets in polluting industries by 5.3% and their foreign output by 9%. Contrary to popular beliefs, heavily regulated firms did not disproportionately increase production in developing nations relative to other countries. Finally, there is limited evidence that heavily regulated U.S. multinationals increased imports

[1] See Gray and Shadbegian, 1995; Jaffe, et al., 1995; Levinson, 1996; Becker and Henderson, 2001; Greenstone, 2002

from their foreign affiliates in response to regulation, and there is robust evidence that firms reacted more strongly to regulation if they manufactured within an industry for which imports have historically accounted for a large percentage of U.S. consumption. Taken together, these results are consistent with the theory that regulation causes a firm to substitute foreign for domestic production.

This paper contributes to the literature on the relationship between environmental regulation and FDI. Previous studies have mostly focused on the impact of a receiving country's (or state's) environmental stringency on inward FDI (Xing and Kolstad, 1998; Smarzynska and Wei, 2001; Mani, Huq, and Pargal, 1996; Levinson and Keller, 2002; Raspiller and Riedinger, 2004; Dean, Lovely, and Wang, 2004). Eskeland and Harrison (1997) is a notable departure from the literature: their paper tests whether the pattern of outbound U.S. investment during the 1980s and early 1990s can be explained by variations in pollution abatement costs across different sectors of the U.S. economy. Both approaches have yielded mixed conclusions, and, for the most part, have failed to uncover robust evidence of industrial relocation in response to environmental regulation.[2]

However, this lack of evidence may be attributed to two factors. First, it is difficult to measure environmental stringency across regions: in general, only broad measures of environmental stringency across host countries or states (participation in treaties, abatement costs) are available, and these are often correlated with other factors important in attracting FDI. Second, most environmental regulations apply to all manufacturing firms in a country or all firms in a particular industry, and therefore, it is quite difficult to find a control group against which to evaluate the effects of new regulations. Previous studies have typically tested whether the effect of environmental stringency differs across industries of varying pollution intensity, under the hypothesis that the regulation effect on FDI is concentrated in polluting industries. However, there have been concerns in the literature (Jaffe, 1995; Smarzynska and Wei, 2001) that this strategy may potentially confound industry specific trends in FDI (such as oil shocks, recessions) with regulation.

This paper aims to overcome these limitations and establishes whether a causal relationship exists between environmental regulation and FDI. Following Eskeland and Harrison (1997), I analyze whether tougher environmental regulation at home increases outbound FDI. Rather than using industry-level measures of environmental stringency, this study exploits the plau-

[2]In fact, Mani, Huq, and Pargal (1996) and Dean, Lovely, and Wang (2004) find that foreign investors tend to invest in areas with high environmental stringency.

sibly exogenous variation in firm-level regulation created by the Clean Air Act Amendments (CAAA). Following their passage in 1970, the Environmental Protection Agency established separate national ambient air quality standards—a minimum level of quality that all U.S. counties are required to meet—for four criteria pollutants. Each year, counties whose air concentrations exceed federal standards for a specific pollutant receive a **nonattainment** designation for that pollutant, while counties that are in attainment of federal standards receive an **attainment** designation. Manufacturing plants that emit a criteria pollutant in a county designated nonattainment are subject to relatively tougher regulatory oversight than emitting plants in attainment counties.

The nature of the CAAA regulatory program allows for a modified differences-in-differences approach to test whether firms were more likely to expand their overseas manufacturing operations when the U.S. counties in which they operate fell into nonattainment and were, thereby, subject to tougher environmental oversight. In contrast to the previous literature, this approach allows for the estimation of regulation effects that are purged of bias associated with industry specific trends. This is particularly important because, during this period, there were many factors (e.g. oil shocks, country liberalizations, technology changes) that may have had differential impacts on industry-level FDI. In addition, because the CAAA induced substantial variation in the level of regulation faced by an individual firm across time, I can compute the effect of regulation that is independent of firm specific characteristics (e.g. production process, firm size) that may also potentially affect FDI. As a result, this paper overcomes objections in the literature (for example, Zarsky, 1999) that earlier studies on the impact of environmental regulation ignored firm specific effects.

To implement this strategy, I take advantage of a confidential, firm-level dataset collected by the Bureau of Economic Analysis (BEA), of the U.S. Department of Commerce, on the activities of U.S. based multinational firms. The data provide detailed information on the financial and operating characteristics of U.S. firms manufacturing abroad between the years 1966 to 1999. I augment this dataset with annual data on the four pollutant-specific, attainment/nonattainment designations for each U.S. County and with detailed data on the U.S. operations of each multinational firm.

The paper proceeds as follows. Section 2 discusses the Clean Air Act Amendments and the conceptual framework. Section 3 describes the empirical strategy and data. Section 4 presents the estimation results, while Section 5 provides a discussion of the results. Section 6 concludes.

2 The Environment and Foreign Direct Investment

2.1 The Clean Air Act Amendments

This study uses the variation in firm level regulation induced by the Clean Air Act Amendments (CAAA) to determine whether firms expand their foreign manufacturing operations in response to domestic environmental regulation. Initially passed in 1970, the CAAA stipulated that the Environmental Protection Agency (EPA) classify U.S. counties into pollutant-specific nonattainment and attainment categories, based on the ambient concentrations of four relevant pollutants: carbon monoxide (CO), tropospheric ozone (O_3), sulfur dioxide (SO_2), and total suspended particulates (TSP).[3] Each July, the classifications are reevaluated, and every U.S. County is officially reclassified as being either in or out of attainment of the national standards for each of the criteria pollutants.

Relative to attainment counties, strict regulatory oversight is exerted on polluting manufacturers in nonattainment counties. When a county falls into nonattainment, the law requires its state to develop a State Implementation Plan (SIP), which lays out specific regulations for every major source of each pollutant for which the county is in nonattainment. The plans impose substantial regulations on both new and existing manufacturing facilities. In general, the SIPs stipulate that new investments or plant renovations must be paired with the installation of state-of-the art pollution abatement equipment. Existing plants are subject to "reasonably available control technologies," which usually involves retrofitting existing equipment. States may also dictate changes in an industry's production process, such as forcing existing printers in nonattainment counties to substitute highly polluting inks with more expensive, cleaner versions. Furthermore, the regulations make it more costly for an existing plant to modify its operations, as they require that the entire plant comply with current standards for new sources. In contrast, large-scale investments in attainment counties require relatively cheaper abatement equipment, and existing plants are essentially unregulated.[4] Non-polluters are free from regulation in both categories of counties.

In nonattainment counties, the regulations are vigorously enforced by both federal and state agencies, and violating manufacturers may face extensive "civil penalty plus recovery of any economic benefit of non-compliance" and orders requiring the "correction of the violation."[5]

[3] I classify a county as nonattainment for ozone if it is in nonattainment for Nitrogen Oxide or Volatile Organic Compounds.

[4] New and modified sources in attainment counties that emit large quantities of the criteria pollutant are subject to the "best available control technologies." However, this is negotiable for individual cases and, unlike the nonattainment counties, this is sensitive to economic burdens.

[5] EPA Compliance Website

Although individual states have some leeway to create and implement the SIP, the EPA enjoys substantial oversight of each state's enforcement activities. In particular, the EPA may withhold federal highway funding, impose a federal moratorium on new plant construction, and seize control over the state's environmental policy if it deems that a state is delinquent in its responsibilities.

Enforcement efforts appear to have had "bite." The CAAA substantially affected U.S. industrial activity. Cohen (1998) documents the effectiveness of the regulations at the plant level. A series of papers (for example, Kahn, 1997; Greenstone, 2002) show that the regulations retarded the growth of polluting manufacturers in nonattainment counties. Moreover, Becker and Henderson (2000) provide evidence that, controlling for socioeconomic conditions across counties, firms were more likely to choose an attainment county for a new plant.[6]

Further evidence of the bite of the regulation can be found in firm reactions: in 1997, the business community attempted (unsuccessfully) to lobby against the EPA's plans to alter ozone standards, which would have effectively doubled the number of counties in nonattainment for ozone.[7] Lastly, perhaps the most compelling piece of evidence that the regulations are successfully enforced is the fact that air pollution concentrations declined at a relatively faster rate in nonattainment counties subsequent to the regulations (Henderson, 1996; Chay and Greenstone, 2003).

2.2 Sources of Policy Variation

The particular structure of the CAAA regulatory program enables a compelling identification strategy with which to determine the effect of tougher environmental regulation on a firm's foreign production decisions.

Most importantly, the regulations only apply to manufacturing facilities operating within nonattainment counties, inducing variation in the level of regulation across firms. This allows me to compare the effect of regulation across firms within the same industry, and thus remove shocks (oil shocks, new technologies, recessions) common to a particular industry that may potentially be correlated with regulation.

Second, the policy was designed to ensure that all counties that achieve nonattainment status are similarly regulated. The CAAA emission standards are federally mandated and, thus,

[6] Several papers found results contrary to Becker and Henderson (2000). For example, Schwab and McConnell (1990) concluded that a county's nonattainment designation did not deter new plants in the motor vehicle industry. Their estimation strategy, though, did not account for the fact that counties are often in nonattainment because polluting plants have historically viewed them as productive, cost-effective places to locate.

[7] "Supreme Court Roundup: Justices Broaden their look at the Clean Air Act." New York Times, 2001.

consistently applied throughout the country. Although individual states formulate separate enforcement policies, the EPA has sufficient mechanisms to ensure that each state similarly regulates polluting manufacturers. As a result, this eliminates the possibility that differences in tastes or other characteristics across counties are potentially correlated with firm production choices, thus biasing the estimated regulation effects.

Another possible concern is that nonattainment and attainment counties may have different underlying socioeconomic conditions (such as population density, unionization rates), which may cause a spurious correlation between the probability that a county earns a nonattainment designation (high pollution) and the FDI of firms operating within these counties. However, because non-emitting plants are not subject to CAAA regulation in either type of county, I can isolate changes in the FDI outcomes of non-emitting firms across U.S. counties to remove the effect of manufacturing in a nonattainment county that is independent of regulation. In addition, because a county's designation varies over time, I can control for differences between counties over time, ensuring that time varying factors common to nonattainment counties (wage growth, population growth) are not confounded with the effects of regulation.

Finally, the designation of nonattainment status is reevaluated annually. A firm that is subject to varying levels of regulation at different points in time can be followed, thereby allowing the paper to include estimates that are derived from within a firm. This methodology ensures that firm specific factors (firm size, production technologies) do not drive the results.

2.3 Conceptual Framework

The results presented in this paper provide a good measure of the effect of the CAAA regulatory program on U.S. outbound FDI, as the program is currently written. However, the results may underestimate the overall effect of environmental regulation, and this should be taken into account when generalizing them to other settings.

The identification strategy relies on the comparison of firms across U.S. counties with varying regulation levels. Regulation increases the expected costs of production, and if these costs become prohibitively high, a firm might relocate. In this case, a firm has two options: move to another (less regulated) U.S. county or move abroad. Quite simply, if the expected profits of foreign production exceed the profits of producing within another U.S. county, the firm will move abroad; otherwise the firm will relocate within the United States.

The estimated regulation effect, therefore, measures the actual change in FDI that results from the CAAA regulation. However, some firms residing in high regulation counties will shift production to low regulation counties rather than moving abroad (and some firms in low regulation counties will shift production abroad in response to regulation). Therefore, this strategy provides a lower bound of the effect of regulation had it been equally implemented across the United States. The extent to which this lower bound underestimates the overall effect depends on the magnitude of firms that switched to another U.S. county.

There are numerous reasons why the expected costs of foreign production may be greater than the costs of producing in another county, and each reason has different implications for the interpretation of the estimated regulation effect. For example, consider a world with adjustment costs, where firms cannot instantaneously react to regulation. A firm may be unwilling to pay the costs of relocating to another U.S. county that, though unregulated today, has a nonzero probability of future regulation. In this case, the bias of the regulation effect would be smaller than the case where it is costless for a firm to shift between U.S. counties.

Finally, consider the most extreme scenario: it is possible that the expected costs of U.S. regulation are sufficiently high that all U.S. firms would prefer shifting production abroad. However, in the short run, only firms for whom the expected compliance costs exceed the adjustment costs will relocate. Firms would never shift production to another U.S. county. Thus, the empirical strategy would provide an unbiased estimate of the short-run effect of environmental regulation (in the long run, regulation would force all firms abroad).

In summary, this paper measures the actual outsourcing effects of U.S. environmental policy during the last 40 years. Furthermore, the estimated results can be viewed as a lower bound on the overall effect of environmental regulation on firm behavior, helping us to better understand the welfare consequences of country-level environmental policies.

3 Empirical Strategy

In this section, I first describe the regression framework. Next, I discuss the construction of the CAAA regulation variable. I conclude with a detailed description of the data.

3.1 Regression Framework

This paper employs a modified differences-in-differences approach to determine the effect of CAAA regulation on the foreign manufacturing operations of U.S. based multinationals. In particular, I test whether firms were more likely to increase foreign production within an industry if a large share of their U.S. manufacturing facilities (in that industry) were regulated.

Multinational firms regularly operate in multiple industries, making it difficult to classify a firm as belonging only to a "dirty" or "clean" industry. To address this issue, I disaggregate both the regulation data and foreign investment data to the level of a firm (indexed by f) by industry segment (indexed by i). The panel structure of the data allows me to follow these segments across years (indexed by t). In a given year, an individual firm may have up to 45 industrial segments. The baseline empirical specification is as follows:

$$Y_{fit} = \beta_0 + \beta_1 Ind_{fi(t-k)} + \beta_2 Non_{fi(t-k)} + \beta_3 Reg_{fi(t-k)} + \alpha_{fi} + \delta_{ft} + \eta_{it} + \varepsilon_{fit} \tag{1}$$

where (t-k) indexes the most recent year for which FDI data was available. Y_{fit} is a measure of a firm's direct foreign production within an industrial segment (including capital stock, output, and sales). ε_{fit} is the stochastic error term.

$Reg_{fi(t-k)}$ is a lagged measure of a firm-industry's exposure to CAAA regulation, for any pollutant. Specifically, it is the lagged percentage of a firm's U.S. plants that were effectively regulated under the CAAA within an industrial segment, where an individual manufacturing plant is considered "regulated" if the U.S. plant is in a dirty industry and located in a nonattainment county. The construction of $Reg_{fi(t-k)}$ is discussed in detail in Section 3.2.

$Ind_{fi(t-k)}$ is a vector of "industries at home" dummy variables that indicate whether a firm manufactured within a domestic industry in a given year, and whose effects are time varying to capture shocks common to firms manufacturing in a particular U.S. industry. These variables remove the main effect of manufacturing in a domestic industry.

$Non_{fi(t-k)}$ is a vector of variables that give the proportion of a firm's U.S. manufacturing facilities, in an industrial segment, that are located in a nonattainment county, by year.[8] $Non_{fi(t-k)}$ parametrically controls for the main effect of manufacturing in a nonattainment county. This is especially important because operating within a nonattainment county may affect FDI independently of regulation if counties in nonattainment systematically differ than those in attainment (for example, counties that are in nonattainment differ from those in attainment in observable characteristics such as rates of unionization and average education level).[9]

[8] $Non_{fi(t-k)}$ is defined as $\frac{1}{N_{fi(t-k)}} * \left(\sum_{p=1}^{N_{fi(t-k)}} \Phi \left(\sum_{z} (Nonattain_{pc(t-k)z}) > 0 \right) \right) * 100$

[9] It is important to note that $Non_{fi(t-k)}$ constrains the main effect of manufacturing in a nonattainment county to be identical across counties. I would ideally relax this restriction and include a vector of time varying, county fixed effects. However, given the number of observations, I cannot control for the ensuing 18,000 county-year fixed effects. Nonetheless, since the emission standards (and policy implementation) are the same for each nonattainment county, the main threat to the estimation strategy comes from differences in trends between firms manufacturing in nonattainment and attainment counties, not between particular counties. Consequently, this restriction should not significantly alter the results.

The panel structure of the data allows for additional controls that purge the regulation effect of bias associated with industry and firm specific trends, which may be potentially correlated with regulation. Specifically, I include firm by industry (α_{fi}), industry by year (η_{it}) and firm by time (δ_{ft}) fixed effects. The inclusion of industry by year fixed effects (η_{it}) removes shocks to FDI that are common to all firms investing abroad within an industry in a particular year. Including industries by year fixed effects is especially important if certain industries increased FDI during this period for reasons unrelated to environmental regulation (e.g. the U.S. automobile industry significantly shifted production to Mexico after NAFTA).

Firm by year fixed effects (δ_{ft}) remove the mean FDI across all of a firm's industrial segments in a particular year. This controls for unobserved factors that equally affect FDI across a firm's polluting and nonpolluting segments (e.g. a change in a firm's credit ratings or senior management).

Finally, firm by industry fixed effects (α_{fi}) absorb the unobserved heterogeneity in the determinants to FDI that are common to a particular industry within a given firm. In effect, this allows a firm-industry that is unregulated in one period to act as a comparison group for itself when regulated in other periods. These controls are important if we believe that a firm-industry's exposure to regulation is potentially correlated with factors inherent to a firm-industry (such as technology or size).

The parameter of interest, β_3, measures the effect of belonging to a domestic, polluting industry and the degree to which a firm-industry operates in nonattainment counties on a firm's FDI. In the simplest case, where each firm manufactures in only one industry and one county in the United States, this specification would reduce to a simple differences-in-differences model, where Reg_{fit} is a dummy variable indicating whether the firm-industry was regulated and β_3 captures the variation in foreign production specific to firms in domestic, polluting industries (relative to non-polluters) in nonattainment counties (relative to attainment ones). However, in any given year, a firm may operate in multiple U.S. Counties (the average multinational in the sample manufactures in 6 U.S. Counties per year). Rather than simply indicating whether the firm-industry is regulated, the regulation variable measures the percentage of a firm-industry's U.S. operations that are regulated, thereby allowing the model to fully exploit differences in a firm-industry's exposure to regulation.

In summary, the estimated regulation effects are purged of many likely sources of bias associated with transitory shocks to an industry, inherent firm by industry characteristics, and transitory shocks to a firm. However, the estimated regulation effects are not robust to transitory determinants of FDI specific to firms in dirty industries that are primarily located in nonattainment counties. In other words, the results are subject to bias if we believe that the main effect of manufacturing in a nonattainment county differs for firms in clean and dirty industries.

3.2 Measuring Environmental Regulation

This section details the construction of the firm by industry regulation variable, Reg_{fit}, and how the assumptions underlying its construction affect the interpretation of the empirical results.

I compute Reg_{fit} as the percentage of a firm's U.S. plants, within each industrial segment, that were effectively regulated for any pollutant under the CAAA. For each of the four criteria pollutants, I divide industries into two categories: emitting and non-emitting. I follow Greenstone (2002) and define an industry as pollutant-emitting if the industry contributed 7% or more to total industrial emissions of the pollutant (Table 1). Using this rule, U.S. plants manufacturing in emitting industries collectively account for between 72 and 91% of the total U.S. industrial emissions of each criteria pollutant.

I define an individual plant p as regulated for pollutant z if it belongs to an industry i that emits z (Ind_{piz}=1), and it is located in a county c that is in nonattainment for pollutant z at given time t ($Nonattain_{pctz}$=1):

$$Ind_{piz} * Nonattain_{pctz} = 1$$

where z belongs to the set of criteria pollutants {CO, O_3, SO_2, TSP}. Accordingly, I define a plant as regulated for any pollutant if the following condition is satisfied:

$$(\sum_z Ind_{piz} * Nonattain_{pctz}) > 0$$

For each firm "f" by industry "i" by year "t," I sum the number of regulated U.S. plants and divide this by the number of a firm's U.S. plants in that industry (N_{fit}). This gives the percentage of a firm's U.S. plants that were regulated within *each* of its industrial segments:

$$Reg_{fit} = \frac{1}{N_{fit}} * \left(\sum_{p=1}^{N_{fit}} \Phi \left(\sum_z (Ind_{piz} * Nonattain_{pctz}) > 0 \right) \right) * 100$$

where $\Phi()$ is an indicator function which takes the value of 1 if the U.S. plant faces regulation for at least one pollutant.[10]

[10] A simple example of how the regulations are calculated is provided in an Appendix.

The remainder of this section highlights several core assumptions implicit in the construction of Reg_{fit}. First, Reg_{fit} restricts the effect of regulation in non-emitting industries to be zero. As a result, the estimated regulation effect heavily relies on the cutoff used to divide industries into the emitting and non-emitting categories. The sensitivity of the result to the 7% cutoff is explored in Section 4.7.

Second, the regulation variable assumes that all manufacturing plants within an emitting industry actually emit that pollutant and may, therefore, be affected by regulation (and, similarly, that all manufacturing plants in non-emitting industries do not emit and are unregulated). For the most part, plant-level emissions data are unavailable, hindering the classification of *individual* plants as emitters or non-emitters.[11] However, even if these data were available, it is unclear whether plant-level emissions data would provide a better estimate of an individual plant's exposure to regulation. Plants in nonattainment counties are required to reduce emissions. A plant that has reduced emissions in response to regulation may be incorrectly labeled as a non-emitter, and thus wrongly classified as unregulated.

Third, because I count each plant only once in Reg_{fit}, I implicitly assume that the average costs of regulation are identical for each plant, regardless of the number of pollutants for which the plant faces regulation. Furthermore, each pollutant is weighted equally in Reg_{fit}. Thus, I assume that the average compliance costs of regulation are identical for each pollutant. Section 4.5 relaxes both these assumptions by allowing each of the four regulatory programs to impact foreign production separately.

Finally, I assume that each plant affects a firm's foreign investment decisions regardless of individual characteristics of the plant (plant size, age of the plant). In Section 4.7, I construct an alternative measure of a firm's exposure to regulation as a function of plant characteristics.

3.3 Data

This paper brings together a variety of data sources to determine the impact of domestic environmental regulations on the foreign manufacturing outcomes of U.S. multinational firms. This section describes the sources and structure of the data.

[11] Starting in 1987, a sample of plant level emissions data became available (Toxic Release Inventory). However, it is not altogether clear how to match this plant-level data to the level of a firm, and this source does not include data on all criteria pollutants.

3.3.1 Regulation Data

The attainment/nonattainment data are taken from the Code of Federal Regulations and the EPA's national pollution monitoring network.[12] All counties are considered to be in "attainment" prior to 1972, because the CAAA were not fully enforced until late 1971. For all years between 1972 and 1977, a county is labeled as nonattainment if it had a pollution monitoring reading that exceeded the relevant federal standard in the appropriate year. Since the EPA has not maintained historical records of the designations prior to 1978, these data provide the closest approximation of nonattainment designation in this period. After 1978, the data are taken directly from the Code of Federal regulations.[13]

Figure 1A plots the number of counties with a nonattainment designation for each pollutant over time; vertical lines indicate years for which investment data (described below) are available. The figure clearly illustrates that the Ozone (O_3) regulatory program was the most pervasive, followed by particulate matter (TSP). The number of nonattainment counties peaked in the late 1970s-early 1980s, due to factors such as the deterioration of air quality in attainment counties and the EPA's increasing awareness of which counties exceeded federal standards. With the exception of small increases in the number of nonattainment counties in the early 1990s, the number of nonattainment counties has steadily declined after 1980.[14]

Figure 1B plots the number of counties that experienced a change in status over the following year. In addition to being the period where regulation was most pervasive, the 1970 to early 1980 period also saw the greatest county-level fluctuations in nonattainment status. For example, prior to 1985, approximately 110 counties experienced a change in ozone designation over the previous year; this number fell to 45 during the subsequent period.

3.3.2 Foreign Direct Investment Data

Foreign manufacturing outcomes are obtained from confidential, affiliate level data collected by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce on the activities of U.S. based multinational firms. A multinational firm is defined as the combination of a single U.S. entity that has made the direct investment, called the U.S. parent, and at least one

[12] Michael Greenstone generously provided these data.

[13] The 1972-1977 estimated data are an underestimate of the scope of the regulations. Many counties lacked pollution monitoring equipment. In this case, a county was labeled as in "attainment." In the robustness section, I explore the sensitivity of the results to the estimated data; as a preview, the results remain unchanged.

[14] Prior to 1979, the ozone standard prohibited the second highest daily maximum concentration from exceeding .08 parts per million. In 1979, the standard dropped to .12, partly explaining the subsequent decline in ozone-nonattainment counties.

foreign business enterprise, called the foreign affiliate. Because the International Investment and Trade in Services Survey Act ensures that the "use of an individual company's data for tax, investigative, or regulatory purposes is prohibited," the BEA believes survey responses are overwhelmingly truthful, and that the coverage of data is unusually complete. Moreover, since the data contain the percentage of each parent's ownership in each affiliate, it is possible to determine ownership stakes in the presence of indirect ownership, providing the most accurate available picture of U.S. investment positions abroad.

The BEA surveys can be linked across years, creating a comprehensive panel on the financial and operating characteristics of U.S. firms manufacturing abroad. Extensive data are available for 1966,[15] 1977, 1982, 1989, 1994, and 1999, when the BEA conducted benchmark surveys.[16] The selection criterion for the survey varied across years, causing the data to be censored. In 1966, all foreign affiliates with sales, assets, or net income in excess of $50000 in absolute value were required to report to the BEA. The cutoff jumped to $0.5 million in 1977, $3 million in 1982-1994, and $7 million in 1999.[17] To rectify this, I imposed a uniform censoring point ($5.591 million 1982 USD) across all years.[18]

I substantially reorganized the survey data in two ways. First, to create measures of a U.S. based multinational's scope of foreign manufacturing within each industrial segment (assets, plant and property expenditures, expenditures to produce goods, etc.), I computed the U.S. parent's ownership stake in each foreign affiliate, and then aggregated the data from the foreign affiliates to the level of the U.S. parent firm, by industry and year.[19] To calculate a firm's foreign capital in each industrial segment, total foreign affiliate assets were multiplied by the percentage of affiliate sales in each industry. While this methodology represented the best approximation of capital use given the data limitations, it is subject to measurement error if the capital to labor ratios vary significantly across industries. In this case, this approach may systematically underestimate the foreign capital dedicated to capital-intensive industries.

Second, the FDI data include a firm-year observation only if the firm had foreign assets, sales

[15] While researchers have extensively used the 1977-1999 data, the affiliate-level 1966 data have not previously been used for academic research. Significant changes were made between the 1966 and 1977 survey, complicating the analysis (parent identification codes changed, industry classification codes were more aggregated, etc).

[16] Starting in 1983, annual surveys were conducted, but since the cutoff for participation was significantly higher than in benchmark years, the annual surveys were not used in the analysis.

[17] The rise in the cutoff is attributed to paperwork reduction laws.

[18] The level of assets falling below the cutoff comprises a minimal percentage (0.38%) of total assets abroad, suggesting that the bottom-coding problem is negligible (estimated from the 1999 FDI data). Nonetheless, missing "middle" years were interpolated to mitigate problems associated with censored data. The percentage of interpolated data is low (less than .5% of the firm-industry-year observations), and the results are robust to the interpolation.

[19] Industrial classifications are based on ISI classifications, giving 45 industries in manufacturing.

or income in that year. An analysis using only these data would fail to capture, for example, a heavily regulated multinational firm that did not produce abroad in a given year, biasing the estimated regulation effects upwards. To remove this potential bias, I completed the panel: for each firm, I obtained the birth and closure dates from a variety of electronic and print sources.[20] If a firm operated in the United States in a given year, but was absent from the survey data, I assigned the firm "zero" FDI for that year. As such, the empirical work presented in this paper captures both channels through which regulation impacts a multinational's foreign production choices. First, the analysis captures whether a firm will move abroad in response to regulation or, in other words, whether a firm will become a multinational. Second, it determines whether a firm that already produces abroad will increase its foreign production activities in response to regulation.

This study does not include firms that never produced abroad between the years of 1966 and 1999. Thus, while the regulation effects derived in this paper provide a good estimate of a multinational's response to regulation, the effects are most likely an overstatement for the entire universe of firms. However, from a policy standpoint, we care most about the multinational response to regulation. Other firms have such high barriers to foreign production that realistic levels of regulation may never cause them to produce abroad.[21]

Figures 2A and 2B graph the foreign assets allocated to manufacturing by U.S. based multinationals overall and excluding high income, OECD countries for the years 1966-1999.[22] The figures split foreign assets by pollution-intensive industries versus clean industries. After 1982, foreign assets in clean industries grew at a relatively faster rate. This is not surprising, as it has been suggested that, due to the nature of their technologies, industries with the largest pollution abatement costs also happen to be the least footloose (Ederington, Levinson and Minier, 2003). The figures illustrate that the trend in FDI for pollution intensive and clean industries differs, implying that an analysis simply comparing the effect of environmental regulations on FDI across industries may suffer from bias associated with these trends.

[20] Firm births and closures were mainly taken from various volumes of Moody's Industrials and firm websites. These data sources were supplemented by Hoover's Company Database, bankruptcy articles, and several additional sources. The 5% of firms who were either missing a birth date, closure date, or both, were assigned to be operating for the duration in which investment data was available.

[21] To obtain data on firms that had never invested abroad during this period, I matched Compustat to the BEA data. However, the match was poor for a variety of reasons. First, the BEA data includes private firms, while Compustat does not. Second, the Compustat data for the 1960s and 1970s was not comprehensive. Third, the level of firm level aggregation differs between the two data sets. The effective match rate between Compustat and the BEA data was about 50%. Due to these data limitations and the differences in observable characteristics between multinationals and other firms, I decided to limit the analysis to multinationals.

[22] I use the World Bank definition for high income, OECD country.

3.3.3 Plant Data

To compute the regulation variable, I use data on the location and the industry of a firm's U.S. manufacturing facilities. I manually matched the firms in the BEA foreign investment data to detailed U.S. manufacturing facility data. The Census Bureau's Census of Manufacturing is the most comprehensive facility level data collected, but it was unavailable for this study. Alternatively, I obtained data from a yearly series of print manufacturing directories entitled "Marketing Economics Key Plants." The directories include 10% of U.S. facilities (about 40,000 facilities per year), which account for approximately 80% of value added in U.S. manufacturing.

The patterns in the "Marketing Economics" sample are quite similar to patterns in other U.S. manufacturing facility data. In Figure 3, I graph the percentage of emitting plants located in a nonattainment county from the Marketing Economics Data and the County Business Patterns, for 1994. Although the County Business Patterns data include many more plants, the two datasets exhibit near identical patterns in industrial composition and in the percentage of emitting plants that reside in nonattainment counties.[23] In addition, though the "Marketing Economics" sample only includes large plants (100 or more employees), it should still provide an accurate picture of the number of a firm's plants that were significantly affected by regulation: Becker and Henderson (2000) provide anecdotal evidence that the inspection and enforcement activities of the CAAA centered on large plants.

For each manufacturing plant in the Marketing Economics directories, I coded the firm name, state code, county code, SIC code and approximate employment. Next, each firm-year observation in the BEA data was manually matched to the U.S. manufacturing facilities that the firm operated at the time of the previous benchmark survey: firms in the 1999 survey were matched to plant data in 1994, firms in the 1994 survey were matched to plant data in 1989, etc.[24] Changes in company names and subsidiaries were tracked using a series of print and electronic sources.[25] Despite the interest in understanding the interaction between manufacturing patterns in the United States and outbound FDI, this is, to my knowledge, the first time the BEA's outbound FDI dataset has been linked to detailed information on the location of the multinationals' manufacturing facilities within the United States.

Firms indicating that their primary SIC code was either banking or services were eliminated

[23] Figure 3 holds for other years as well; for brevity, only information from 1994 is presented.

[24] There are 2 exemptions from this rule: Firms in the 1977 data set were matched to the 1966 plant directory, but if a firm had no plants listed in the 1966 plant directory, the firm was matched to its corresponding 1972 plants—the first effective year of the regulation. Second, the directories began in 1966, and, as a result, firms in 1966 were matched to their 1966 plant data in order to obtain data for county and industry codes.

[25] Hoover's Online Premium Directory, Moody's Industrials, Firm websites, Lexus-Nexus, etc.

from the analysis. Out of the remaining firms, 67% (2235) were matched to at least one manufacturing plant.[26] The final sample was drawn from these 2235 firms.

3.3.4 Descriptive Statistics

Descriptive statistics for the main variables are shown in Table 2. All monetary variables are in thousands of 1982 dollars. The analysis in this paper used 56,385 firm by industry by year observations from 2,235 firms. If a firm never manufactured in an industry at home nor abroad, I exclude the firm-industry from the analysis, causing the number of observations included per firm to vary. However, this exclusion should not significantly alter the results, as the estimated coefficient on regulation ($\text{Reg}_{fi(t-k)}$) is conditional on having operated at least one U.S. plant within an industry in a given year ($\text{Ind}_{fi(t-k)}$).

The first two columns of Table 2 include FDI in all countries, while the second two columns exclude FDI to high income, OECD Nations. Several key patterns emerge from the table. First, the level of multinational activity in high income countries dwarfs the activity in other nations. For example, the average firm-industry's foreign assets excluding high income countries (7612) is less than a quarter of all foreign assets (37118).

Second, a firm-industry that hold assets abroad in a given year is more likely to be regulated in the past (7% of plants regulated) than the overall average (6%). However, because of variation in the regulation variable, I cannot reject that the hypothesis that this difference is zero.

Finally, the Ozone (O_3) program was most pervasive, and, therefore, it follows that the average firm-industry is disproportionately regulated for O_3 (5.35%).

4 Regression Results

I begin by presenting regression results on the effect of firm by industry regulation on foreign assets (Section 4.1) and other selected outcome measures (Section 4.2). Second, I test whether U.S. regulation causes firms to disproportionately move to developing countries (Section 4.3). Third, I determine whether the impact of regulation varies by pollutant (Section 4.4) and whether the impact is larger for certain industries (Section 4.5). Fourth, I aggregate the firm-industry data to the level of the firm in order to determine whether firm-level regulation affects FDI (Section 4.6). I conclude with a series of specification checks (Section 4.7).

[26] The majority of unmatched firms listed their primary SIC codes as nonmanufacturing.

4.1 The Effect of the CAAA on Foreign Assets

This section documents the impact of the CAAA on a firm's foreign assets in its polluting segments. I first present the results using only the cross-sectional variation in the data, and then present the full panel analysis.

Table 3 gives the results from estimating Equation 1, over the 1966-1999 time period, where the foreign assets of a firm by industry by year is the dependent variable. The main coefficient of interest, β_3, is presented; a positive value of β_3 implies that a firm increases its foreign assets in dirty industries in response to CAAA regulation. For ease of interpretation, the table also includes the mean elasticity of the regulation. The columns correspond to specifications that include different sets of controls; the exact controls are noted at the bottom of the table. As the regulation effects are derived from the interaction of manufacturing in a heavily polluting industry in the United States and residing in a nonattainment county, the main effects of manufacturing in a domestic industry ($\text{Ind}_{fi(t-k)}$) and manufacturing in a nonattainment county ($\text{Non}_{fi(t-k)}$) are always included. The mean foreign assets for a firm-industry is \$37,188,000.

The Column 1 specification presents the estimated regulation effect from exploiting the pooled cross-sectional variation in the data. In other words, I exclude firm by industry, industry by year, and firm by year fixed effects. The estimated effect of regulation is large (735.35) and highly significant.[27] The Column 2 specification adds industry by year fixed effects (η_{it}), which purge the estimated regulation effects of all transitory differences in the mean foreign assets across industries. This estimate is not significantly different than the estimate presented in Column 1. However, firms tend to invest abroad in industries in which they manufacture at home, and therefore the industry at home variables included in the specification in Column 1 ($\text{Ind}_{fi(t-k)}$) may have already captured the trend in FDI, by foreign industry.

In the specifications presented in Columns 1 and 2, the estimated regulation effect may simply capture the difference in FDI between firms. For example, suppose that larger firms are more likely to be regulated and more likely to manufacture abroad. Then, the estimated coefficient would potentially confound the regulation effect with firm size. In the specification reported in Column 3, I take advantage of the panel structure of the data and include firm by industry fixed effects. The estimate of β_3 falls from 735 in Column 2 to 320 in Column 3. This difference suggests that firm specific factors are an important determinant of FDI,

[27] Constraining the effect of the industries at home and nonattainment variables to be constant over time produced similar results to Table 4A, but are omitted for brevity. All omitted results can be obtained from the author upon request.

and therefore, estimates of the regulation effect using cross-sectional data, where it is difficult to control for unobserved factors across firm by industry groups, may overstate the effect of environmental regulation on FDI.

Column 4 reports results from including industry by year, firm by industry, and firm by year fixed effects.[28] In this specification, the coefficient estimate on regulation is purged of possible sources of bias associated with transitory shocks to an industry, inherent firm by industry characteristics, and transitory shocks to a firm. The estimate of β_3, which is similar to Column 3, indicates that a 1 percentage point increase in the lagged percentage of plants regulated in an industry leads to a $329,000 increase in a firm's stock of foreign assets in that industry (significant at the 5% level). This corresponds to a 0.9% increase in foreign assets for the average firm-industry. To put these numbers into context, suppose that the average level of regulation is imposed upon a previously unregulated firm-industry (i.e. 6% of a firm-industry's plants are now regulated). The model predicts that the firm would increase its foreign assets in that industrial segment by 5.3%.[29]

The estimated regulation effect captures two channels through which regulation may affect FDI: by inducing a firm to invest abroad the first time and by motivating a firm to increase manufacturing at a previously existing plant. I estimated the effect of regulation on a dummy variable for whether the firm-industry manufactured abroad in a given year. The results (not shown here) suggest that regulations do not increase the probability that a firm will invest abroad. Rather, regulation causes firms to increase manufacturing at already existing manufacturing plants.

Potential (spurious) correlations may exist between regulation and a firm's foreign assets in an industry, if the total number of U.S. plants a firm-industry operates in a given year is correlated with its foreign assets. Specifically, operating more plants raises the probability of operating a plant in a nonattainment county, while simultaneously decreasing the probability of operating only "regulated" plants. Firm by industry fixed effects control for these correlations between firms (as they remove average firm by industry characteristics), but do not control for changes within a firm (since the number of plants a firm operates can change over time). Similarly, the firm by time fixed effects control for plant growth across all of a firm's industrial

[28] For computational ease, the data are demeaned using the two-way fixed effects model, and standard errors are appropriately adjusted.

[29] The regressions were run on the level of assets, and the mean elasticity of regulation is presented. Transforming the data by the log function would constrain the effect of regulation to be proportional to the firm's foreign assets, ensuring that the magnitude of the regulation effect was not simply driven by the largest firms. However, the data include a large fraction of zeros for years in which the firms did not invest abroad in an industry, and therefore, the log function is not appropriate.

segments, but do not control for disproportionate plant growth in one segment. To test whether this potential correlation drives the results, the specification in Column 5 controls for the lagged number of plants a firm operates in a given year. The results remain virtually unchanged.

I conclude this section by presenting the estimated coefficients of the CAAA under an alternative assumption regarding the timing of regulation effects on FDI. The regulation measure in Table 3 assumed that only regulations from the year of the last investment survey affects the FDI decisions of firms (for example, regulation in 1977 affected investment in 1982, but regulation in 1978-1981 does not). I made this assumption because there are typically delays in enforcement activities when a county falls into nonattainment, and there may also be a delayed response of investment to regulation.[30] Alternatively, I construct the average level of regulation (weighed by year) during the period prior to the investment, and determine whether this new regulation measure impacts foreign assets (Appendix Table A1). The point estimates presented in Table A1 are not significantly different than those presented in Table 3.

4.2 The Effect of the CAAA on Other Foreign Production Outcomes

This section documents the effect of the CAAA regulation on other measures of foreign production. Table 4 presents the results from the specification that controls for firm by industry, firm by year, and industry by year fixed effects. Therefore, the estimated regulation coefficients are comparable with Table 3, Column 4. For ease of interpretation, the mean elasticity of regulation is also presented.

Column 1 reports the estimation results for an alternative measure of a firm's capital stock: plant and property expenditures (PPE). In addition to including the physical capital stock of the foreign affiliate, the asset variable includes the affiliate's equity investments in other firms. In contrast, the PPE measure only includes the physical capital stock (land, machinery, etc), perhaps providing a less noisy measure of foreign production activities. The coefficient on regulation is positive (125) and significant at the 1% level.

Next, I investigate the effect of regulation on a multinational's foreign output. Although changes in a firm's foreign capital stock may provide evidence on permanent changes in foreign production, they may not capture transitory changes in foreign manufacturing during a given year. Suppose that a firm's manufacturing facility operates at less than full capacity.[31] A firm

[30] Berman and Bui (1998 and 2001) document that the plant level regulations associated with nonattainment status often set compliance dates a number of years in advance.

[31] It has been well documented that many plants operate under capacity, and that capacity utilization movements are not random, but can be viewed as systematic results of a rational economic optimization process undertaken by the firm. In particular, multifactor productivity tends to be procyclical (Berndt and Morrison,

may, thus, increase production by more fully utilizing existing capital structures, rather than investing in new equipment. In this case, using the foreign capital stock as a measure of foreign production would cause a downward biased measure of the regulation effect. In addition, the assets and PPE variables are recorded through a book value system. This system permanently records the value of an investment at its purchase price, and the value is never updated to reflect inflation or changes in the goods market value. Because this system overstates the relative contribution of a recent investment (which is entered in current dollars), the increase in foreign capital as a fraction of total capital may be an upwardly biased measure of current production levels. A firm's foreign output does not suffer from either bias, and, therefore, may provide a better measure of transitory changes in production.

Column 2 and 3 report the estimation results for two measures foreign output: the real expenditures on foreign goods and services and the real foreign Gross Product, respectively. Once again, β_3 is positive and significant (point estimates of 702 and 290, and mean elasticities of 1.5 and 2.1 respectively). This implies that imposing the mean level of firm by industry regulation causes the average firm to increase its foreign output (as measured by the expenditures on goods and services) by roughly 9% within a polluting industry.

In Column 4, I test whether a firm increases imports from its foreign affiliates in response to tougher environmental regulation. A firm may utilize FDI as a means of penetrating a local market, or, alternatively, to produce goods for export. In the context of this study, it is interesting to understand whether the United States was the final destination of the additional foreign goods produced in response to regulation, and hence whether imports substituted domestic production. It is worth mentioning that although a foreign affiliate can export directly to other companies within the United States, roughly one-third of world trade is intra-firm trade (Antras, 2003) and, in our particular sample, sales to the U.S. parent firm account for 62% of all sales to the United States. As such, this is an important indicator of whether a firm substitutes foreign goods for its own domestic production. The effect of regulation on intra-firm trade is positive (131) and economically significant: a 1 percentage point increase in regulation leads to 1.6% increase in imports by the average firm by industry. However, this is not precisely estimated.

Finally, Column 5 reports the estimation result where the real sales from the foreign affiliate to the United States, through any firm, is the dependent variable; the coefficient is positive (99), but not precisely estimated.

1981; Morrison 1985).

4.3 The Relative Impacts of Regulation on FDI to Developing Countries

This section addresses whether environmental regulations alter the international location decisions of polluters. In particular, opponents of U.S. environmental regulation fear that regulation forces firms to shift manufacturing to developing countries, which are generally less able or less willing to impose tough environmental policies (pollution havens or race to the bottom effects). If this concern is justified, U.S. environmental policies may have significant distributional impacts, as pollution and jobs shift to developing nations.

Economic theory, however, does not necessarily predict that firms will disproportionately increase investment to developing nations. The regulations do not alter conditions (interest rates, costs) across foreign nations, and therefore, at the margin, we would not automatically expect a change in the distribution of a firm's foreign portfolio. Furthermore, even if the regulations motivate a firm to invest in countries with weaker standards, the firm may not necessarily increase production in a developing country. A firm's location choice depends upon a variety of factors that affect the business environment, of which environmental law is only one; for example, a firm that requires a flexible workforce might not invest in a country that has the weakest environmental laws if it also has the most rigid labor laws.

The empirical evidence on whether multinationals invest in developing nations to exploit weaker environmental policies is mixed. Gamper-Rabindran and Jha (2004) show that after India's 1991 liberalization, there were greater inflows of FDI into dirty industries relative to cleaner ones. On the other hand, Eskeland and Harrison (1997) find little evidence that foreign investors are concentrated in dirty sectors, and show that foreign plants are actually more energy efficient than domestic plants in Mexico, Venezuela, Morocco, and Cote D'Ivoire.

In Figure 4, I plot the average ratio of foreign assets in developing nations to total foreign assets, by polluting and clean industries. For all years, the ratio is higher for clean industries. There is not a discernible change in the difference in ratios over time, confirming Eskeland and Harrison's result that dirty U.S. industries are not disproportionately increasing their concentration in developing countries.

In Table 5 and 6, I present statistical evidence on whether firms will relocate to developing countries when they are faced with more stringent environmental regulation. Table 5 replicates the regression results presented in Table 3 and 4, excluding FDI to high-income, OECD countries. I find evidence that multinationals invest in developing countries when faced with higher levels of U.S. regulation. For example, a 1 percentage point increase in the lagged percentage of regulated plants corresponds to a \$59,000 (for the average firm, 0.8%) increase in the stock of foreign assets within a firm's polluting segment. This estimate is significant at the 15% level. However, the mean elasticity of foreign assets to regulation in developing countries (0.8%) is not noticeably different than the mean elasticity (0.9%) for all countries.

Table 6 presents a formal test of whether multinationals disproportionately increase FDI to the developing world in response to regulation. I re-estimate equation 1 with the ratio of FDI in less developed countries to total FDI as the dependent variable. For each outcome measure, the mean of the dependent variable is listed in brackets at the top of the table. Across all outcomes, the results are indistinguishable from zero, implying that the share of a firm's investment in poorer countries is not determined by U.S. environmental regulations.

4.4 Individual Pollutants

If abatement costs vary by pollutant, each pollutant-specific regulatory program (CO, O_3, SO_2, and TSP) should have a distinct effect on FDI. In particular, one would expect FDI to disproportionately increase in response to regulation of pollutants with high marginal abatement costs.

Unfortunately, it is difficult to measure marginal abatement costs by pollutant. In general, abatement cost data come from manufacturing plant surveys, but plants may be unable to separate costs by pollutant if equipment can abate multiple pollutants. Moreover, Hartman, Wheeler and Singh (1994) have documented that the marginal cost of pollution abatement varies across industry. For example, in the Paper Industry, the marginal cost of pollution abatement is highest for O_3/CO (214 USD '79 per ton of reduced emissions), while in the Agricultural Chemical Industry, marginal O_3/CO abatement (158) is cheaper than SO_2 (285). As a result, it is difficult to rank individual pollutants by their marginal abatement costs.

More recent evidence suggests that, in practice, the CO regulatory program disproportionately retarded the growth of manufacturing (Greenstone, 2002). This implies that it may be the most costly of the four regulatory regimes.

In order to estimate the separate effects of each regulatory program on foreign production, I compute four measures of pollutant specific regulation:

$$\operatorname{Re} gZ_{fit} = \frac{1}{N_{fit}} * \left(\sum_{p=1}^{N_{fit}} \Phi(Ind_{piz} * Nonattain_{ptz}) > 0 \right) * 100$$

This measure is similar in attributes to Reg_{fit}, and can be interpreted as the percentage of a firm's U.S. plants in an industrial segment that are regulated for pollutant Z.

For each pollutant, I estimate Equation 1, replacing $\text{Reg}_{fi(t-k)}$ with the pollutant-specific measure of firm by industry regulation:

$$Y_{fit} = \beta_0 + \beta_1 Ind_{fi(t-k)} + \beta_2 NonZ_{fi(t-k)} + \beta_3 \operatorname{Re} gZ_{fi(t-k)} + \alpha_{fi} + \delta_{ft} + \eta_{it} + \varepsilon_{fit} \quad (2)$$

Note that Equation 2 differs from Equation 1 in that $\text{Non}_{fi(t-k)}$ has been replaced by $\text{NonZ}_{fi(t-k)}$, which is defined as the percentage of plants in a nonattainment county for pollutant Z.

Columns 1 – 4 of Table 7 present the results from estimating Equation 2 for each of the 4 regulatory programs. The CO program appears to have the largest effect (514, significant at 15%), followed by O_3 (275, significant at 5%). The coefficients on regulation for the TSP (Column 3) and SO_2 (Column 4) programs are indistinguishable from zero.

Equation 2 captures the effect of each regulatory program on FDI; however, many plants are subject to more than one of the nonattainment designations, and as such the coefficient estimates in Equation 2 may potentially confound the effects of each of the nonattainment designations. Alternatively, I estimate the effect of each regulatory program, holding constant the effect of regulation for other pollutants:

$$Y_{fit} = \beta_0 + \beta_1 Ind_{fi(t-k)} + \sum_z \beta_{2z} NonZ_{fi(t-k)} + \sum_z \beta_{3z} RegZ_{fi(t-k)} + \alpha_{fi} + \delta_{ft} + \eta_{it} + \varepsilon_{fit} \quad (3)$$

Column 5 presents the estimates of the coefficients of interest (β_{3CO}, β_{3O_3}, β_{3SO_2}, and β_{3TSP}) from Equation 3. Once again, CO and O_3 regulation have significant effects on FDI, while the estimated effect of TSP and SO_2 regulation are indistinguishable from zero. The estimates do not significantly differ from estimating the effect of each regulatory regime separately, suggesting that the marginal effect of regulation for a second pollutant is equal to the average effect of being regulated for that pollutant.

Overall, the results found in this exercise are consistent with prior work: the previous literature found that CO regulation had the largest effect on domestic production, and therefore, we would also expect CO regulation to have the largest impact on foreign production. Moreover, the O_3 program was the most prevalent regulatory program within the United States, with the largest number of counties affected. A firm trying to evade regulation would have least incentive to switch counties within the United States, as the probability of a county falling into nonattainment for O_3 is higher than for other pollutants.

4.5 Exploring the Heterogeneity across Industries

In this section, I explore whether the effect of environmental regulation varies across industrial characteristics. In particular, I focus on whether the regulation effect varies with the extent of an industry's import penetration within the United States.

Industries with high import penetration, roughly defined as the ratio of imports to domestic production, may react substantially more to regulation for a variety of reasons: less protective measures of trade, a U.S. comparative disadvantage in that industry, etc. Using the NBER trade database, I construct a measure of import penetration as the ratio of the value of U.S. imports to the value of U.S. shipments, by industry (IMPEN_i). To smooth temporary fluctuations, the ratio is averaged over eight years (1958-1965). I then interact IMPEN_i with the firm by industry environmental regulation variable ($\text{Reg}_{fi(t-k)}$):

$$Y_{fit} = \beta_0 + \beta_1 Ind_{fi(t-k)} + \beta_2 Non_{fi(t-k)} + \tag{4}$$

$$+\beta_{31} Reg_{fi(t-k)} + \beta_{32} IMPEN_i + \beta_{33}(Reg_{fi(t-k)} * IMPEN_i) + \alpha_{fi} + \delta_{ft} + \eta_{it} + \varepsilon_{fit}$$

The parameter of interest, β_{33}, captures the additional impact of regulation for high import penetration industries (Pulp and Paper, Petrol Refining, Lumber) relative to low import penetration industries (Newspapers, Fabricated Metals).

Table 9 presents the results from estimating Equation 4 for selected outcome measures. Column 1 presents the results where the dependent variable is a firm-industry's foreign assets; β_{33} is positive (86) and significant. This implies that regulation has larger effects for firms in dirty, high import penetration industries relative to dirty, low importation industries.

In Column 2, I replace the import penetration ratio with a dummy variable indicating whether the industry is above median import penetration. The results are striking—the effects of regulation can be predominately attributed to high import penetration industries (629). Columns 3 and 4 present the coefficient estimates based on the specifications where the expenditures on foreign goods and services is the dependent variable, while Columns 5 and 6 present them for intra-firm trade. These results indicate that firms increase foreign output in response to regulation relatively more in industries in which imports have historically accounted for a large percentage of U.S. consumption.

4.6 Firm Level Regression

As an alternative strategy, I estimate the effect of regulation on a firm's total foreign production, rather than the effect on a firm's production within an industrial segment. In particular, I fit the following equation to firm level data:

$$Y_{ft} = \beta_0 + \beta_1 Ind^*_{f(t-k)} + \beta_2 Non^*_{f(t-k)} + \beta_3 Reg^*_{f(t-k)} + \theta_f + \nu_t + \varepsilon_{fit} \quad (5)$$

where $Reg^*_{f(t-k)}$ is the lagged percentage of a firm's U.S. plants under regulation, $Ind^*_{f(t-k)}$ is a vector of dummies that control for the firm's domestic industries, $Non^*_{f(t-k)}$ controls for the percentage of plants a firm has in a nonattainment county, θ_f is a firm fixed effect and ν_t is a year fixed effect.

Regulation effects calculated at the level of the firm can be informative if there are spillover effects from dirty to clean industries. Foreign investment tends to be lumpy, primarily due to the fixed costs of investing abroad. If a firm facing tougher regulation at home is more likely to pay the fixed costs of creating infrastructure abroad, it may be easier for that firm to manufacture across all industries. However, the firm-level results may be misleading if regulated firms shift simply foreign resources from clean to dirty industries. In this case, even if total foreign production remained constant, a reallocation between industries would have considerable effects on pollution patterns and welfare.

The results of the firm level regressions are presented in Table 9. An increase in CAAA regulation causes a significant increase in the total foreign capital stock and foreign output of a firm; the effect on sales is indistinguishable from zero.

4.7 Specification Checks

I probed the robustness of the estimates to determine the sensitivity of the results (Table 10), but I found little evidence contradicting the basic conclusions of this paper. Each cell is the coefficient estimate of β_3 from Equation 1. Each row represents a different outcome measure, while each column represents a different specification. All regressions include firm by industry, firm by year, and industry by firm fixed effects, and are therefore comparable to the results presented in Table 4 (Column 5) and Table 5.

4.7.1 Employment Weighted Regulation

In constructing Reg_{fit}, I restricted the effect of regulation to be identical for each of the firm by industry's plants, regardless of the characteristics (such as the size) of the plant. This assumption is tenuous if, for example, a firm finds regulation more costly when its largest plant becomes subject to regulation. Alternatively, I weight each plant by its approximate employment (E_{pit}) when constructing the regulation variable, and replace Reg_{fit} with an employment-weighted measure of regulation:[32]

$$EmpReg_{fit} = \frac{1}{\sum_{p=1}^{N_{fit}} E_{pit}} * \left(\sum_{p=1}^{N_{fit}} E_{pit} * \Phi \left(\sum_{z} (Ind_{piz} * Nonattain_{ptz}) > 0 \right) \right) * 100$$

The results, presented in Column 1 of Table 10, remain robust: the regulation effect on foreign capital stock and output are positive and significant, while the effect on sales is positive, but not precisely estimated.

4.7.2 Estimated Regulation Data

The EPA did not maintain data on the county-level designations between the years 1972 to 1977, and therefore, predicted data were used in the analysis for these years. However, as Appendix Figure 1 shows, the predicted data series underestimates the actual number of nonattainment counties, particularly for O_3. To ascertain the sensitivity of the results to the predicted data, I use the designation of the county in 1978 (the first year of preserved nonattainment designations) as the designation of the county in 1972 and 1977. The results, presented in Column 2 of Table 10, remain robust.

4.7.3 Lower Cutoff for Emissions Standards

I label an industry to be an "emitter" of a pollutant if the industry contributed 7% or more to industrial emissions of that pollutant. My analysis relies on the comparison between non-emitters and emitters, and, therefore, it is important that the assignment rule correctly classifies industries, as misclassification will bias the estimated regulation effects. In Table 10, Column 3, I present the estimation of Equation 1 where an industry is labeled an emitter if the industry has

[32] I lack U.S. plant-level asset data. Otherwise, I would weight each U.S. plant by its assets when constructing the regulation variable in order to discern whether the decision to increase manufacturing abroad is a function of the size of the regulated plant.

contributed 4.5% or more to industrial emissions. The results remain robust, largely because the change from the 7% to 4.5% cutoff does not cause many industries to flip from the non-emitting to emitting category.

4.7.4 Varying Sample Construction

In Table 10, Columns 4 and 5, I determine the sensitivity of the regulation estimates to sample construction. First, I re-estimate equation 1 for firms that operated throughout the entire period. If the CAAA regulations caused firms to shut down, and firms who are anticipating closure make fewer foreign investments while alive, then the estimated regulation effects would be biased downward. The point estimates of regulation (Column 4) are larger across all outcome measures (for example, the effect on foreign assets is now 450 versus 329 in Table 4). However, firms that operate throughout the entire period have higher mean FDI (the mean foreign assets is 44836). As such, the mean elasticity of FDI to regulation does not differ from the full sample.

Second, in the early years of regulation, the regulations were unanticipated. In later years, firms for whom the regulations bind may have already left (or avoided) counties that had a high probability of falling into nonattainment. In this case, firms remaining in nonattainment counties would be those with negligible marginal pollution abatement costs. As such, the estimated regression coefficients would be systematically biased downward. In Column 5, I limit the analysis to the early years of regulation (1966-1982). While the point estimate of the coefficient are smaller (for example, 136 on foreign assets), firms also tended to invest less during this period (the mean foreign assets is 17,973). Hence, the mean elasticity during the early years of regulation is not significantly different from the estimated elasticity for the entire 1966-1999 period.[33]

5 Discussion

The preceding empirical work provides evidence that U.S. based multinationals increased FDI in response to U.S. "clean air" policies. Specifically, my analysis suggests that the CAAA regulations caused the average multinational firm to increase its foreign assets in polluting industries by 5% and its foreign output by 9%. These findings warrant additional discussion regarding their meaning and possible welfare implications.

[33] Nonattainment designations in the early period are estimated due to missing data. As such, regulation estimates in earlier period contain more noise than in later periods.

5.1 Substitution of U.S. Manufacturing

The findings in this paper suggest that U.S. multinationals may substitute foreign for domestic production in response to U.S. regulations. In particular, I find that regulation causes firms to increase both foreign production and intra-firm trade. However, these substitution effects are small relative to total multinational production in the United States.

I can compute the approximate percentage of U.S. multinational activity that this increased foreign production accounts for. The analysis predicts that U.S. multinationals will increase their foreign assets by 5.3% in polluting industries in response to the mean CAAA regulation. Therefore, for the year 1977, the regulations amounted to $52 billion of total foreign assets in polluting industries.[34] This increase represents approximately 0.6% of the stock of multinationals' domestic assets in polluting industries.

5.2 Comparison with Tax

Regulation impacts a firm's production decisions by increasing the cost of domestic production, and can therefore be seen as a production tax. To determine whether the magnitude of the estimated regulation effect is plausible, I can compare it with a rough estimate of how an "environmental tax" would impact FDI.

The best estimates currently place U.S. environmental compliance costs at 2% of the total cost of production (Jaffe, et al, 1995). Prior to the passage of CAAA, the United States had little environmental regulation, and, therefore, I assume that these costs are fully attributable to the CAAA regulation. Two percent of costs is roughly equal to 12% of a multinational's profits (1999 BEA Data). Thus, the CAAA regulation can be viewed as equivalent to a 12% profit tax.

To my knowledge, an estimate of the tax elasticity of outbound investment is unavailable. Instead, I use a measure of the inward tax elasticity of investment, -0.6, from Gorden and Hines (2002) as a proxy for the outbound elasticity. Thus, a 12% environmental tax is associated with a 6.8% increase in FDI, which is comparable in magnitude to the 5.3% estimate derived in this paper.

[34] I use the year 1977 because it is the first year of foreign investment data after the regulations were imposed.

5.3 Welfare Implications

This study finds that multinationals may circumvent environmental laws by manufacturing in alternative locations. Therefore, while country-level policies may reduce local pollution, they have the potential to leave the level of global pollution unchanged (or, perversely, even increase it), and may have important distributional consequences.

However, a comprehensive study on who gains (and who loses) from these policies is complicated by several factors. First and foremost, the analysis depends on whether one takes a global or a U.S. perspective. U.S. environmental policy shifts manufacturing (and, therefore, pollution) abroad. Some foreign countries may tolerate higher pollution levels in order to further economic growth (Krueger & Grossman, 1995), and therefore, it is not obvious that countries receiving U.S. FDI experience a welfare loss from an increased presence of dirty industries.

From a U.S. perspective, environmental regulation reduces U.S. pollution levels and can provide significant health benefits and general improvements in the quality of life.[35] On the other hand, these improvements may come at a substantial cost: the cost of production and employment shifting abroad, externalities from global pollution, and changes in the prices of consumer goods.

While this study aims to understand the costs of lost production, the calculated regulation effects can only be used as a guide in determining these costs. First, this study does not capture all possible changes in foreign production. For example, suppose that domestic firms cannot compete with foreign firms after regulation. Foreign goods may therefore flood the market (import substitution) causing U.S. firms to shutdown. Second, I cannot fully predict the counterfactual. If firms would have eventually shifted production abroad even in the absence of regulation (and the regulations simply speed up the process), the ensuing welfare effects would be different than if the firms move solely in response to regulation. Finally, even if production and jobs shifted abroad, one would expect labor and capital to be reallocated within the United States. As such, the true costs of regulation depend on the adjustment costs of switching resources to other sectors.

6 Conclusions

This paper provides new evidence on the relationship between environmental regulation and FDI. I find evidence that the Clean Air Act Regulations caused U.S. based multinational firms

[35] See Smith and Huang (1995); Henderson (1996); Chay and Greenstone (2003); Currie and Neidell (2004).

to increase their foreign production in emitting industries. In particular, my analysis predicts that multinationals increased their foreign assets by 5.3% and their foreign output by 9% in response to tougher regulation. This increase accounted for roughly 0.6% of the multinationals' domestic assets in polluting industries. However, contrary to common claims, I find that heavily regulated firms did not disproportionately increase foreign investment in developing countries.

This paper provides limited evidence that heavily regulated U.S. firms increase imports from their foreign affiliates in response to regulation. In addition, I find robust evidence that firms react more strongly to regulation when they operate in an industry where imports have historically accounted for a large percentage of U.S. consumption. On the whole, these results are consistent with the theory that regulation causes a firm to substitute foreign for domestic production.

In light of the recent debates on outsourcing, my results suggest that American environmental regulations have contributed to the flight of manufacturing. However, these results should not be misinterpreted as a criticism of environmental law nor a call to reverse environmental policy within the United States. Substantial research has shown that these policies are effective at reducing air pollution concentrations and that cleaner air provides substantial monetary benefits to homeowners and significant health benefits. Thus, it is possible that the welfare gains from the shifting investment abroad may still outweigh the costs.

7 Appendix

To fully understand the construction of Reg_{fit}, consider the following example (Appendix Table A2). Firm A operates four plants in the United States: two plants in the Motor Vehicle Industry and one plant each in the Petrol Refining and Food Industries. For each industrial segment of a Firm A, Reg_{fit} is constructed as follows:

- The Motor Vehicle Industry contributes to 7.4% of industrial emissions of O_3, and therefore both of Firm A's plants within this industry are considered O_3 emitters ($\text{Ind}_{\text{Motor Vehicle}, O_3}=1$). Since Plant 2 is located in a county that is in attainment for O_3, it is "unregulated." $\text{Reg}_{\text{Firm A, Motor Vehicle, t}}$ equals 50%.

- The Petrol Refining Industry emits both O_3 and SO_2. Although Plant 3 resides in a county that is in attainment for O_3, its county is in nonattainment of federal standards for SO_2. Therefore, Plant 3 is considered regulated. Since Plant 3 is the only plant Firm A operates in the Petrol Refining Industry, $\text{Reg}_{\text{Firm A, Petrol, t}}$ equals 100%.

- The Food Industry does not emit a criteria pollutant. $\text{Reg}_{\text{Firm A, Food, t}}$ equals 0.

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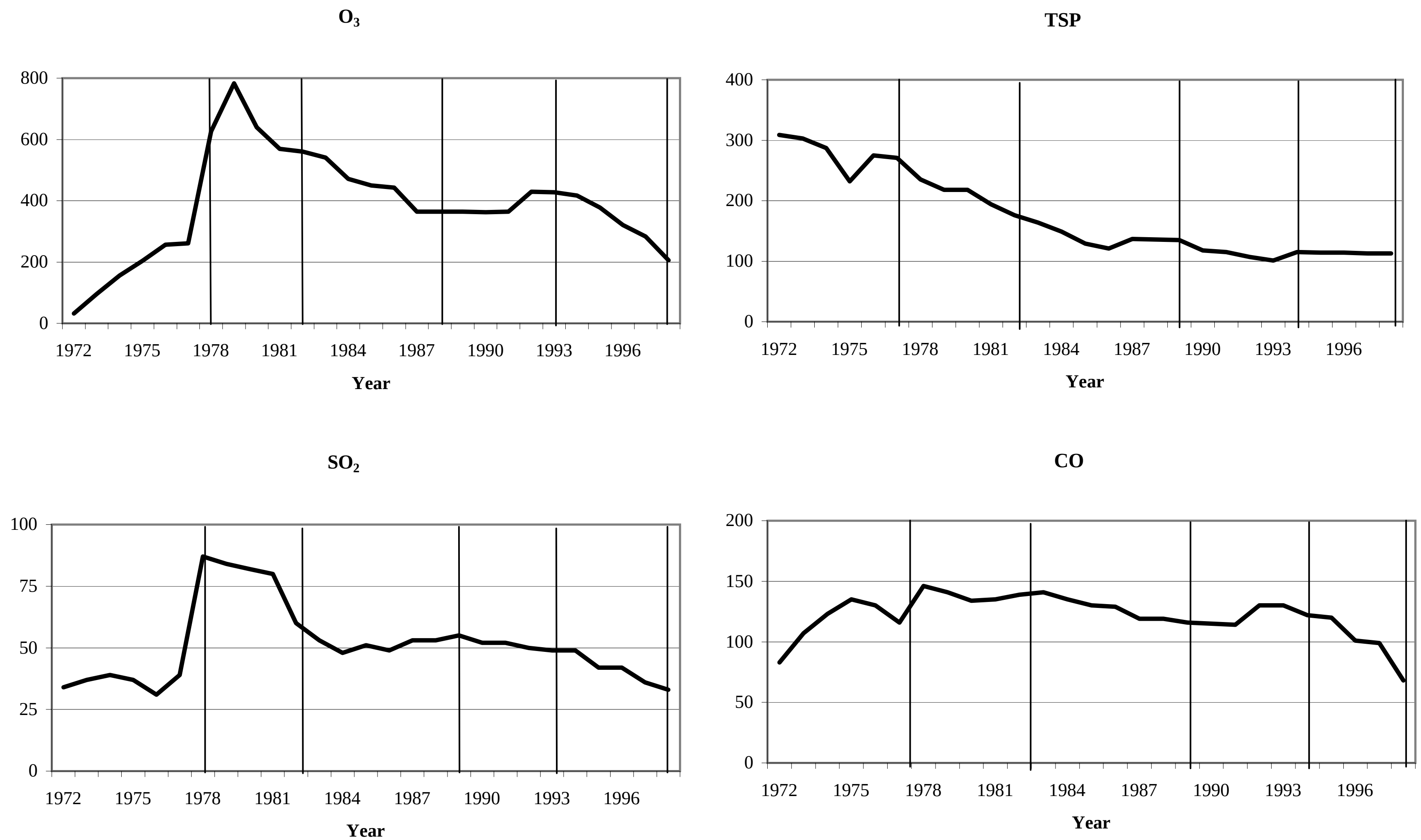
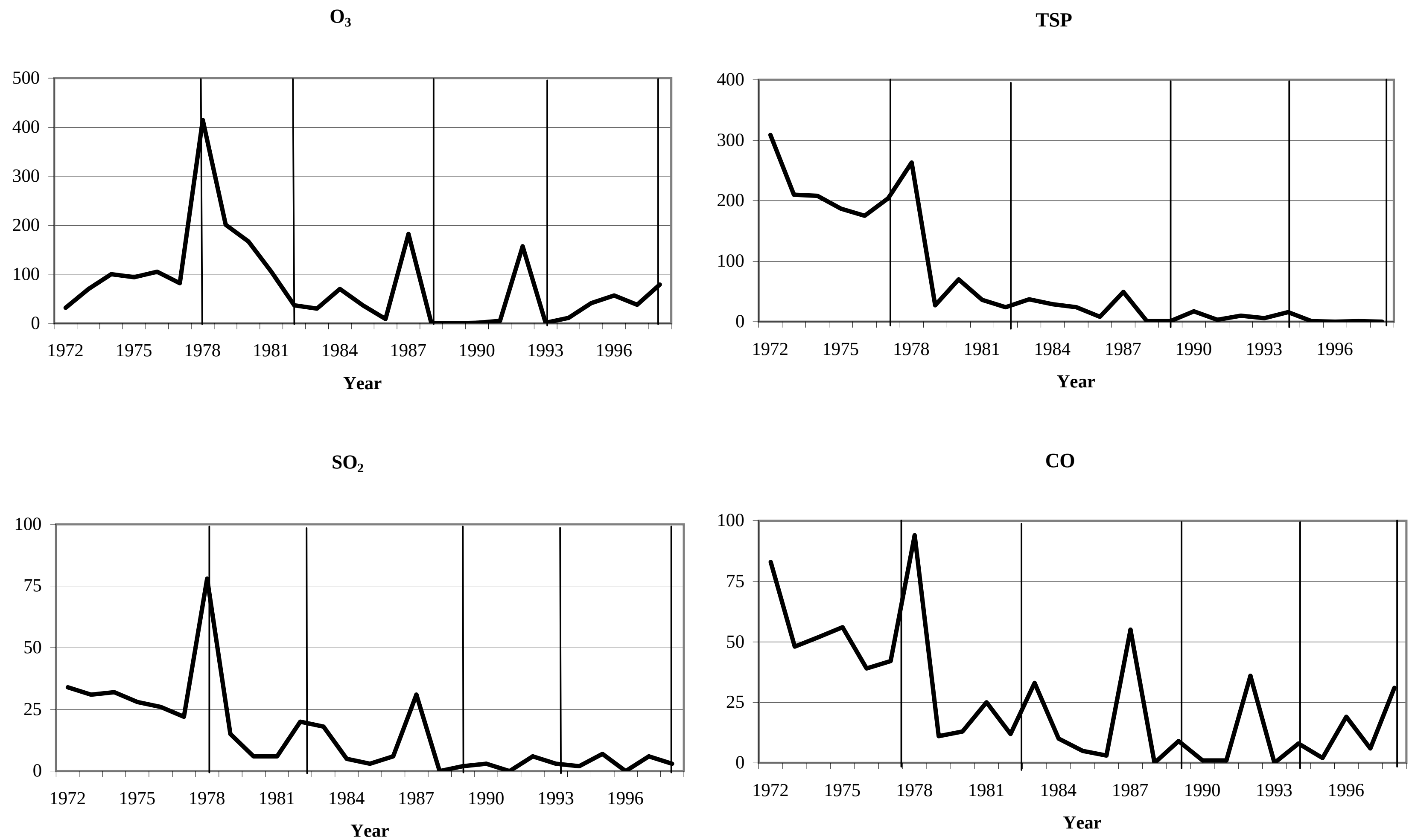
Figure 1A: Number of Counties with Nonattainment Status, by Pollutant



Notes: (1) Data come from the EPA Greenbook, EPA Pollution Monitoring Network (courtesy of Michael Greenstone) (2) The bars correspond to BEA Benchmark Survey Years

Figure 1B: Number of Counties with a Change in Status, by Pollutant



Notes: (1) Data come from the EPA Greenbook, EPA Pollution Monitoring Network (courtesy of Michael Greenstone) (2) The bars correspond to BEA Benchmark Survey Years

Figure 2A: Foreign Assets in Manufacturing of U.S. Based Multinationals, by Industrial Pollution Status

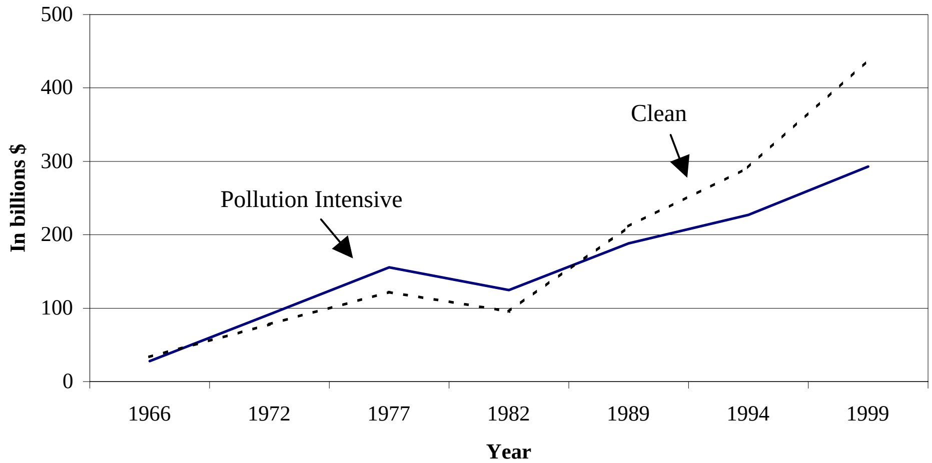
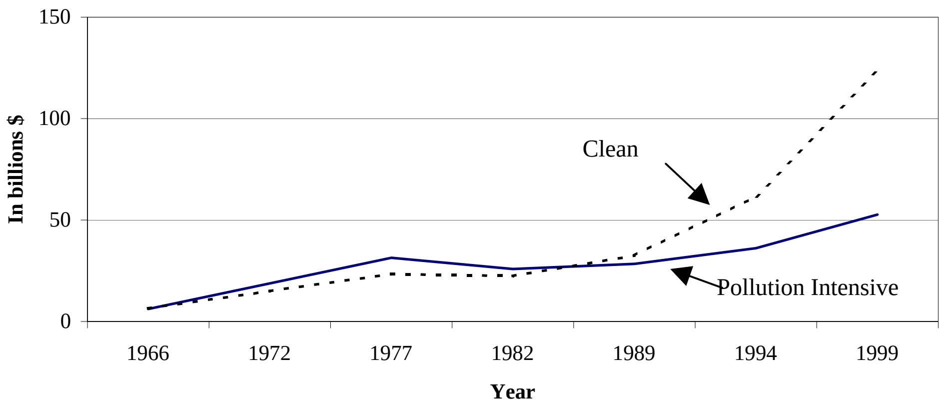


Figure 2B: Foreign Assets in Manufacturing excluding High Income, OECD Nations, by Industrial Pollution Status



Source: Author Calculation From BEA Investment Survey (Estimated 1972)

Table 1: Which Industries Emit Which Pollutants?

Industry (SIC code)	O_3	SO_2	TSP	CO
Fabricated Metals (34)	x			
Inorganic Chemicals (2812-9)		x		
Iron and Steel (3312-3, 3321-5)	x	x	x	x
Lumber and Wood Products (24)			x	
Motor Vehicles, Bodies and Parts (371)	x			
Nonferrous Metals (333-4)		x		x
Organic Chemicals (2861-9)	x			
Petroleum Refining (2911)	x	x		x
Printing (2711-89)	x			
Pulp and Paper (2611-31)	x	x	x	x
Rubber and Misc. Plastic Products (30)	x			
Stone, Clay, Glass and Concrete (32)	x	x	x	
Percent of Industrial Emissions Accounted For	80.7%	91.2%	71.90%	84.8%

Notes: (1) Metal and Non-Mining make up approximately 33% of industrial emissions of TSP. Since only the manufacturing sector is studies in the paper, these sectors are omitted from the calculation of the percentage. (2) Ozone regulations consist of regulation for VOCs and Nitrogen Dixoide. The industries in question account for 80.1% of VOCs. While the Stone, Clay and Glass industry is responsible for only 2.2% of VOC emissions, it is responsible for 18.6% of omissions of Nitrogen Dioxide and is included as an Emitter of O_3 (3) Data from EPA Sector Notebooks (1995) and Greenstone (2002)

Figure 3: Plant Data Versus County Business Patterns Data, 1994

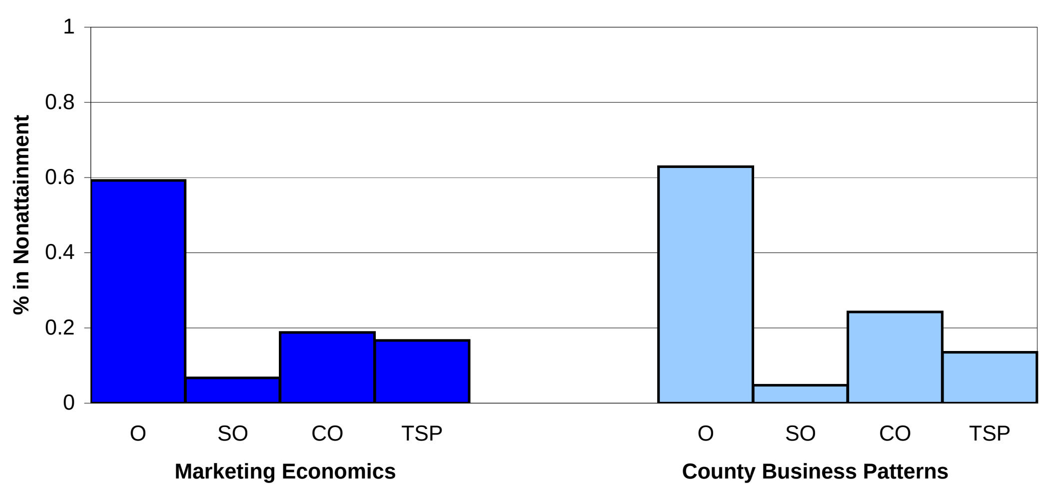


Table 2: Descriptive Statistics of Key Variables

	All Foreign Affiliates		Excluding Affiliates in High Income, OECD Nations	
	Overall	Conditional on Foreign Assets>0	Overall	Conditional on Foreign Assets>0
Variable	(1)	(2)	(3)	(4)
Foreign Assets	37118	162885	7612	33403
	(451013)	(933916)	(103110)	(214000)
Plant and Property Expenditures	12148	53309	2678	11753
	(172855)	(359069)	(38875)	(80781)
Costs of Goods and Services	45903	201436	9085	39866
	(728007)	(1514785)	(149734)	(311713)
Gross Product	14149	62092	3378	14824
	(340721)	(711683)	(238336)	(499117)
Sales From Foreign Affiliates to U.S. Firm	8109	36193	2865	12801
	(307384)	(649205)	(260066)	(549817)
Sales From Foreign Affiliates to U.S.	13216	57995	2900	12943
	(320534)	(669544)	(259804)	(549257)
Firm by Industry Regulation (Reg_{fit})	5.99	7.16	5.99	7.16
	(22.24)	(22.76)	(22.24)	(22.76)
Firm by Industry Regulation: CO_{fit}	0.48	0.49	0.48	0.49
	(6.02)	(5.10)	(6.02)	(5.10)
Firm by Industry Regulation: O_{fit}	5.35	6.33	5.35	6.33
	(21.10)	(21.53)	(21.10)	(21.53)
Firm by Industry Regulation: SO_{fit}	0.39	0.53	0.39	0.53
	(5.38)	(5.59)	(5.38)	(5.59)
Firm by Industry Regulation: TSP_{fit}	0.93	0.94	0.93	0.94
	(8.65)	(7.69)	(8.65)	(7.69)

Notes: (1) The level of observation is a firm by industry by year (for 2235 firms). Col 1 & 3 have 56,385 firm by industry by year observations, while Col 2 & 4 have 12,385 observations. (2) Outcome variables are constructed from the BEA Direct Foreign Investment Benchmark Surveys for 1966-1999. All outcome variables are in real thousands of 1982 USD (deflated using U.S. industry PPI from Federal Reserve Bank of St Louis FRED II) (4) Def of "High Income, OECD" comes from the World Bank.

Table 3: Regression Results, Real Foreign Assets as Dependent Variable

	(1)	(2)	(3)	(4)	(5)
Firm by Industry Regulation (Reg_{fit})	735.3	735.3	319.9	329.9	329.9
	(130.6)	(130.9)	(103.1)	(131.9)	(131.7)
Mean Elasticity	2.0	2.0	0.9	0.9	0.9
Industry at Home, By Year	x	x	x	x	x
Nonattainment, By Year	x	x	x	x	x
Firm by Industry			x	x	x
Firm by Year				x	x
Industry by Year		x		x	x
Number of Plants					x
Number of Plants Squared					x

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

Table 4: Regression Results, Other Outcome Variables

	Plant & Property Exp (1)	Exp on Goods & Services (2)	Gross Product (3)	Sales, U.S. Parent Firm (4)	Sales, U.S. (5)
Firm by Industry Regulation (Reg_{fit})	125.9	702.1	290.9	131.4	99.7
	(44.6)	(196.0)	(138.6)	(130.0)	(134.1)
Mean Elasticity	2.0	1.5	2.1	1.6	0.8
Industry at Home, By Year	x	x	x	x	x
Nonattainment, By Year	x	x	x	x	x
Firm by Industry	x	x	x	x	x
Firm by Year	x	x	x	x	x
Industry by Year	x	x	x	x	x

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

Figure 4: Ratio of Foreign Assets in Developing Countries to Total

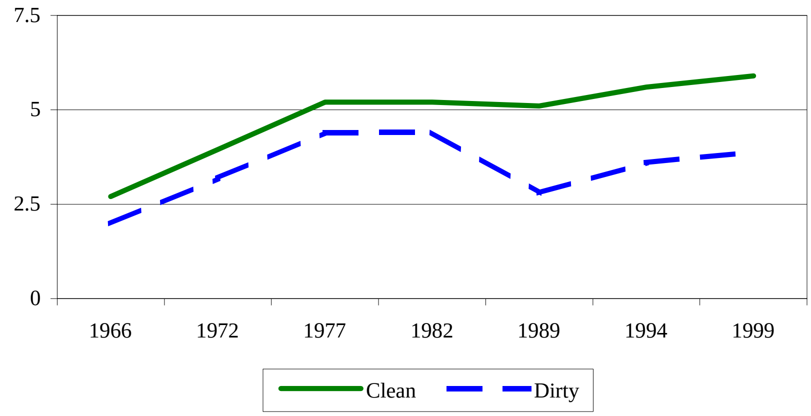


Table 5: Regressions, Excl High Income, OECD Nations

	Foreign Assets (1)	Plant & Property Exp (2)	Exp on Goods & Services (3)	Gross Product (4)	Sales, U.S. Parent Firm (5)	Sales, U.S. (6)
Firm by Industry Regulation (Reg_{fit})	59.5	29.3	102.0	47.4	51.6	23.6
	(38.3)	(14.0)	(54.9)	(111.9)	(122.3)	(122.5)
Mean Elasticty	0.8	1.1	1.1	1.4	1.8	0.8
Industry at Home, By Year	x	x	x	x	x	x
Nonattainment, By Year	x	x	x	x	x	x
Firm by Industry	x	x	x	x	x	x
Firm by Year	x	x	x	x	x	x
Industry by Year	x	x	x	x	x	x

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

Table 6: Regulation Effects on the Ratio of Production in Developing Countries to Total Foreign Production

	Foreign Assets [4.37]	Plant & Property Exp [5.23]	Exp on Goods & Services [4.40]	Gross Product [4.50]	Sales, U.S. Parent Firm [2.51]	Sales, U.S. [2.21]
	(1)	(2)	(3)	(4)	(5)	(6)
Firm by Industry Regulation (Reg_{fit})	0.003	0.003	0.007	0.054	-0.002	0.003
	(0.007)	(0.061)	(0.015)	(0.427)	(0.006)	(0.006)
Industry at Home, By Year	x	x	x	x	x	x
Nonattainment, By Year	x	x	x	x	x	x
Firm by Industry	x	x	x	x	x	x
Firm by Year	x	x	x	x	x	x
Industry by Year	x	x	x	x	x	x

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

Table 7: The Effect of Pollutant Specific Regulatory Programs on Foreign Assets

	(1)	(2)	(3)	(4)	(5)
Firm by Industry Regulation: CO_{fit}	514.8				514.9
	(319.2)				(340.6)
Firm by Industry Regulation: O_{fit}		275.4			267.7
		(129.6)			(132.7)
Firm by Industry Regulation: SO_{fit}			-139.6		-242.7
			(336.9)		(352.4)
Firm by Industry Regulation: TSP_{fit}				-64.1	-191.0
				(233.6)	(251.7)
Industry at Home, By Year	x	x	x	x	x
Nonattainment, By Year	x	x	x	x	x
Firm by Industry	x	x	x	x	x
Firm by Year	x	x	x	x	x
Industry by Year	x	x	x	x	x

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

Table 8: Interacted With Lagged Import Penetration

	Foreign Assets		Exp on Goods & Services		Sales, U.S. Parent Firm	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm by Industry Regulation (Reg_{fit})	124.0	-69.1	422.7	28.8	156.4	89.9
	(154.0)	(165.5)	(230.0)	(247.2)	(152.7)	(164.1)
Reg_{fit} *$IMPEN_i$	86.0		116.8		156.4	
	(32.6)		(48.7)		(152.7)	
Reg_{fit} *$IMPEN_i$(Above Median)		692.2		1167.9		72.3
		(171.6)		(256.3)		(170.2)
Industry at Home, By Year	x	x			x	x
Nonattainment, By Year	x	x			x	x
Firm by Industry	x	x			x	x
Firm by Year	x	x			x	x
Industry by Year	x	x			x	x

'Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted. (3) "IMPEN" stands for the averaged import penetration.

Table 9: Firm Level Regressions

	Capital Stock		Output		Sales	
	Foreign Assets [199950.0] (1)	Plant & Property Exp [64928.9] (2)	Exp on Goods & Services [248742.6] (3)	Gross Product [76783.3] (4)	Sales, U.S. Parent Firm [12197.3] (5)	Sales, U.S. [69955.4] (6)
Firm-Level Regulation	616.8	336.3	1205.2	530.7	160.0	59.1
	(421.5)	(147.9)	(694.2)	(229.6)	(183.0)	(192.7)
Mean Elasticity	0.3	0.5	0.5	0.7	1.3	0.1
Industry at Home, By Year	x	x	x	x	x	x
Nonattain, By Year	x	x	x	x	x	x
Year	x	x	x	x	x	x
Firm	x	x	x	x	x	x

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm at time "t" (10016 observations for 2235 firms). (2) Dependent Variable Means listed in Brackets. (3) All standard errors are robust.

Table 10: Specification Checks

	Employment Weighted (1)	1972 &1977 assigned 1978 status (2)	Using Lower Percentage for "Emitter Status" (3)	Alive All Years (4)	1966-1982 Sample (5)
			A. Assets		
Firm by Industry Regulation (Reg_{fit})	393.6	307.7	332.2	450.5	136.7
	(123.9)	(132.5)	(129.8)	(133.4)	(104.9)
			B. Plant & Property Expenditures		
Firm by Industry Regulation (Reg_{fit})	157.0	119.8	702.6	966.0	294.3
	(42.0)	(45.0)	(193.8)	(200.2)	(196.6)
			C. Expenditures on Goods & Services		
Firm by Industry Regulation (Reg_{fit})	800.1	705.6	131.8	180.1	47.7
	(184.9)	(197.8)	(44.1)	(45.4)	(49.1)
			D. Gross Product		
Firm by Industry Regulation (Reg_{fit})	229.0	338.9	284.0	409.5	118.2
	(130.7)	(139.8)	(137.1)	(143.4)	(248.4)
			E. Sales, U.S. Parent Firm		
Firm by Industry Regulation (Reg_{fit})	166.1	135.0	123.0	173.5	21.3
	(122.7)	(131.2)	(128.6)	(134.4)	(256.1)
			F. Sales, U.S.		
Firm by Industry Regulation (Reg_{fit})	144.9	108.4	97.1	146.7	-45.3
	(126.5)	(135.3)	(132.6)	(137.3)	(255.1)

Notes: (1) The entries are from regressions where the dependent variable is the listed variable of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

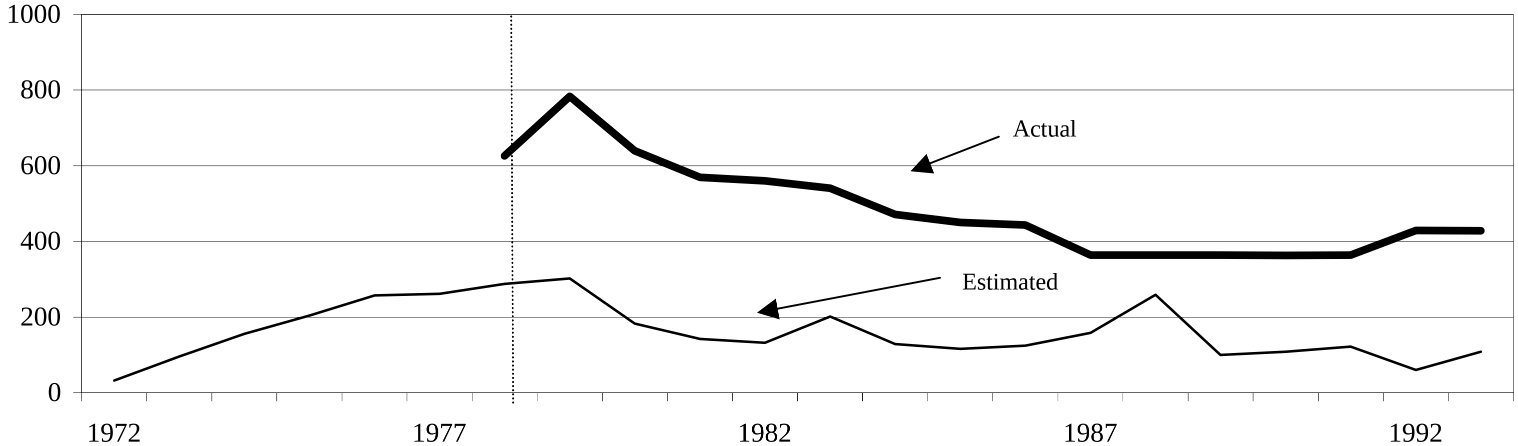
Appendix Table A1: Regression Results, Real Foreign Assets as Dependent Variable

	(1)	(2)	(3)	(4)	(5)
Firm by Industry Regulation (Reg_{fit})	859.6	858.5	374.9	218.4	207.3
	(199.0)	(199.4)	(160.6)	(129.5)	(129.5)
Mean Elasticity	2.3	2.3	1.0	0.6	0.6
Industry at Home, By Year	x	x	x	x	x
Nonattainment, By Year	x	x	x	x	x
Firm by Industry			x	x	x
Firm by Year				x	x
Industry by Year		x		x	x
Number of Plants					x
Number of Plants Squared					x

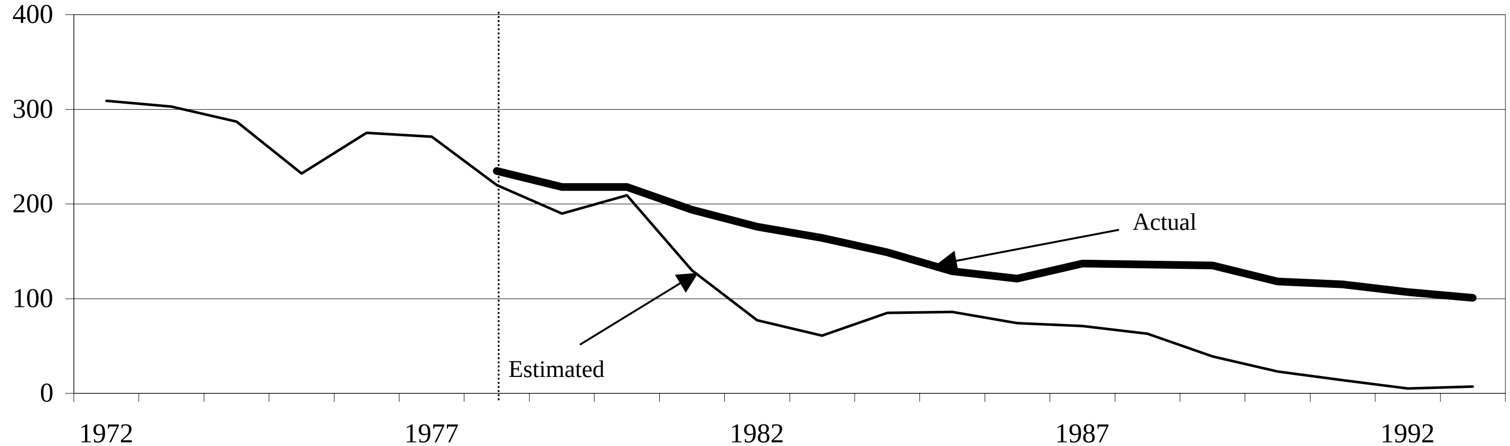
Notes: (1) The entries are from regressions where the dependent variable is the real foreign assets of a firm in an industry at time "t" (56385 observations for 2235 firms). (2) All regressions computed using two way effects model, and standard errors are appropriately adjusted.

Appendix Figure 1: Comparing the Estimated Versus Actual Nonattainment Status

Ozone



TSP



Appendix Table A2: Calculating Firm by Industry Regulation for Firm A (Reg_{fit})

		Troposheric Ozone (O_3)			Sulfur Dioxide (SO_2)			
Industry	U.S. Plants	Industry Emits	Nonattain	"Effectively Regulated"	Industry Emits	Nonattain	"Effectively Regulated"	Reg_{fit}
Motor Vehicle	Plant 1	Yes	Yes	Yes	--	--	--	50%
	Plant 2	Yes	--	--	--	--	--	
Petrol Refining	Plant 1	Yes	--	--	Yes	Yes	Yes	100%
Food	Plant 1	--	--	--	--	Yes	--	0%